C03-TMDL-03

LOWER BLACKFOOT TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN

Sediment, Trace Metal and Temperature TMDLs

December 2009

Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

Tim Byron, Project Manager Mike Van Liew, Modeling Assistance

Cooperators:
Blackfoot Challenge
Blackfoot Challenge TMDL Work Group

Significant Contributors:
Brian McDonald, Blackfoot Challenge
Dave Mannix, Blackfoot Challenge
Robert Anderson, Hydrometrics, Inc.
Karin Boyd, Applied Geomorphology, Inc.
David Marshall, K.C. Harvey, Inc.

ERRATA SHEET FOR THE "LOWER BLACKFOOT TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN – SEDIMENT, METALS AND TEMPERATURES"

This TMDL was approved by EPA on December 23, 2009. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version has a minor change that is explained and corrected on this errata sheet. If you have a bound copy, please note the correction listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

Appropriate corrections have already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

The following table contains corrections to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the "Lower Blackfoot Total Maximum Daily Loads and Water Quality Improvement Plan – Sediment, Metals and Temperatures" document.

Location in the TMDL	**Original Text**	**Corrected Text**
Table EX-1, Pollutants of Concern by Water Body, Keno Creek, Water Body ID	MT76F002_018	MT76F006_040
Table 2-1, Section 2.3, Page 16, Stream Assessment Unit column, Keno Creek	MT76F002_018	MT76F006_040
Table 2-1, Section 2.3, Page 16, Stream Assessment Unit column, Washoe Creek	MT76F006-901	MT76F006-090

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

EXECUTIVE SUMMARY

The Lower Blackfoot TMDL planning area is located in Missoula, Powell, and Granite counties and encompasses 377 square miles of mixed federal, state, and private land ownership. It includes the Blackfoot River watershed downstream of the Clearwater River confluence (**Appendix A, Figure A-2**). Elevations range from approximately 3,280 to 7,504 feet above sea level with a mean of 5,330 feet. The streams drain from conifer forested mountain slopes into broad, alluvial grassland and shrubland valleys. The mainstems of the Blackfoot River and the lower reaches of Elk, Camas, and Union creeks flow through agricultural valleys where most land uses are related to livestock production.

The Clean Water Act requires the development of TMDLs that specify water quality conditions that support all beneficial uses associated with the classification category. The planning area waters are classified as B-1, supporting uses for drinking, culinary and food processing after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

This document combines a framework approach to TMDL development and a generalized watershed restoration strategy. The framework approach to TMDL development in the Lower Blackfoot planning area is in response to the requirement to specifying maximum daily pollutant loading from a typically limited amount of data describing existing flow and water quality conditions. The major pollutant categories in the planning area waters are excess sediment, metals and elevated stream temperatures. The extent of the impaired water bodies in the planning area is displayed in figures in **Appendix A** against several natural resource, land cover and land use themes.

Sediment impairments were identified as a degree of departure from fine sediment content and channel habitat condition targets deemed protective of the most sensitive uses: aquatic life and cold water fisheries. Gross sediment loading estimates from general landscape processes and sources are divided into daily loads from predominant land uses with the combined aid of a coarse resolution sediment loading model, aerial photo interpretation and field assessments.

Temperature impairment was assessed through a review of data collected during the 2006 growing season. Stream channel shading conditions were determined from a combination of field stream assessments and interpretation of aerial photography. The selected data were used in conjunction with a daily time step temperature loading model to determine whether water temperature increases were within those allowed by the temperature standards for B-1 streams.

A limited amount of water quality sampling and flow measurements were used to characterize trace metals loading during high and low flow conditions. The metals TMDLs are presented in the form of a daily loading equation using established numeric concentration standards and a margin of safety.

Sediment source assessments identified roadway and land use related loading sources. Restoration strategies focus on implementing best management practices for road construction and maintenance, livestock grazing, irrigated forage production, timber harvest and residential development.

The framework TMDLs presented in this document are considered as a point of departure to be adjusted with information from future, more targeted assessment and restoration efforts. They are proposed here in the context of adaptive management, a process of making initial land and water management adjustments, monitoring the resulting water and land condition responses, and modifying management options and water condition goals toward meeting water quality standards and supporting beneficial uses.

The restoration process identified in this document is voluntary, cannot divest water rights or private property rights, and does not financially obligate identified stakeholders unless such measures are already a requirement under existing Federal, State, or Local regulations. Restoration strategies are intended to balance the varying uses of water while adhering to Montana's water quality and water use laws. This document is intended to describe the current knowledge of water quality conditions and propose a path for water quality restoration. As more knowledge is gained through the restoration process and monitoring, this plan will need adjustment to accommodate evolving scientific information and incorporate lessons learned in observing environmental responses to land and water management. Montana's water quality programs provide for future TMDL reviews and offers technical and financial assistance toward restoring water quality.

The document structure provides specific sections that address TMDL components and watershed restoration. They are described in **Section 1.0**. The table that follows contains a summary of the TMDL components addressed in this document. **Table Ex-1** that follows contains a summary of the TMDL components addressed in this document. Table EX-1 does not contain information on nutrient TMDLs in the Lower Blackfoot. Nutrient TMDL development has been postponed pending the proposal of numeric nutrient standards by DEQ and the review and establishment of these standards through rule making.

Table Ex-1. Summary of Required TMDL Elements for the Lower Blackfoot River TMDL Planning Area

	Stream Name – Pollutant/s	Water Body ID
Pollutants of Concern By Water body	Ashby Creek, West Fork – Sediment, Total Phosphorus	MT76F006_020
	Ashby Creek, East Fork – Sediment, $NO_2 + NO_3$-N, Total Phosphorus	MT76F006_050
	Belmont Creek - Sediment	MT76F006_070
	Blackfoot River, Monture Creek to Belmont Creek – Temperature, Total Phosphorus, Total Nitrogen	MT76F001_032
	Blackfoot River, Belmont Creek to mouth – Unionized Ammonia	MT76F001_033
	Camas Creek – Sediment, Total Phosphorus	MT76F006_060
	Upper Elk Creek, Headwaters to Stinkwater Creek – Sediment, NO_3-N, Cadmium	MT76F006_031
	Lower Elk Creek, Stinkwater to mouth – Sediment, Temperature	MT76F006_032
	Keno Creek – Not Assessedt	MT76F006_040
	Union Creek – Solids (Suspended/Bedload), Arsenic, Copper, Temperature, Total Phosphorus	MT76F006_010
	Washoe Creek – Sediment, Total Phosphorus, Total Kjeldahl Nitrogen, $NO_2 + NO_3$-N	MT76F006_091
Pollutant Sources	Road Erosion Livestock Grazing Irrigated Hay Production Silviculture Activities Placer Mining Residential Development Unknown Sources	
Targets	**Sediment** <u>Channel Type - B</u> • Riffle Surface Substrate Percent < 6 mm - ≤ 20 • Riffle Surface Substrate Percent < 2 mm - ≤ 10 • Pool Frequency (count per mile) - ≥ 48 • Residual Pool Depth (ft) - ≥ 1.1 • Width:Depth Ratio - 12-16 • Median Percent Surface Fines < 6 mm in Poll Tailouts - ≤ 17 • Macroinvertebrate Multi-Metric Index (MMI) Score - > 48 • Macroinvertebrate RIVPACS Observed/Expected Score - ≥ 0.8 • Percent Woody Vegetation Extent - ≥ 88 • Percent Pool Extent - ≥ 22 • Percent Woody Debris Aggregate Extent - ≥ 12 • Entrenchment Ratio - ≥ 2.2 • Woody debris Frequency (count per mile) - ≥ 127	

Table Ex-1. Summary of Required TMDL Elements for the Lower Blackfoot River TMDL Planning Area

	Stream Name – Pollutant/s	**Water Body ID**
	<u>Channel Type - C</u> • Riffle Surface Substrate Percent < 6 mm - ≤ 22 • Riffle Surface Substrate Percent < 2 mm - ≤ 7 • Percent McNeil Core Sediment < 6.35 mm - 27 • Percent McNeil Core Sediment < 0.85 mm - 6 • Pool Frequency (count per mile) - ≥ 55 • Residual Pool Depth (ft) - ≥ 2.0 • Width:Depth Ratio - ≤ 19 • Median Percent Surface Fines < 6 mm in Poll Tailouts - ≤ 23 • Macroinvertebrate Multi-Metric Index (MMI) Score - > 48 • Macroinvertebrate RIVPACS Observed/Expected Score - ≥ 0.8 • Percent Woody Vegetation Extent - ≥ 84 • Percent Pool Extent - ≥ 35 • Percent Woody Debris Aggregate Extent - ≥ 8 • Entrenchment Ratio - ≥ 2.2 • Woody debris Frequency (count per mile) - ≥ 74 <u>Channel Type E</u> • Riffle substrate: <6mm (%) - ≤36 • Riffle substrate: <2mm (%) - ≤20 • Pool Frequency (pools/mile) - ≥40 • Residual Pool Depth (ft) - ≥1.5 • Median W:D Ratio - 6-11 • Woody Vegetation Extent (%) - ≥74 • Marcoinvertebrate Multi-Metric Index - ≥48 • Pool Extent (%) - ≥29 • Woody Debris Aggregate Extent (%) - ≥12 <u>Channel Type - Eb</u> • Riffle Surface Substrate Percent < 6 mm - 37 • Riffle Surface Substrate Percent < 2 mm - ≤ 35 • Pool Frequency (count per mile) - ≥ 50 • Residual Pool Depth (ft) - 0.8 • Width:Depth Ratio - ≤ 11 • Median Percent Surface Fines < 6 mm in Poll Tailouts - ≤ 42 • Macroinvertebrate Multi-Metric Index (MMI) Score - > 63 • Macroinvertebrate RIVPACS Observed/Expected Score - ≥ 0.8 • Percent Woody Vegetation Extent - ≥ 100 • Percent Pool Extent - ≥ 10 • Percent Woody Debris Aggregate Extent - ≥ 12 • Entrenchment Ratio - ≥ 2.2 • Woody debris Frequency (count per mile) - ≥ 73	

Table Ex-1. Summary of Required TMDL Elements for the Lower Blackfoot River TMDL Planning Area

	Stream Name – Pollutant/s	Water Body ID
	Channel Type - Eb4 • Riffle Surface Substrate Percent < 6 mm - 45 • Riffle Surface Substrate Percent < 2 mm - ≤ 35 • Pool Frequency (count per mile) - ≥ 50 • Residual Pool Depth (ft) - 0.8 • Width:Depth Ratio - ≤ 11 • Median Percent Surface Fines < 6 mm in Poll Tailouts - ≤ 42 • Macroinvertebrate Multi-Metric Index (MMI) Score - > 63 • Macroinvertebrate RIVPACS Observed/Expected Score - ≥ 0.8 • Percent Woody Vegetation Extent - ≥ 100 • Percent Pool Extent - ≥ 10 • Percent Woody Debris Aggregate Extent - ≥ 12 • Entrenchment Ratio - ≥ 2.2 • Woody debris Frequency (count per mile) - ≥ 73 **Iron** 1000 µg/L (Chronic aquatic life standard) **Temperature (B-1 waters)** Woody vegetation shade replacement allowing maximum 1°F allowable increase over naturally occurring temperature when naturally occurring <67ºF or; maximum 0.5°F increase over naturally occurring temperature when naturally occurring is >67ºF; Channel width:depth per sediment targets by channel type; Lower Elk Creek Union Creek ≥15% flow augmentation July 15th -August 15th Lower Elk Creek Union Creek	

Table Ex-1. Summary of Required TMDL Elements for the Lower Blackfoot River TMDL Planning Area

	Stream Name – Pollutant/s	Water Body ID
Required TMDLs	**Sediment** Ashby Creek, East Fork Ashby Creek, West Fork Belmont Creek Camas Creek Upper Elk Creek Lower Elk Creek Keno Creek Union Creek Washoe Creek **Metals** **Iron** Union Creek **Temperature** Lower Elk Creek Union Creek	
Allocations	**Sediment** Allowable loading and reductions allocated to principal land uses by impaired segment. **Metals** Union Creek Iron 38% reduction from the Copper Cliff source plus natural background sources of iron that are either particulate bound or dissolved; **Temperature** Allocations to temperature surrogate parameters by segment: • Needed percent increases in woody riparian vegetation as bankline extent of woody vegetation by listed segment, • Channel width:depth ratio per sediment targets by channel type in Lower Elk Creek and Union Creek, • ≥15 percent increase in stream flow during July 15th to August 15th -;- Lower Elk Creek and Union Creek	
Margin of Safety	**Sediment** • Liberal assumption in size of hillslope contributing area; • Inclusion of “forest roads” HRU in hillslope sediment source assessment; • Assumed minimum achievable reduction of 25 percent in human caused stream bank erosion on the best condition streams; • One percent assumed annual culvert failure rate	

Table Ex-1. Summary of Required TMDL Elements for the Lower Blackfoot River TMDL Planning Area

	Stream Name – Pollutant/s	Water Body ID
	• Adaptive management goals for sediment. **Metals** • Explicit 10 percent reduction in allowable after mixing concentration from chronic aquatic life standard of 1,000 µg/L to 900 µg/L **Temperature** • Conservative estimate of shade potential (80-90 percent)	
Seasonality	**Sediment** Daily distribution of loading based on hydrologic seasons. **Metals** Loading based on flow and target metal concentration **Temperature** Daily loads based on flow and current temperature that both vary seasonally.	

SECTION 1.0
INTRODUCTION

1.1 Background

This document, *Lower Blackfoot Total Maximum Daily Loads (TMDLs) and Water Quality Improvement Plan*, describes the Montana Department of Environmental Quality's present understanding of water quality problems in rivers and streams of the Lower Blackfoot Planning Area of the Blackfoot River Watershed and presents a general plan for resolving them. Guidance for completing the plan is contained in the Montana Water Quality Act and the federal Clean Water Act. The Montana Water Quality Act directs Montana DEQ to consult with local conservation districts and watershed advisory groups in developing and implementing these plans.

Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act, in 1972. The goal of this act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters". The Clean Water Act requires each state to set water quality standards that define and protect designated beneficial water uses - for example fish and aquatic life, wildlife, and agricultural, industrial, and drinking water uses - and to monitor their attainment. Streams and lakes not meeting the established standards (called *impaired waters*), and those not expected to meet the standards (called *threatened waters*), must be identified, listed and prioritized for corrective action. The list of threatened and impaired waters is known as the 303(d) list, named after Section 303(d) of the Clean Water Act which mandates the monitoring, assessment and listing of water quality limited water bodies.

Water quality limited waters must be prioritized for development of "Total Maximum Daily Loads", or TMDLs, for the listed pollutants. Both Montana state law (Section 75-5-703 of the Montana Water Quality Act) and the federal Clean Water Act require the development of total maximum daily loads for impaired and threatened waters where a measureable pollutant (for example, sediment, nutrients, metals or temperature) is the cause of the impairment. The Montana Water Quality Act further defines methods by which impaired waters will be identified, and establishes procedures and a schedule for developing TMDLs on a statewide basis.

A TMDL refers to the maximum amount of a pollutant a stream or lake can receive and still support all of its designated uses, or the level of reduction in pollutant loading that is needed to fully attain water quality standards. The goal of TMDLs is to eventually attain and maintain water quality standards in all of Montana's streams and lakes, and to improve water quality to levels that support all state-designated beneficial water uses.

The development of TMDLs and water quality improvement strategies includes several sequential steps that must be completed for each impaired water body and for each contributing pollutant (or "pollutant/water body combination"). These steps include evaluating the degree and sources of the impairment(s), quantifying the magnitude of pollutant contribution from each source, and establishing allowable limits (or total maximum daily loads) for each pollutant.

Next, the current pollutant load is compared to the loading capacity (or maximum loading limit) of the particular water body and the amount of pollutant reduction needed from each contributing source is determined. These are called pollutant allocations. Finally, restoration strategies are developed that, when implemented, will lead to the full support of the water body's designated beneficial uses. Because TMDLs are completed for each pollutant/water body combination, this framework water quality improvement plan contains several TMDLs.

In some cases, the TMDLs may not be capable of fully restoring the designated beneficial uses without the addition of other restoration measures. For example, impairment causes such as streamflow alterations or dewatering, habitat degradation, and streambank or stream channel alterations may limit the full attainment of a water body's beneficial uses even after TMDLs have been implemented. These are referred to as "pollution" problems, as opposed to impairments caused by any type of discrete "pollutant", such as sediment or metals. TMDLs, *per se*, are not intended to address water use support problems not directly associated with specific pollutants. However, many water quality restoration plans (**Section 9.0**) describe strategies that consider and address habitat, streamflow, and other conditions that may impair beneficial uses, in addition to problems caused by more conventional water pollutants. The desired goal of any well designed water quality improvement strategy is to restore impaired waters to a condition that supports all designated beneficial uses, and maintains a condition of full water quality standards attainment, through comprehensive restoration approaches.

1.2 Document Description

This document presents a framework water quality improvement plan and TMDLs for water quality-limited stream segments in the Lower Blackfoot Planning area. The water pollutants affecting the Lower Blackfoot River planning area that are addressed by this plan include sediment, metals, and elevated water temperatures. These pollutants have been shown to impair some designated uses of these streams, including aquatic life, cold water fisheries, and primary contact recreation (See **Table 2-1**).

The *Lower Blackfoot TMDLs and Water Quality Improvement Plan* is intended to provide a framework for water quality improvement. The plan sets specific, measureable water quality improvement goals for each impaired stream segment and pollutant of concern, and describes a set of on-the-ground restoration measures for reducing pollutant loads and improving overall stream health. The document also describes a continuing water quality monitoring plan and an adaptive management strategy for fine-tuning the restoration plan over time, if needed.

This plan has been written and structured to be readable by a non-technical audience. The main body of the document provides an overview of the water quality problems, their sources, and the proposed solutions. Additional technical details, including assessment methods and results, and proposed water quality improvement measures, are included in appendixes at the back of the main document for further reference.

The document has been organized in sections, as follows. Following this introduction, the plan discusses the water quality standards that apply to the Lower Blackfoot Planning Area **(Section 2.0)**. Next is a description of the physical characteristics of the Lower Blackfoot which must be considered in order to develop a successful water quality management plan (**Section 3.0**). **Sections 5.0** through **7.0** is the main focus of the plan and describes the pollutants of concern that are addressed by this plan (sediment, metals, and temperature). Each of these sections also describes the stream segments affected by each pollutant and provides summaries of the contributing sources and the proposed TMDLs. **Section 8.0** specifies the pollutant loads, needed reductions to pollutant loads, and allocations of allowable loads to land use sources. **Section 9.0** of the report discusses water quality restoration objectives and presents a proposed implementation strategy. This section also describes a water quality monitoring plan for evaluating the long-term effectiveness of the *Lower Blackfoot TMDLs and Water Quality Improvement Plan*. **Section 10.0** contains the comments received by DEQ on the Pubic Review Draft of the document and their corresponding responses.

1.3 Public Participation

This section describes the state laws and policies that pertain to stakeholder and public participation in the Montana TMDL process. It also describes stakeholder and public involvement in the development of TMDLs and the Water Quality Improvement Plan by the Blackfoot Challenge and its partners.

1.3.1 State Policy

Local community participation and support are invaluable in the TMDL planning process as well as the implementation process. The Montana Water Quality Act specifically requires Montana DEQ to consult with conservation districts and watershed advisory groups during the water quality restoration planning process. Stakeholder involvement is especially important in TMDL implementation because most water quality improvement plans rely heavily on voluntary cooperative approaches. Additionally, it is recognized that public involvement may vary from one planning area to another because of differing levels of stakeholder interests and concerns. **Section 1.3.2** provides a summary of the measures that were undertaken in the Lower Blackfoot Planning Area to meet the intent of the state TMDL coordination policy.

DEQ encourages local conservation districts and watershed groups to assume a local leadership role in organizing watershed based water quality improvement efforts because they include a diverse membership that reflects local land and water uses in the community. The state's policy is that local watershed groups and conservation districts shall determine their own level of participation in the Montana TMDL planning process. Where there is limited local interest, DEQ may be required to assume a broader role in the TMDL planning process.

The Montana Water Quality Act requires that control of nonpoint sources of pollution called for within TMDL plans must be addressed through voluntary cooperative approaches that are based on reasonable land, soil, and water conservation practices. Additionally, the state law specifies that Montana TMDL plans must not interfere with water rights or private property rights, and must not financially obligate participants unless such measures are already a requirement under other existing federal, state, or local regulations. Control of point sources of pollution (discrete discharges) recommended within TMDL plans are achieved through the state's MPDES wastewater discharge permit program.

Voluntary approaches are the most practical means of addressing the cumulative impacts of many diffuse nonpoint sources in a watershed. However, there may be exceptions for certain activities that are regulated through existing local, state, and federal regulations. These include, but may not be limited to, streamside management zone requirements for timber harvest, minimum septic design standards and siting criteria, local zoning requirements for riparian or streambank protection, and requirements of the Montana 310 Law, which affords protection to natural stream beds and banks. Regardless of the approach, DEQ staff pledge to work with landowners, other agencies, and all stakeholders to select and implement water quality improvement measures that are compatible with local needs while still attaining the water quality standards.

1.3.2 Stakeholder and Public Participation

As it has done with other planning areas in the watershed, the Blackfoot Challenge played an important role in the development of TMDLs and the Water Quality Improvement Plan for the Lower Blackfoot Planning Area. The primary means of stakeholder and public participation in this process was the Blackfoot Challenge's TMDL Work Group. State and federal agencies, conservation organizations, private landowners, corporations, and consultants are all represented on the Blackfoot TMDL Work Group.

Regular meetings of the Blackfoot TMDL Work Group have occurred throughout the development of this plan. The Blackfoot TMDL Work Group helped shape assessment methodologies and monitoring plans for the Lower Blackfoot Planning Area. Many members also participated in the collection of field data during a two-week assessment of streams in the Lower Blackfoot in September 2006. Blackfoot TMDL Work Group members have reviewed numerous interim and draft documents related to this plan and have provided valuable input, data, and direction to the process.

While private landowners are represented, it would be impossible to include all private landowners from the Lower Blackfoot Planning Area in the TMDL Work Group. The Blackfoot Challenge has taken additional steps to include private landowners from the lower Blackfoot in the planning process. Prior to initiating planning efforts, the Blackfoot Challenge hosted a public meeting in the lower Blackfoot outlining the steps involved in plan development. Following the meeting, letters were sent to landowners with information on plans for data collection and field assessment work. As a result of these efforts, several landowners participated in the assessment of streams on their property. While a less direct approach, the Blackfoot Challenge also includes updates on the status of the plan in local newspapers and newsletters. Landowners and stakeholders in the lower Blackfoot were notified via mail of the release of the plan for public review, copies of the plan were placed in public locations, and a public meeting was held on December 15, 2008 at the Potomac-Greenough Community Center located in Potomac, Montana from 7:00 pm – 8:30 pm. Public comments received by DEQ during the course of the public comment period are contained in **Section 10.0** with their corresponding responses.

SECTION 2.0
REGULATORY FRAME WORK

2.1 TMDL Development Requirements

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify water bodies within its boundaries that do not meet water quality standards. The document entitled "Water Quality Integrated Report for Montana", prepared by the Water Quality Planning Bureau of the Department of Environmental Quality (MT DEQ 2006), identifies threatened and impaired waters and describes the methodology for determining impairment status. The biannual development of this document, formerly referred to as the 303(d) List, is intended to fulfill the CWA requirement to identify waters not meeting standards.

An "impaired water body" is a water body or stream segment for which sufficient credible data show that the water body or stream segment is failing to achieve compliance with applicable water quality standards (Montana Water Quality Act; Section 75-5-103(11)). A "threatened water body" is defined as a water body or stream segment for which sufficient credible data and calculated increases in loads show that the water body or stream segment is fully supporting its designated uses but threatened for a particular designated use because of: (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices; or (b) documented adverse pollution trends (Montana Water Quality Act; Section 75-5-103(31)). State Law and section 303 of the CWA require states to develop TMDLs for impaired and threatened water bodies.

A TMDL is a pollutant budget identifying the maximum amount of a pollutant that a water body can assimilate without exceeding applicable standards. TMDLs are the mass of a pollutant entering a water body per unit of time and are most often expressed in pounds per day. TMDLs include pollutant loads from point sources, nonpoint sources, and naturally occurring sources. Due to inherent uncertainty in pollutant loading estimates, TMDLs must incorporate a margin of safety. TMDLs must also consider the seasonality of pollutant loading. In Montana, TMDLs are commonly developed in the context of a watershed-wide water quality restoration plan. Along with pollutant-specific TMDLs, this plan also includes recommendations for restoring beneficial uses affected by more general, reach-scale impairment causes such as aquatic or riparian habitat degradation or flow modification that are not addressed by reductions in pollutant loading.

TMDLs are developed for each water body-pollutant combination identified on the list of impaired or threatened waters. Montana State Law regarding TMDL development (75-5-703(8)) directs DEQ to "support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL ……" This directive is reflected in the TMDL development and implementation strategy within this plan. Water quality protection practices are not considered voluntary where they exist as requirements under Federal, State, or Local regulations.

2.2 Water Bodies and Pollutants of Concern

A total of 26 pollutant-water body combinations are accounted for in the Lower Blackfoot River TPA. All pollutants, except nutrients, have been addressed in the pollutant problem reviews, TMDLs, or watershed restoration plans presented in this document. Nutrient TMDLs in the Lower Blackfoot TPA have been postponed pending the proposal of numeric nutrient standards by DEQ and the review and establishment of these standards by the Board of Environmental Review (BER). TMDLs were not prepared for impairments where additional information suggested that the initial listings may need to be reviewed or where conditions since listing have improved such that the pollutant no longer impairs a beneficial use. Where a pollutant is no longer considered an impairment cause, justification is provided. **Table 2-1** provides an impairment listing summary for the Lower Blackfoot, the affected beneficial uses, TMDLs prepared in this document, and recommendations for further review of impairment determinations.

2.3 Impairment Listing Summary and TMDLs Written

A recent court ruling and subsequent settlements have obligated the U.S. EPA and the State of Montana to address pollutant-water body combinations from the 1996 list of impaired waters. State and federal TMDL guidance also recommends that the most recent list be used for determining the need for TMDLs. Therefore, consideration of both the 1996 and 2006 impairment listings are reflected in the TMDLs contained in this document.

Although the 1996 list of impaired waters was based on data suggesting use support problems, the data sets in many cases were small and determinations required considerable professional judgment. Since 1996, DEQ has developed a more thorough assessment process to identify impaired waters. The Sufficient Credible Data Assessment & Beneficial Use-Support Determinations (SCD/BUD) Process was developed in response to legal stipulations (75-5-702 MCA), and it is being used to update past impairment listings. Due to an improved data review process, impaired uses, causes, and sources described in the 2006 Water Quality Integrated Report for Montana may differ from past listings. Where new data and interpretations have revised the listing status, TMDL development is based on the new information.

This document addresses sediment, temperature and metals impairments. There are nine water body segments within the Lower Blackfoot River TPA that have sediment-related listings on the 2006 303(d) List: the east and west forks of Ashby Creek, Belmont Creek, Camas Creek, the upper and lower segments of Elk Creek, Keno Creek, Union Creek and Washoe Creek (**Table 2-1**; DEQ, 2006a). Sediment TMDLs have been completed for these stream segments. The sediment-related impairments are associated with siltation, sedimentation, and suspended sediment and are further discussed for each water body in **Section 5.0**.

Table 2-1. Summary of 2006 and 1996 303(d) Listings and TMDL Status (Pollutant-related causes of impairment are in bold.)

Stream Assessment Unit	Probable Cause	2006 303d	1996 303d	Beneficial Uses Affected*	2008 TMDL Review	TMDL Completed	Further Review Needed
Ashby Creek, West Fork MT76F006_20	**Sedimentation/ Siltation**	X		CWF	Yes	Yes	No
	Alteration in streamside or littoral vegetative covers	X		AL, CWF	N/A	N/A	N/A
	Total Phosphorus	X		AL, CWF	No	No	Yes
Ashby Creek, East Fork MT76F006_50	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
	Alteration in streamside or littoral vegetative covers	X		AL, CWF	NA	NA	NA
	NO_2+NO_3-N	X		AL, CWF	No	No	Yes
	Total Phosphorus	X		AL, CWF	No	No	Yes
Belmont Creek MT76F006_70	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
Blackfoot River (Monture Cr. to Belmont Cr) MT76F001_032	**Total Phosphorus**	X	X	AL, CWF	No	No	Yes
	Total Nitrogen	X	X	AL, CWF	No	No	Yes
	Water Temperature	X		AL, CWF	Yes	No	Yes
Blackfoot River (Belmont Cr. to mouth) MT76F001_033	**Unionized Ammonia**	X		AL, CWF	No	No	Yes
Camas Creek MT76F006_60	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
	Total Phosphorus	X		AL, CWF	No	No	Yes
	Flow Alteration	X	X	AL, CWF	NA	NA	NA
	Water Temperature		X	AL, CWF	No	No	Yes
Day Gulch MT76F006_80	NA	NA		Use Support Not Assessed	Yes	No	Yes

Table 2-1. Summary of 2006 and 1996 303(d) Listings and TMDL Status (Pollutant-related causes of impairment are in bold.)

Stream Assessment Unit	Probable Cause	2006 303d	1996 303d	Beneficial Uses Affected*	2008 TMDL Review	TMDL Completed	Further Review Needed
Elk Creek (Headwaters to Stinkwater Cr.) MT76F006_031	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
	NO_3-N	X		AL, CWF	No	No	Yes
	Cadmium	X		AL, CWF	Yes	No	Yes
	Physical substrate habitat alteration	X		AL, CWF	NA	NA	NA
Elk Creek (Stinkwater Cr. to mouth) MT76F006_032	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
	Alteration in streamside or littoral vegetative covers	X	X	AL, CWF	NA	NA	NA
	Water Temperature	X		AL, CWF	Yes	Yes	
Keno Creek MT76F006_040	NA	No		Use Support Not Assessed	Yes	Yes	Yes
Union Creek MT76F006_010	Physical substrate habitat alteration	X		AL, CWF	NA	NA	NA
	Arsenic	X		AL, CWF	Yes	No	Yes
	Copper	X		AL, CWF	Yes	No	Yes
	Iron	No		AL	Yes	Yes	Yes
	Solids (Suspended/ Bedload)	X		AL, CWF	Yes	Yes	No
	Total Phosphorus	X		AL, CWF	No	No	Yes
	Water Temperature	X	X	AL, CWF	Yes	Yes	No
Washoe Creek MT76F006_090	**Sedimentation/ Siltation**	X	X	AL, CWF	Yes	Yes	No
	Total Phosphorus	X		AL, CWF, PCR	No	No	Yes
	Total Kjeldahl Nitrogen	X		AL, CWF, PCR	No	No	Yes
	NO_2+NO_3-N	X		AL, CWF, PCR	No	No	Yes

All 303(d) listed probable causes shown in **bold** in **Table 2-1** (i.e. siltation, sedimentation, suspended solids, etc) are associated with specific pollutants. Sediment, temperature and metals impairments will be addressed within this document. A complete listing history and listing justifications for each water body are available from the Montana Clean Water Act Information Center located at the following web address: http://cwaic.mt.gov/default.aspx. Although TMDLs address pollutant loading, implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some pollution related impairment causes such as the physical substrate habitat alteration causes listed above for Upper Elk Creek and Union Creek.

Water temperature is listed as an impairment cause for three stream segments: Lower Elk Creek, Union Creek and the Blackfoot River mainstem between Monture Creek and Belmont Creek. The mainstem segment straddles the boundary between the Middle and Lower Blackfoot TMDL planning areas. The reach from Monture Creek to the Clearwater River is in the Middle Blackfoot TPA; the reach from the Clearwater to Belmont Creek is in the Lower Blackfoot TPA. Temperature modeling for the entire listed segment was completed as part of the Middle Blackfoot thermal loading analysis (**Section 8.2.2.3**). The analysis concluded that water temperature increases occurring within the Monture to Belmont segment are within those allowed by the B-1 temperature standard and a temperature TMDL for the Blackfoot mainstem is not required. Therefore, this document specifies temperature TMDLs for Lower Elk Creek and Union Creek only.

Metal listings in **Table 2-1** include those for arsenic and copper in Union Creek and cadmium in Elk Creek. A recent assessment of metals loading in these streams supported only the need for an iron TMDL in Union Creek.

2.4 Potential Future TMDL Development

Additional data collection and analysis was undertaken for pollutants within several water bodies where impairment conditions were suspected, but not previously confirmed during application of DEQ’s assessment process using methods consistent with State Law (75-5-702). The results from this work will be made available in the DEQ files, and may lead to additional TMDL development at a later time for these and possibly other water body – pollutant combinations. The water body – pollutant combinations that are recommended for additional assessment include:

Blackfoot River mainstem - nutrients
Ashby Creek, West Fork – total phosphorus
Ashby Creek, East Fork – total phosphorus, NO_3+NO_2-N
Camas Creek – thermal modification, total phosphorus
Elk Creek, upper – NO_3-N
Union Creek – total phosphorus
Washoe Creek – total Kjeldahl nitrogen, NO_3+NO_2-N, total phosphorus,

2.5 Applicable Water Quality Standards

Water quality standards include the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a water body. The ultimate goal of this water quality restoration plan, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Pollutants addressed in this Water Quality Restoration Plan include sediment, metals, and thermal modification. This section provides a summary of the applicable water quality standards for each of these pollutants.

2.5.1 Classification and Beneficial Uses

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

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

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

All water bodies within the Lower Blackfoot River TPA are classified as B-1. The descriptions of the B-1 surface water classification are presented in **Table 2-2**.

Table 2-2. Montana Surface Water Classification and Designated Beneficial Uses Applicable to the Lower Blackfoot River Watershed

Classification	Designated Uses
B-1 CLASSIFICATION	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

2.5.2 Standards

In addition to the Use Classification described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ, 2006b). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective in instances of long-term (i.e., life long) exposures as well as through direct, short-term contact such as swimming.

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

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant" or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that water body.

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

The standards applicable to the list of pollutants addressed in the Lower Blackfoot TPA are summarized below.

Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 2-3.** The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a water body's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses.

Table 2-3. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is: 5 NTU for waters classified as B-1.
17.30.602(17)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(21)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Metals

Numeric standards for water column metals in Montana include specific standards for the protection of both aquatic life and human health. Acute and chronic criteria have been established for the protection of aquatic life. The numeric criteria for cadmium, copper, chromium, lead, nickel, silver, and zinc vary according to the hardness of the water. Among these, copper is the only metal of concern in the Lower Blackfoot TPA. **Table 2-4** lists the numeric aquatic life and human health criteria from Circular DEQ-7 for the metals that are impairment causes in the Lower Blackfoot TPA. These values are used to determine standards exceedences in this document. The metals data record indicates that other metals are below water quality standards.

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

Table 2-4. Montana Numeric Surface Water Quality Standards Guide for Metals

Parameter	Aquatic Life (acute) (µg/L)[a]	Aquatic Life (chronic) (µg/L)[b]	Human Health (µg/L)[a]
Arsenic (TR)	340	150	Pre- 01/23/06 – 18 Post- 01/23/06 - 10
Cadmium	0.52 @25 mg/L hardness	0.097 @25 mg/L hardness	5
Copper	3.79 @ 25 mg/L hardness	2.85 @ 25 mg/L hardness	1300
Iron (TR)	-	1000	300

[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
Note: TR – total recoverable.

The human health standard for arsenic reflects Montana’s recent adoption of the national Maximum Contaminant Level (MCL) of 10 µg/L, effective as of January 23, 2006. For analyses prior to this date, the former health advisory level of 18 µg/L is used to determine compliance with standards. The human health standards for iron and manganese are secondary maximum contaminant levels which are based on aesthetic water properties such as taste, odor, and the tendency of these metals to cause staining. Neither iron nor manganese is classified as a toxin or a carcinogen. Therefore, narrative standards adopted for these metals state that concentrations “must not reach values that interfere with the uses specified in the surface and ground water standards” (Circular DEQ-7 DEQ 2006b). The secondary MCLs for iron and manganese serve as use support “guidance” together with consideration of the number, degree, and timing of exceedences and the concentrations of these metals likely to occur after conventional treatment. If the data indicate that the human health guidance values for iron and manganese would be consistently exceeded after conventional treatment, use of the water body for drinking water is considered impaired for these constituents. Iron also has a chronic aquatic life standard of 1000 µg/L used to determine impairment for aquatic life and cold water fishery uses.

Montana also has a narrative standard that pertains to metals in sediment. No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will, or are likely to, create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife (ARM 17.30.623(2)(f)). This narrative standard applies to metals laden sediment.

Temperature

Montana's temperature standards were originally developed to address situations associated with point source discharges, making them somewhat awkward to apply when addressing nonpoint source issues. In practical terms, the temperature standards specify a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards specify a maximum allowable rate of temperature decrease and a maximum temperature reduction below naturally occurring to avoid fish and aquatic life temperature shock.

For waters classified as B-1, a 1ºF maximum increase above naturally occurring water temperature is allowed within the range of 32ºF to 66ºF; within the naturally occurring range of 66ºF to 66.5ºF, no discharge is allowed which will cause the water temperature to exceed 67ºF; and where the naturally occurring water temperature is 66.5ºF or greater, the maximum allowable increase in water temperature is 0.5ºF. A 2ºF per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55ºF. A 2ºF maximum decrease below naturally occurring water temperature is allowed within the range of 55ºF to 32ºF (ARM 17.30.623(2)(e)).

The term "naturally occurring" is defined in Montana's water quality standards as "conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural" (ARM 17.30.602 (19). Regarding dam operations, guidance for interpretation of the term "reasonable operation" is given by the General Operation Standards (ARM 17.30.636 (1) that state that "Owners and operators of water impoundments that cause conditions harmful to prescribed beneficial uses shall demonstrate to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects."

2.5.3 Reference Condition Approach for Narrative Standards

DEQ uses the reference condition approach in determining if narrative water quality standards are being achieved. The term "reference condition" is defined as the condition of a water body capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. Montana's water quality standards define "reasonable land, soil, and water conservation practices" as those that protect beneficial uses (ARM 17.30.602(24)). Reasonable land, soil, and water conservation practices include, but are not limited to, the best management practices applicable to the pollution producing activities within a watershed (DEQ, 2006a).

The standards further define developed land where all reasonable land, soil, and water conservation practices have been applied as a “naturally occurring” condition (ARM 17.30.602(19)). Therefore, reference condition is a useful standard of comparison because it reflects a naturally occurring condition on developed lands where, in the context of historic land uses, all beneficial uses are supported. The intention is to differentiate between naturally occurring conditions and widespread or significant alterations of biology, chemistry, or stream morphology due to human activity. The narrative water quality standards applicable to sediment, temperature, turbidity, and pH are based on the departure from naturally occurring conditions, making the use of reference conditions important for judging compliance with these particular standards.

Comparison of conditions in a water body to reference water body conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the suspended sediment concentration of a stream during the summer base flow should not be compared to that of a reference stream during a spring runoff event. In addition, a comparison should not be made to the lowest or highest values of a reference site, which represent the outer boundaries of reference conditions.

The following approaches may be used to determine reference conditions:

Primary Approaches

- Regional Approach: Comparing conditions in a water body to baseline data from minimally impaired water bodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Historical Approach: Evaluating historical data relating to condition of the water body in the past.
- Unimpaired Segment Approach: Comparing conditions in a water body to conditions in another portion of the same water body, such as an unimpaired segment of the same stream.

Secondary Approaches

- Literature Approach: Reviewing literature (e.g. a review of studies of fish populations, etc.) that were conducted on similar waterbodies that are least impaired.
- Professional Opinion Approach: Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the water body’s fisheries health or capability).
- Modeling Approach: Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional reference or other primary reference data are available and uses the secondary approach to estimate reference condition when there are no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

2.5.4 Developing Parameter Values or Ranges for Reference Condition

Use of Mean and Standard Deviation versus the Use of Median and Percentiles
Assessing the degree of water quality impairment through a comparison with reference conditions requires developing representative reference values to use in the comparison. Statistical means or averages are commonly used because they integrate both natural variability and measurement variability into a single summarizing number. The comparison is made between means or average values from a reference data set with means derived from data collected from the water body being assessed to determine whether the latter compares favorably with or falls within the range of one standard deviation around the reference mean. This comparison assumes a “normal” or symmetrical distribution of the data around each of the means. Normal data distributions are rare among water resources data sets that more commonly tend to have a non-normal distribution (Hensel and Hirsch, 1995). In addition, the small data sets commonly encountered for water quality parameters can often yield unreliable mean values due to extreme values or skewed distributions. For these reasons it is more appropriate to use non-normal or non-parametric statistical measures when setting reference values for most water quality parameters.

Normally distributed data are evaluated according to their degree of variance from a central mean, non-normally distributed data are most often evaluated based upon how they are ranked from lowest to highest. Ranked data are summarized according to their position among four quartiles of the data set. Quartiles are used to split the data distribution into four groups, each containing 25 percent of the measurements. A “box and whisker” diagram with labeled quartiles of a hypothetical reference data distribution is illustrated on the right in **Figure 2-1** with two comparison data points on the left.

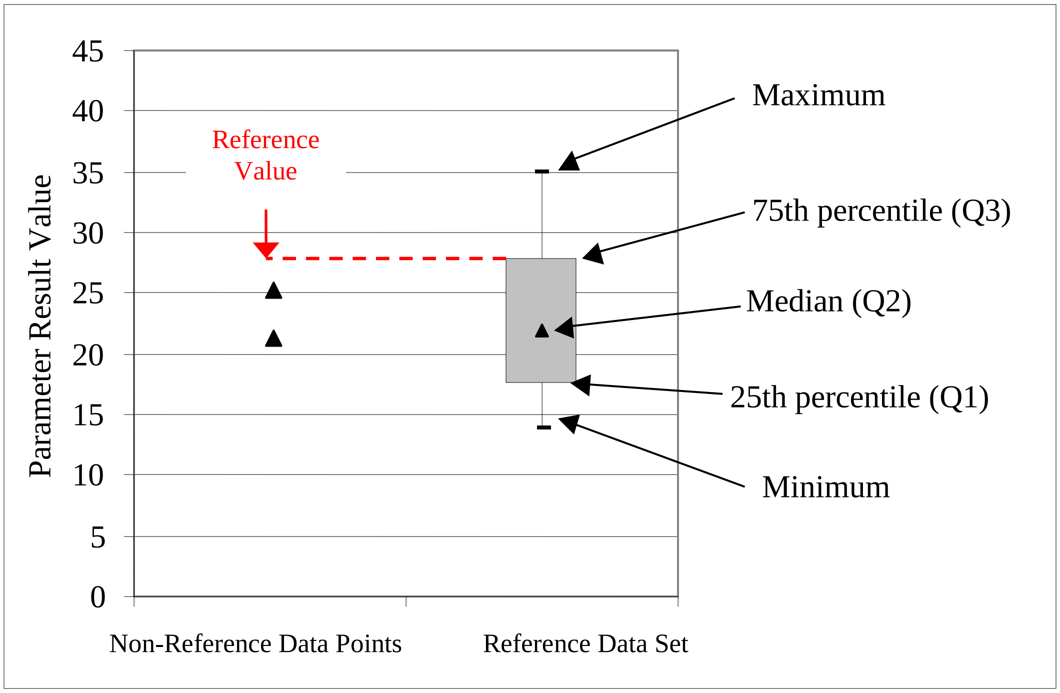


Figure 2-1. Box and Whisker Diagram of Ranked Data Distributed in Quartiles

The convention for naming quartiles is “Q1” for the first (lowest) quartile, below which 25 percent of the measurements fall; “Q2” for the second quartile (the median), below which 50 percent of the samples fall; and “Q3” for the third quartile, below which 75 percent of the samples fall. The non-parametric quartile range is a more realistic approach than using the parametric mean and standard deviation because water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on parametric statistical summaries if the data are not normally distributed or if the data set is small. The box and whisker diagram is a relatively straightforward visual representation of the dispersion of observations in a data set.

Selection of the appropriate reference data quartile as a water quality goal or target depends upon whether larger or smaller values represent the preferred water quality condition. If smaller values are preferred, as with percent fine sediment in spawning gravels for example, Q3 of the reference distribution is used as a potential target value. Values greater than Q3 are interpreted as being beyond the expected range of this parameter for a stream representing reference conditions for fine sediment. Alternately, should larger values equate to an improved water quality condition, as in the case with a parameter such as pool frequency, Q1 of the reference data set would be the selected target since a lower number is below the range of pool frequency expected for a reference condition stream. Depending upon the preference for either a higher or lower value, Q3 or Q1 reference values can be applied as TMDL targets for comparison with limited data points from a non-reference water body of interest. As in **Figure 2-1**, if all comparison values are lower than the appropriate reference value, the target or reference condition is satisfied for that parameter, and this comparison can be used as evidence toward a potential non-impairment conclusion.

When the data set from the non-reference water body of interest is small, the individual data points are compared to the appropriate quartile from a reference data set. When the data set from an unassessed water body is larger, its quartile values are calculated and compared to those of the reference data set for determining impairment status. This approach is illustrated in **Figure 2-2**.

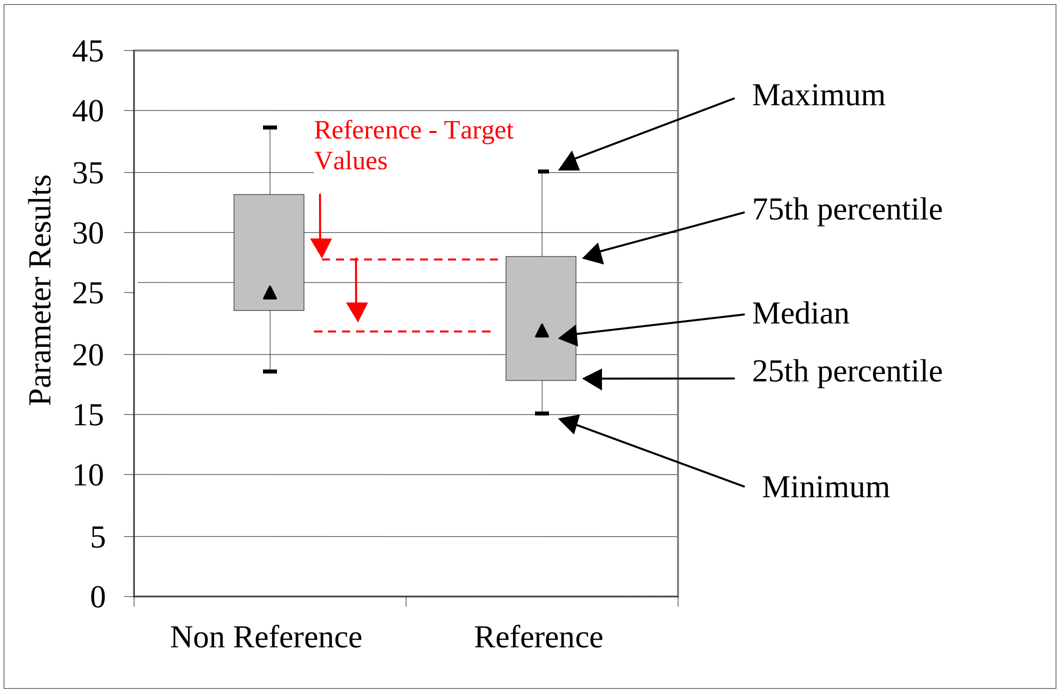


Figure 2-2. Comparison of Non-Reference to Reference Distributions Using a Target 75th Percentile (Lower Values More Desirable)

When comparing reference to non-reference distributions, both the median (Q2) and Q3 (or Q1 if lower values are preferred) are used in the comparison. In the **Figure 2-2** example, both of these quartiles are higher in the non-reference data set, suggesting potential impairment. In order to apply this approach to support an impairment determination, human-caused pollutant sources or stressors linked to the water quality parameter in question must be present, implying potential for conditions to be improved to where non-reference and reference data distributions compare more favorably. The use of this approach requires a sufficient amount of non-reference data to establish quartile values and develop boxplot diagrams.

Comparing non-parametric, distributional statistics for interpreting narrative water quality standards and developing numeric targets is consistent with EPA guidance for nutrient criteria (EPA, 2000). Furthermore, the selection of the appropriate Q1 or Q3 values as use support criteria from a reference data set is consistent with ongoing DEQ guidance for interpreting narrative water quality standards where there is adequate confidence in the quality of the reference data set (Suplee, 2004). As this confidence diminishes or improves, adjustments will be needed in selecting the appropriate quartile. For parameters, where lower values reflect higher water quality conditions, the reference Q2 value may be more appropriate with only “fair” confidence in the quality of a reference data set. The 90th percentile of the reference distribution may be the most appropriate target with “very high” confidence in a reference data set.

When comparing data from reference water bodies to that collected on non-reference water bodies, it is often desirable to stratify or divide the data set for each into subsets that functionally contribute to the variability of the measurements or observations. The stratification of data according to stream channel type, stream size, geologic setting, or prevailing climate is a common means to manage variability and reduce the likelihood of mistakenly attributing differences due to natural setting or system size to those caused by human influences. Meaningful stratification will limit comparisons to those between functionally equivalent systems.

SECTION 3.0
WATERSHED CHARACTERIZATION

This section describes the physical and ecological settings of the Lower Blackfoot TMDL planning area.

3.1 Location and Description of the Watershed

The Blackfoot River watershed lies in west central Montana, extending from approximately 30 miles northwest of Helena to seven miles east of Missoula (**Appendix A, Figure A-1**). For TMDL planning purposes, the Blackfoot Watershed was divided into four planning areas (from upstream to downstream); the Blackfoot Headwaters, Nevada Creek, the Middle Blackfoot, and the Lower Blackfoot (**Appendix A, Figure A-2**).

The Lower Blackfoot planning area covers approximately 377 square miles (241,052 acres). This is the watershed area from the confluence of the Blackfoot River and the Clearwater River to the confluence of the Blackfoot River with the Clark Fork River. The drainage area of listed streams in the Lower Blackfoot planning area is given in **Table 3-1** in both square miles and acres.

Table 3-1. Drainage of Listed Streams in the Lower Blackfoot Planning Area.

Streams Name	**Drainage Area (Square Miles)**	**Drainage Area (Acres)**
West Ashby Creek	4.5	2,866
East Ashby Creek	6.0	3,781
Belmont Creek	29.3	18,733
Camas Creek	40	25,839
Upper Elk Creek	28	18,063
Lower Elk Creek	23	14,652
Keno Creek	2.6	1,640
Union Creek	51	32,533
Washoe Creek	8.5	5,422

Elevations in the lower Blackfoot planning area range from 3,280 to 7,504 feet above sea level with a mean of 5,330 feet.

3.2 Geology

The Blackfoot River watershed has a long and complicated geologic history. Exposed rocks range from Precambrian-age (1.5 billion year old), shale, siltstone, sandstone, and carbonate, to Quaternary-age (15,000-year-old) glacial deposits (Alt and Hyndman 1986). The Precambrian formations belong to a grouping of rocks called “Belt” rocks. Belt rocks formed from almost 500 million years of deposition of sediments into a large inland sea called the Belt Basin. These sedimentary deposits are remarkably consistent over large distances and are over 40,000 feet thick locally. During the formation of the Rocky Mountains from 75 to 60 million years ago, Belt rocks in the area of the Blackfoot watershed were uplifted, folded and thrust eastward over younger Paleozoic and Cretaceous sedimentary rocks. Granite intruded into the Belt rocks both before and after thrusting and resulted in the formation of several mineral deposits. Large portions of the watershed were subsequently covered with volcanic rocks during the middle Tertiary period (approximately 40 million years ago). Remnants of these rocks are found primarily in the southern portion of the watershed as are sedimentary deposits derived from these volcanic rocks. More recently, the Blackfoot River watershed area was subjected to two major periods of glaciation, the Bull Lake glaciation about 70,000 years ago and the Pinedale glaciation of 15,000 years ago. Glaciation strongly influences the current landscape as evidenced by numerous moraines and associated hummocky topography, kettle lakes, and broad expanses of flat glacial outwash.

The geology of the Lower Blackfoot planning area (**Appendix A, Figure A-3**) consists mostly of Proterozoic sedimentary rocks, which comprise 60 percent of the area (Mudge et al. 1982, Lewis 1998). Quaternary alluvium and glacial deposits are the next most prevalent and comprise 14 percent of the planning area. Five other rock types, including volcanic, sedimentary, and intrusive formations cover the remaining 26 percent of the planning area (**Table 3-2**). Intrusive rocks are located in the headwater portions of Elk Creek and Ashby Creek and easily erode into sand sized stream substrate. This controls the natural substrate composition of these streams and influences substrate TMDL targets described in **Section 5.0**.

Table 3-2. Geology of the Lower Blackfoot planning area.

Generalized Rock Type	Percent of PlanningArea
Proterozoic Sedimentary Rocks	59.9%
Quaternary Alluvium and Glacial Deposits	14.0%
Tertiary Sedimentary Rocks	14.0%
Paleozoic Sedimentary Rocks	5.9%
Cretaceous and Tertiary Intrusive Rocks	5.8%
Proterozoic Intrusive Rocks	0.2%
Cretaceous and Tertiary Volcanic Rocks	0.2%

3.3 Soils

The STATSGO (State Soil Geographic Database) provides a consistent means of assessing generalized soil characteristics on a watershed scale. Fifteen soil units are present in the Lower Blackfoot planning area, five of which cover 76 percent of the planning area (**Appendix A, Figure A-4**). The most abundant five soil units are gravelly loams and correspond with the location of Quaternary alluvium and glacial deposits. The 10 minor soil units as a group correlate well with exposures of intrusive and extrusive igneous rocks as well as various Belt lithologies.

Although generalized, the STATSGO database also provides information on the physical and chemical properties of soils. The majority of soil types present have similar surface textures, are moderately well to well drained, and have a depth to water table between three and six feet. These dominant soils (**Table 3-3**) are neither prime farmland nor hydric soils supporting wetlands.

Table 3-3. Major soil units in the Lower Blackfoot planning area.

Soil Map Unit Name	Percent Area	Surface Texture
WINKLER-EVARO-ROCK OUTCROP (MT647)	25.5%	Gravelly sandy loam
WINKLER-EVARO-TEVIS (MT646)	20.8%	Gravelly loam
WALDBILLIG-HOLLOWAY-BATA (MT610)	13.5%	Gravelly silty loam
BIGNELL-WINKLER-CROW (MT046)	10.4%	Gravelly loam
HOLLOWAY-WINKLER-ROCK OUTCROP (MT283)	5.8%	Gravelly silty loam

More detailed soil data are available in the Missoula, Powell, and Granite County SSURGO (Soil Survey Geographic) databases. In addition, the USFS Region 1 Land Type Association database which covers national forest lands, is a good surrogate for detailed soil data, and can assist with identification of soils more sensitive to both natural and human-caused disturbances.

3.4 Climate

The Lower Blackfoot planning area contains five continuously operating weather stations. This includes one National Oceanographic and Atmospheric Administration (NOAA) station, one Remote Access Weather Station (RAWS), one Montana Department of Transportation (MDT) station, and two Snowpack Telemetry (SNOTEL) stations (**Table 3-4**).

Table 3-4. Weather stations in the Lower Blackfoot planning area.

Location	Type	Elevation (ft)	Period of Record
Potomac	NWS	3600	1964 - present
Greenough	MDT	3799	1998 - present
Stinkwater Creek	RAWS	5428	1998 - present
Lubrecht Flume	SNOTEL	4680	1983 - present
N. Fk. Elk Creek	SNOTEL	6250	1971 - present

The average annual total precipitation at Potomac is 14.8 inches with 55.4 inches total snowfall (**Appendix A, Figure A-5**). At the North Fork Elk Creek SNOTEL station, average annual total precipitation is 28.9 inches (**Appendix A, Figure A-6**).

Estimated climate information can be obtained using the PRISM (Parameter-Elevation Regressions on Independent Slopes Model), which uses point measurements of climate data and a digital elevation model (DEM) to extrapolate climatic conditions across the landscape (**Appendix A, Figure A-7**). PRISM data for the Lower Blackfoot planning area indicates a minimum precipitation of 16 inches, maximum precipitation of 55 inches, and a mean precipitation of 25.2 inches for the watershed.

3.5 Hydrology

The surface water hydrology of the Lower Blackfoot planning area reflects relationships between regional precipitation, surface water runoff, and water use. Gauge station data collected by the United States Geological Survey (USGS) near Bonner describe hydrology of the Blackfoot River watershed. The gauge data document a reduction in total basin water yield over the last 20 years (**Appendix A, Figure A-8, Figure A-9)**.

One of the longest records available for stream gauging stations in the area is from the mouth of the Blackfoot River near Bonner. Data from this gauge show that average peak flows prior to 1983 were substantially higher than those since 1983. From 1940 to 1983, the average annual flood discharge was 9,807 cfs (**Appendix A, Figure A-8**). Over the last 25 years, the average annual peak discharge at Bonner has declined to 7,137 cfs. On average, Blackfoot River peak flows have been about 30 percent lower during the last 25 years as compared to 1940-1983.

Over the past 25 years on the Blackfoot River near Bonner, the largest reductions in mean monthly discharge relative to the prior 44 years occurred during the months of May through July, or during spring runoff (**Appendix A, Figure A-9**).

Stream flow trends in the Blackfoot River basin indicate that markedly low intensity spring runoff characterizes the last 25 years, compared to the prior 44 years. The only event to exceed 11,000 cfs at Bonner during the last 25 years occurred on May 18 1997, when the USGS stream gauge recorded a discharge of 15,800 cfs. During the 25 years prior, discharge exceeded 11,000 cfs eight times. The basin-wide reduction in both annual peak and mean monthly discharges in the Blackfoot River basin correlates to overall climate trends described in the Middle Blackfoot and Nevada Creek TMDL report (MT DEQ, 2008). Over the past 100 years, EPA estimates that in areas of Montana, precipitation declined about 20 percent (EPA 1997).

3.6 Stream Geomorphology

The streams in the Lower Blackfoot TMDL planning area reflect both natural processes driven by the influences of geology and hydrology, and human impacts such as mining, logging, stream corridor grazing, and residential development. Geology tends to affect the nature of sediment delivered to planning area streams. For example, the geology in headwaters areas includes Precambrian Belt series rocks that have a relatively low erosion potential (Belmont Creek) as well as highly erosive Cretaceous age granitic rocks that typically erode as sands (Elk Creek, Keno Creek, and West Ashby Creek). The hydrology of streams in the planning area reflects snowmelt runoff hydrographs, where annual peak flows occur during spring snowmelt.

The streams of the Lower Blackfoot planning area typically originate in terrain that exceeds 5500 ft in elevation. In their headwaters areas, most streams flow through steep, narrow valley bottoms that are laterally confined and support narrow riparian corridors (A/B channel types, Rosgen 1996). In numerous stream valleys in the upper watersheds, the confining valley walls have been historically logged. In some areas, such as on Keno Creek, the valley bottom riparian areas have been harvested for timber as well. Some mining has occurred in these headwaters areas, such as on Union Creek and Day Gulch. Mining in Day Gulch resulted in extensive re-grading of the valley bottom. As streams flow into lower gradient lowland areas, several traverse broad alluvial valleys prior to entering the mainstem Blackfoot River. On several streams, the transitional areas at the upstream ends of these valleys are extensively placer mined. Elk Creek has a rich history of placer mining near the Yreka mining camp. Currently in this area, the channel flows through a heavily placer mined valley bottom with dredge ponds and tailings piles that confine the channel. Some restoration has occurred in this area to mitigate the impacts of placer mining.

Both Elk Creek and Union Creek, two major tributaries to the Blackfoot River, flow through broad alluvial valleys prior to descending to the entrenched Blackfoot River corridor. These valleys include an area near Ninemile Prairie (Elk Creek) and the Potomac Valley (Union Creek). Both of these valleys were inundated by Glacial Lake Missoula, one of the largest lakes ever impounded behind an ice dam (Alt, 2001). The Glacial Lake Missoula ice dam formed when glaciers of the most recent ice age reached their maximum southerly extent around 15,000 years ago. The ice dam failed several dozen times, and each time, catastrophic flooding occurred in eastern Washington through the Columbia River corridor. Age dates of ash contained within flood deposits indicate that the last flooding occurred approximately 13,000 years ago (Alt, 2001).

Glacial Lake Missoula flooded all of the mountain valleys of the Clark Fork drainage, including the Blackfoot River valley above Clearwater Junction. Lake deposits derived from the lake extend into the Middle Blackfoot and Nevada Creek TMDL planning areas, and up the Clark Fork river near Drummond (Alt, 2001).

The broad alluvial valleys of Elk Creek and Union Creek exhibit significant impacts from recent agricultural land uses. Stream corridor grazing is common, and the channels are commonly entrenched and/or overwidened due to bank trampling or channel straightening efforts. In the Potomac Valley, recent residential development with stream corridor grazing on relatively small land parcels has further affected stream geomorphology. Woody riparian vegetation density in these valleys tends to be low, and bank stability is variable.

Within the Lower Blackfoot planning area, the mainstem Blackfoot River is entrenched within a well-defined river valley with a moderate slope and steep valley walls. The valley wall geology is mostly Precambrian Belt Series rocks. Due to the low erodability of these rocks, the tributary streams that enter the lower Blackfoot River (Belmont Creek, Union Creek, and Elk Creek) all have steep reaches at their mouths where they abruptly enter the Blackfoot River stream corridor. These reaches tend to be stable, coarse grained, moderately confined channels characterized by step-pool habitat.

3.7 Vegetation

The USGS GAP vegetation analysis serves as a good source of vegetation cover information at a watershed scale. This dataset is a national interpretation and reclassification of satellite imagery collected in the early 1990s. Vegetation types in the GAP database for the Lower Blackfoot planning area are typical of rural, forested watersheds in western Montana (Redmond et al 1998) (**Table 3-5; Appendix A, Figure A-10**). Dominant cover types in higher elevations include coniferous forests comprised of lodgepole pine, mixed mesic forests, mixed subalpine, and Douglas fir/lodgepole pine communities. Valley portions of the watershed consist primarily of low to moderate cover grasslands and mixed mesic shrubs. Riparian areas account for only 2.6 percent of the whole watershed. This is probably an underestimate of riparian cover due to the relatively coarse spatial resolution of the dataset and the thin, linear nature of riparian stands.

Agricultural lands reported in the GAP database only include easily identifiable row crops and do not accurately represent the true distribution of other agricultural lands such as hay meadows and pastures. The majority of lands in agricultural production most likely are reported as grasslands in the GAP database.

Table 3-5. Major vegetation cover types in the Lower Blackfoot planning area.

Vegetation Cover Type	Percent Area
Coniferous and Deciduous Forest	74.3%
Grasslands	11.1%
Mesic and Xeric Shrubs	6.7%
Agricultural (Crops)	3.5%
Riparian	2.6%
Rock, Barren, Quarries	1.5%
Standing Burnt Forest	0.1%

Reference: USGS GAP

3.8 Land Ownership

The Lower Blackfoot planning area is largely under private ownership, with Plum Creek Timber Company the largest owner of these lands (**Table 3-6; Appendix A, Figure A-11**). Other private lands comprise about 20.1 percent of the planning area. The State of Montana, the Bureau of Land Management, and the Forest Service own 34.8 percent of the land, collectively.

Table 3-6. Land ownership in the Lower Blackfoot planning area.

Owner	**Percent Area**
U.S. Forest Service	8.4%
Montana State	15.3%
U.S. Bureau of Land Management	11.1%
Plum Creek Timber Company	45.0%
Private land (undifferentiated)	20.1%

The Nature Conservancy (TNC) and The Trust for Public Land (TPL) entered into an agreement with Plum Creek Timber Company to purchase land in western Montana. Approximately 39,200 acres of this purchase falls within the Lower Blackfoot Planning Area. Approximately 4,000 acres will be transferred to the US Forest Service and approximately 30,000 acres may be sold to the Montana Department of Natural Resources and Conservation.

3.9 Land Use

Land use in the Lower Blackfoot planning area is typical of rural watersheds in western Montana. Primary land uses include agriculture, recreation (fishing, boating, camping, hunting), timber production, and historic mining. Urban or residential development covers about 2.8 percent of the watershed, primarily near Potomac and Greenough. This development consists mostly of small ranchettes five to 20 acres in size. Most other residents in the watershed reside on large ranches. Census block data indicates that 2,218 people lived in the planning area in

2000. Future growth, particularly small parcel streamside development, is a concern to residents and land managers.

Land uses that can increase the amount of sediment delivered to streams, or alter stream habitat include mining, agriculture, and timber harvest. In addition, small streamside pastures associated with ranchettes can also have these impacts. **Section 5.0** of this document describes sediment and habitat impairments in more detail.

Land uses that remove water from streams, remove streamside vegetation that provides shade, or widen streams may contribute to water temperature impairments. Elk Creek and Union Creek are on the 303(d) List for temperature and exhibit temperature impairments due to reduced shade. **Section 8.0** of this document describes temperature impairments in more detail.

There are no comprehensive digital datasets of land use for the Lower Blackfoot planning area. The USGS National Land Cover Database (NLCD) provides a partial assessment of agricultural lands in the planning area. This dataset is similar to the GAP vegetation database in that it relies on interpretation of satellite imagery. However, the NLCD dataset reports land cover types that indicate specific land uses, notably agricultural. The NLCD data for the Lower Blackfoot planning area indicate that agricultural uses occur in 4.1 percent of the watershed, mostly at lower elevations. Land cover types indicate that pasture/hay production is the dominant agricultural use with a small amount of crop or small grain production (**Appendix A, Figure A-12**). Because of the difficulty in interpreting land use from satellite imagery, these data most likely under report cover types indicative of land uses such as pasture/hay, cropland, and developed areas.

Recreation activities such as fishing, boating, camping, and hunting are popular in the Lower Blackfoot planning area. According to the MFISH database (http://nris.state.mt.us/), the Blackfoot River regularly ranks in the top ten of recreational fisheries in the region. Other recreational activities associated with tourism are likely to increase in the future.

Plum Creek Timber Company and the USFS have been engaged in timber harvest and grazing activities for a number of years. Their timber harvest, grazing, and agricultural activities in the Lower Blackfoot planning area occur primarily in foothills and montane portions of the watershed (**Appendix A, Figure A-12**).

Mining was a significant land use in the Lower Blackfoot planning area with 67 historic mining prospects listed in the combined abandoned mines databases developed by Montana DEQ, Montana Bureau of Mines and Geology, and the US Bureau of Mines. The mines are concentrated in the Ashby, Camas and Washoe Creek tributaries of Union Creek, as well as Elk Creek. Both drainages contribute directly to the Blackfoot River. In the Union Creek drainage, the primary products of the mines were lead, copper, zinc and silver. The mines in Elk Creek primarily produced gold and barium. Overall, historic mining activity in the Lower Blackfoot planning area is high when compared to nearby areas.

3.10 Fisheries and Aquatic Life

The Lower Blackfoot planning area supports 21 species among eight families of fishes (**Table 3-7**). Salmonids include the native bull trout, westslope cutthroat trout, mountain whitefish, pygmy whitefish and the nonnative kokanee, brook trout, rainbow trout, and brown trout. Some cases of rainbow/cutthroat and brook/bull trout hybrids also exist. All cyprinids, or members of the minnow family occurring in the basin are native, including redside shiner, peamouth, longnose dace, and northern pikeminnow. Two native catastomids or suckers include largescale and longnose suckers. The recently introduced northern pike is the sole member of the esocidae, or pike family. The slimy sculpin is presumably the only member of the sculpin family occurring in the Lower Blackfoot planning area. The introduced yellow perch is the sole member of the perch family in the basin.

Distribution of native bull trout and westslope cutthroat trout are shown in **Appendix A, Figure A-13 and Figure A-14**.

Table 3-7. Fish Species found in the Lower Blackfoot planning area.

Family/Common Name	**Scientific Name**	**Introduced/Native**	**Status**
Salmonidae			
Bull trout	*Salvelinus confluentus*	Native	Threatened
Westslope cutthroat trout	*Oncorhynchus clarki lewisii*	Native	Species of special concern
Brook trout	*Salvelinus fontanalis*	Introduced	
Rainbow trout	*Oncorhynchus mykiss*	Introduced	
Brown trout	*Salmo trutta*	Introduced	
Kokanee	*Oncorhynchus nerka*	Introduced	
Mountain whitefish	*Prosopium williamsoni*	Native	
Pygmy whitefish	*Prosopium coulteri*	Native	
Cyprinidae			
Redside shiner	*Richardsonius balteatus*	Native	
Peamouth	*Mylocheilus caurinus*	Native	
Longnose dace	*Rhinichthys cataractae*	Native	
Northern pikeminnow	*Ptychocheilus oregonensis*	Native	
Centrarchidae			
Bluegill	*Lepomis macrochirus*	Introduced	
Pumpkinseed	*Lepomis gibbosus*	Introduced	
Largemouth bass	*Micropterus salmoides*	Introduced	
Catostomidae			
Largescale sucker	*Catostomus macrocheilus*	Native	
Longnose sucker	*Catostomus catostomus*	Native	
Cottidae			
Slimy sculpin	*Cottus cognatus*	Native	
Esocidae			
Northern pike	*Esox lucius*	Introduced	
Percidae			
Yellow perch	*Perca flavescens*	Introduced	

Since 1990, the Big Blackfoot Chapter of Trout Unlimited; Montana Fish, Wildlife, and Parks; the U.S. Fish and Wildlife Service; and many other cooperators have engaged in an aggressive native fish recovery effort in the Blackfoot watershed. Over 200 fisheries related restoration projects have been completed on 41 tributaries as part of this effort that continues today.

Native species restoration efforts focus on adopting protective regulations, screening irrigation ditches, protecting critical spawning habitat, altering riparian management practices, removing seasonal migration barriers, instream habitat restoration, increasing instream flows and enlisting landowners in perpetual conservation easements. Monitoring restored stream reaches indicate increases in population density and spawning redds, (Pierce et al 2002, Pierce and Podner 2000). Increased bull trout and westslope cutthroat trout densities at lower Blackfoot River sampling locations (Johnsrud and Scotty Brown Sections) suggest tributary restoration efforts in the lower portions of the watershed are improving native mainstem populations. While these efforts have been successful, issues such as extended drought, the emergence of whirling disease, and habitat degradation continue to threaten the health of Blackfoot fisheries and aquatic life.

SECTION 4.0
TMDL ASSESSMENT PROJECTS AND DATA SOURCES

Several projects conducted specifically for TMDL development, as well as existing data, provided the information necessary to complete TMDLs for the Lower Blackfoot planning area. TMDL projects conducted between 2006 and 2008 include:

- Phase 1 TMDL Assessment;
- Base Parameter Field Assessment and Data Analysis;
- Bank Erosion Field Assessment and Data Analysis;
- Hillslope Erosion Assessment Using the Soil Water Assessment Tool (SWAT);
- Road Erosion Assessment;
- Stream temperature data assessment;
- Stream Temperature Field Data Collection,
- Temperature Modeling, and
- Water quality sampling and analysis for nutrients and trace metals.

The following sections provide a brief description of these projects.

4.1 Phase 1 TMDL Assessment

TMDL development for the Lower Blackfoot planning area began in May 2006 with a Phase 1 (preliminary) assessment. This consisted of compilation and review of existing data, development of a watershed characterization report, assessment of data gaps, analysis of aerial photography within a GIS, and field reconnaissance.

The aerial assessment and field reconnaissance provided a framework for reach based assessment of listed streams, by segmenting these streams based on channel morphology, vegetation, and/or land use characteristics. Subsequent work also utilized this reach framework.

4.2 Base Parameter Field Assessment and Data Analysis

The primary data source for habitat impairments in the Lower Blackfoot planning area is the base parameter data collection effort conducted in September 2006. Base parameters are a suite of standard measures of stream channel morphology, stream habitat, vegetation composition, and near stream land use aimed at supporting water quality planning and/or TMDL development for siltation, habitat alterations, temperature, and nutrients. Detailed descriptions of the data collection methodology are contained within the Quality Assurance Project Plan and Sampling and Analysis Plan (DTM 2006). The base parameter methodology builds upon earlier field assessments performed to support the development of water quality restoration plans and TMDLs for the upstream Nevada Creek, Middle Blackfoot, and Blackfoot Headwaters TMDL planning areas. Analysis of the data collected allowed development of statistical norms for these parameters by channel type. From this analysis, Montana DEQ developed targets for these parameters based on departure from the norms.

Field crews collected base parameter data at 25 sites on nine streams within the Lower Blackfoot planning area (**Appendix A, Figure A-15**). **Table 4-1** outlines the data collected.

Table 4-1. Data Collected During the 2006 Base Parameter and Erosion Inventory Assessment

Parameter	**Measure**	**Definition**	**Use in Target Development**
Channel Dimensions	Bankfull width	Cross sectional width of channel at bankfull condition	Width:depth ratio
	Mean bankfull depth	Bankfull depth averaged from 5 equidistant points on cross section	Width:depth ratio
	Max bankfull depth	Bankfull depth averaged from 5 equidistant points on cross section	Width:depth ratio
	Flood prone width	Floodplain width at 2 times max bankfull depth	Entrenchment ratio
	Channel slope	Channel gradient at the assessment site	Channel classification
Woody Vegetative (topbank)	Percent channel length with given vegetation type	Stationed mapping of vegetation assemblage	Percent shade
	Dominant woody vegetation	Generalized vegetation type	
	Percent woody canopy cover	Vegetation canopy cover	
	Average woody vegetation height	Vegetation height	
	Average woody vegetation diameter	Vegetation diameter	
	Average woody vegetation offset	Vegetation offset from streambank	
Channel Morphology/ Habitat	Habitat unit extent	Stationed mapping of pools, riffles, runs, and glides	Percent pool length
	Residual pool depth	Measure of elevation difference between deepest point in pool and downstream hydraulic control.	Residual pool depth
	Average pool width	Average wetted width of the pool	Pool extent
Woody Debris	Woody debris aggregate count	Count of aggregates of woody debris exceeding two inches in diameter and three feet in length	Woody debris concentration
	Woody debris aggregate extent	Length measure of woody debris aggregates	Woody debris aggregate density
Substrate	Pebble Counts	Substrate measurements in riffles	Percent fines in riffles
	Percent Fines Grid	Percent surface fines measurement in pool tailouts	Percent surface fines
Land Use	Land use categorization	Categorization of primary apparent land use along topbank, riparian buffer and floodplain area	
Reach Classification	Rosgen Level II classification	Channel classification based on measured cross section parameters, slope, and substrate	Data stratification and extrapolation

4.3 Bank Erosion Inventory

Concurrent with the base parameter assessment conducted in 2006, field crews inventoried eroding banks to determine the amount of sediment they contribute to the overall sediment load (**Appendix A, Figure A-15**).

4.3.1 Data Collection

The bank erosion inventory recorded the location and characteristics of stream banks with discernable bank erosion within assessed reaches. These data provide the basis for developing a sediment source assessment and load allocation from eroding banks. For tributary streams, this inventory was performed on 1000 foot transects along both banks of the stream coincident with base parameter data collection. For the mainstem Blackfoot River, all eroding banks were mapped and assessed by a field crew floating the river. Reaches Blkft12 through Blkft21 were mapped in this fashion.

The erosion site assessment includes description of each eroding bank within a given assessment reach, including the following:

- Length,
- Height,
- Location (mapped),
- BEHI rating,
- BEHI rating condition,
- Adjusted BEHI rating and condition,
- Bank materials,
- Topbank vegetation type,
- Topbank vegetation density, and
- Proximal land use.

The bank condition evaluation utilized the BEHI method (Rosgen, 2000) and incorporated the following parameters into numerical ratings.

- Bank height/bankfull height ratio,
- Root depth/bank height ratio,
- Root density percent,
- Bank angle,
- Surface protection percent, and
- Bank material particle size.

Field crews measured eroding bank lengths by tape along the thalweg of the stream. Bank height was measured using a stadia rod extended from the toe of the eroding bank to the top of the bank. Locations were recorded with a continuous stationing method. The Bank Erosion Hazard Index (Rosgen, 2000), which allows the determination of the severity of mapped eroding streambanks, was performed according to procedures laid out in the Quality Assurance Project Plan and Sampling and Analysis Plan (DTM 2006).

4.3.2 Data Analysis

Analysis of stream bank erosion inventory data involved several tasks:

- Calculation of erosion rates based on condition and distribution of eroding banks mapped at assessment sites.
- Extrapolation of these rates to reaches of 303(d) streams not assessed.
- Determination of erosion rates of streams not on the 303(d) List.
- Calculation of the total sediment load from bank erosion.
- Estimation of the natural and anthropogenic components of the sediment load.
- Estimation of an achievable reduction of the anthropogenic load.
- Allocation of loads to dominant land uses.

Results of the data analysis are in **Section 5.6.2** below. Detailed descriptions of the data analysis and extrapolation methodologies are in **Appendix E** of this document.

4.4 Soil Water Assessment Tool (SWAT)

The watershed scale simulation model referred to as the Soil and Water Assessment Tool (SWAT) was used to estimate non-point source hillslope erosion loading within the Blackfoot drainage as described in **Section 5.6.1**. The SWAT modeling framework partitioned the watershed into 65 sub-basins that were further divided into Hydrologic Response Units (HRU) having homogeneous climatic conditions, soils, and landcover characteristics. **Appendix D** describes the set-up, calibration and verification of the SWAT model in the Blackfoot River watershed.

4.5 Road Erosion Assessment

Field crews assessed sediment production from a sub-sample of road crossings in the Middle Blackfoot and Nevada Creek TMDL planning areas during the summer of 2005, (RDG, 2006). The assessment followed protocols adapted from the Washington Forest Practices Board Watershed Assessment Methodology (Washington Department of Natural Resources 1997). The sub-sample of crossings represented typical crossing conditions. Data from surveyed crossings was summarized by road ownership, precipitation zone, and surficial geology. Mean road erosion values were calculated for broad ownership, precipitation and surface geology categories identified by GIS analysis. The mean values for these categories were applied to crossings occurring in the same categories in the Lower Blackfoot TPA. Similarly, an estimate of the per crossing mean volume of sediment at risk from culvert failure, developed for the Middle Blackfoot TPA, was applied to Lower Blackfoot crossings. PCTC conducted detailed road sediment inventories in the Ashby Creek and Belmont Creek watersheds in support of Lower Blackfoot TMDL development. These inventories used methods outlined in the Washington Watershed Analysis Methodology (Washington Department of Natural Resources 1997) with refined base erosion rates applicable to western Montana described by Sugden and Woods 92007).

4.6 Temperature Data Collection, Assessment, and Modeling

Assessment of thermal conditions of 303(d) listed streams consisted of:

- Analysis of temperature monitoring data collected by Montana FWP from 1994-2004,
- Assessment of shade from aerial photography and field measurements,
- Deployment of stream temperature sensors to record data from June through September,
- Retrieval of sensors and recorded data,
- Analysis of temperature monitoring data, and
- Temperature modeling using the Stream Network Temperature (SNTEMP) model (**Section 7.0 and Appendix H**).

SNTEMP, the Stream Network Temperature Model, is a mechanistic heat transport model that predicts daily mean and maximum water temperatures at the end of a stream network (Theurer et al., 1984, Bartholow, 2004). Model simulations occur over a single time step, such as a day, and evaluate the effects of changing shade, stream geometry, and flow on instream temperature. The model requires inputs describing stream geometry, hydrology, meteorology, and stream shading. SNTEMP models link multiple stream segments to predict water temperature at the end of the network and at points within the network. The model allows for variability in flow, shade, and other factors at multiple locations within the modeled stream. Effects on stream temperature from one set of stream conditions can then propagate downstream to a stream segment with different conditions. This allows for basin-wide modeling of stream temperatures.

After calibration of a series of SNTEMP models, model simulations predicted the amount of increased shade required to keep peak temperatures within the legally allowable increase of either one half degree or one degree Fahrenheit above natural conditions. Detailed information on the methodology and temperature condition is in **Appendix H**.

4.7 Surface Water and Sediment Sampling and Analysis for Trace Metals

High and low flow surface water and sediment samples were collected during late June and mid-September of 2006 from tributaries within the Lower Blackfoot planning area. The sample locations are illustrated in **Appendix G, Figure G-1**. The results of trace metal analysis results for water and sediment are contained in **Appendix G, Table G-1 and Table G-2** respectively.

4.8 Data Source Summary

The projects described above and additional data sources, such as the trace metals sampling and analysis described in **Section 6.0**, provided the information necessary to determine the need for TMDLs, develop TMDL targets, and develop load allocations. The following table lists critical data sources contributing toward TMDL development for the Lower Blackfoot planning area.

Table 4-2. Data Sources Used For TMDL Development in the Lower Blackfoot Planning Area.

Author	Date	Title	Stream(s)	Reach(es)	Pollutant Category	Parameter
Blackfoot Challenge	2005	McNeil Sediment Core Data	Elk Creek, Belmont Creek	Elk3, Elk7, Elk9, Bel4	Sediment	Substrate
Bollman, W.	2005	A Biological Assessment of Sites in the Blackfoot River Watershed, Pre-Restoration: Powell County, Montana. Report by Wease Bolman, Rithron Associates to Land & Water Consulting, Inc.	Elk Creek, Ashby Creek, Camas Creek, Keno Creek	Elk3, EAshby3, Cam6, Keno4	Sediment, Habitat, Nutrients	Periphyton
DTM Consulting, Inc.	2006	Quality Assurance Project Plan and Sampling and Analysis Plan (QAPP/SAP) Lower Blackfoot River TMDL Planning Area	All	All	Sediment, Habitat, Temperature	Width/Depth, substrate, pool frequency, pool depth, woody debris, entrenchment, vegetation, Temperature
EPA	2006	STORET Database	All		Nutrients, Temperature, Sediment, Metals	NH4, NO2/3, TKN, TN, SRP, TP, TSS Temperature, periphyton
Helena National Forest	1987-2004	McNeil Sediment Core Data	Belmont Creek, Elk Creek	Bel4, Elk7	Sediment	Substrate
Hydrometrics, Inc.	2006	Lower Blackfoot Trace Metal Sampling and Analysis	Ashby Creek, Camas Creek, Elk Creek, Union Creek, Washoe Creek	WAshby3, EAshby3, Cam6, Elk2, Elk5, Elk6, Elk9, Union1, Union4, Union 5, Union10, Union12, Wash3	Metals	Flow, Temperature, DO, SC, TDS, TSS, pH, Base Cations, Total Recoverable Metals Suite
Montana Fish, Wildlife, and Parks	2004	FWP Temperature Database	Elk Creek, Union Creek, Blackfoot River		Temperature	Temperature
Montana Fish, Wildlife, and Parks	2002	The Blackfoot River Fisheries Inventory, Restoration and Monitoring Progress Report for 2001	Elk Creek	Elk 1-10	Habitat	All
Montana Fish, Wildlife, and Parks	2002	A Heirarchical Strategy for Prioritizing the Restoration of 83	Belmont Creek, Elk Creek, Union Creek,	All	Habitat	All

Table 4-2. Data Sources Used For TMDL Development in the Lower Blackfoot Planning Area.

Author	Date	Title	Stream(s)	Reach(es)	Pollutant Category	Parameter
		Impaired Tributaries of the Big Blackfoot River	Ashby Creek, Camas Creek, Washoe Creek			
Montana Fish, Wildlife, and Parks	2001	Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2001	Union Creek, Camas Creek, Ashby Creek, Washoe Creek, Elk Creek	All	Habitat, Temperature	Temperature, Fish Population
Montana Fish, Wildlife, and Parks	1999	Blackfoot River Restoration Project: Monitoring and Progress Report 1997-1998	Belmont Creek, Elk Creek,	All	Habitat, Temperature	Temperature, Fish Population
Montana Fish, Wildlife, and Parks	1990	Inventory of Fishery Resources in the Blackfoot River and Major Tributaries	Union Creek	Union 1-12	Habitat	All
Plum Creek Timber Company	1994	Belmont Creek Watershed Analysis	Belmont Creek, Union Creek, Camus Creek	Bel1, Bel2, Bel3, Bel4, Union1, Union2	Habitat, Temperature, Sediment	All
Plum Creek Timber Company	2005 2006	Road Sediment Inventories of Ashby and Belmont Creeks	Ashby Creek, Belmont Creek	All	Sediment	Eroded Sediment
USGS	2006	NWIS (National Water Information System)	All		Temperature, Sediment	Temperature, TSS

SECTION 5.0
SEDIMENT AND HABITAT IMPAIRMENTS

This section discusses indicators of habitat and sediment impairments and sources of sediment impairments in the Lower Blackfoot TMDL planning area. The following includes:

- A description of current stream impairments due to sediment and habitat conditions,
- Tabulated Type I, Type II, and supplemental indicator target values for selected sediment and habitat parameters,
- An analysis of the departure of stream conditions from those targets,
- Determination of the TMDL requirements with regard to sediment and habitat, and,
- A sediment source assessment that quantifies yearly sediment loadings and estimates the anthropogenic component of each sediment source.

Appendix A, Figure A-15 illustrates the locations of the stream assessment reaches referred to in the target departure discussions below.

5.1 Sediment and Habitat Water Quality Goals and Indicators

The development of a TMDL requires the establishment of quantitative water quality goals referred to as targets. The sediment and habitat related TMDL targets for a water body must represent the applicable numeric or narrative water quality standard for each pollutant of concern, and provide full support of all beneficial uses. For many pollutants with established numeric standards, the water quality standard is the TMDL target. Sediment, however, is a pollutant having narrative rather than numeric standards, as described in **Section 2**. Development of numeric sediment and habitat targets used the primary and secondary reference approaches, also explained in **Section 2**.

The targets applied in this chapter are numeric values or ranges of values for parameters that describe channel substrate composition, channel morphology, and aquatic habitat quality. These targets are intended to meet narrative water quality standards and provide full beneficial use support for water bodies impaired by excess sediment, sediment-caused habitat alterations and flow alterations affecting sediment transport. The beneficial uses impaired by sediment and habitat conditions in the Lower Blackfoot planning area are aquatic life, cold-water fisheries and primary contact recreation. The variety of target parameters reflects the numerous variables that affect these beneficial uses. The parameters describe bankline vegetation conditions, channel shape, floodplain access, channel substrate condition, pool habitat quality and aquatic insect health. Use support decisions often rely upon information on these same parameters because of their influence on stream function, aquatic biota, and aesthetic appearance.

The best target parameters have a strong, measurable link to support of aquatic life, fishery and contact recreation uses. They are derived from reference water bodies where all sediment and habitat conditions are functioning at their potential, given historic land uses and the application of all reasonable land, soil, and water conservation practices. The targets may often provide useful parameters for monitoring restoration success. The determination of a TMDL requirement is a process of comparing the numeric targets to the existing conditions measured on each stream. This comparison is the departure analysis.

5.1.1 Sediment and Habitat Targets and Indicators

A range of targets and indicators have been developed for comparisons with existing sediment and habitat conditions. Each target includes a rationale for its application. All targets developed in this document are subject to further interpretation and modification through time as target parameters are monitored together with water quality and other measures. This adaptive management approach to target adjustments or modifications is further described in **Section 8**. **Appendix C** provides detailed reference parameter development information for the target parameters listed below. As described below, targets fall into three categories based mainly on the strength of the linkage between the parameter and support for beneficial uses impaired by specific sediment sources.

1. **Type I Targets:** Type I targets must be satisfied to ensure full support of the beneficial use. Not meeting a Type I target indicates that a sediment TMDL is required. Type I targets include pool frequency, residual pool depth, percent fines <6mm in riffles (pebble count), and McNeil Core subsurface fines <6.35mm when available (**Table 5-1**).

2. **Type II Targets:** Type II targets are used to supplement Type I targets in determining TMDL requirements. The Type II targets can substitute for Type I targets under some conditions where Type I target data is lacking for a given stream segment and Type II targets provide sufficient information to identify a sediment problem. Where sufficient Type I target data is available, a Type II target can be used to support conclusions based on data for Type I targets. Parameters used for Type II targets include: width to depth ratio, macroinvertebrate populations, percent surface fines < 6 mm in pool tailouts, percent fines <2mm in riffles (pebble count) and McNeil Core subsurface fines < 0.85 mm (**Table 5-1**).

3. **Supplemental Indicators:** Supplemental indicators provide supporting information for the Type I and Type II targets. They do not independently determine the requirement for a TMDL. Supplemental indicators include woody vegetation extent, woody debris aggregate extent, woody debris aggregate frequency, pool habitat extent, and entrenchment ratio (**Table 5-1**).

Upon approval of this document, the targets presented will become the water quality goals associated with the TMDL. Although supplemental indicators have a lesser role in determining TMDL requirements, they are used here and in future assessments in cases where one or more Type I and II targets are not met and the values of supplemental indicators provide useful information regarding use support. Other appropriate technical and science-based information may also be appropriate to investigate target departures or make needed target modifications.

Table 5-1. Parameters utilized to define sediment/habitat related targets and supplemental indicators.

Parameter	Target Type	Impairment Linkages	How Measured
Pool Frequency (Pools/Mile)	Type I	Siltation, Habitat, Flow Alteration	Base Parameter habitat unit mapping
Residual Pool Depth	Type I	Siltation , Habitat, Flow Alteration	Base Parameter habitat unit mapping
Percent <6mm in riffles	Type I	Siltation, Habitat, Flow Alteration	Wolman Pebble Count
Substrate Fines < 6.35 mm	Type I	Siltation, Habitat, Flow Alteration	McNeil Cores
Substrate: Percent <2mm in riffles	Type II	Siltation, Habitat, Flow Alteration	Wolman Pebble Count
Width:Depth Ratio	Type II	Siltation, Habitat,	Standard bankfull cross section measures
Macroinvertebrate Populations	Type II	Siltation, Habitat	Standard DEQ protocols
Percent Surface Fines < 6 mm in Pool Tailouts	Type II	Siltation, Habitat, Flow Alteration	Median for 4 observations from Viewing Bucket
Substrate fines < .85 mm	Type II	Siltation, Habitat, Flow Alteration	McNeil Cores
Woody Vegetation Extent	Supplemental Indicator	Siltation, Habitat, Flow Alteration,	Base Parameter green line vegetation mapping
Pool Extent	Supplemental Indicator	Habitat	Base Parameter habitat unit mapping
Entrenchment Ratio	Supplemental Indicator	Siltation	Standard bankfull cross section measures
Woody Debris Aggregate Extent	Supplemental Indicator	Siltation , Habitat	Base Parameter habitat unit mapping
Woody Debris Aggregate Frequency	Supplemental Indicator	Siltation , Habitat	Base Parameter habitat unit mapping

5.1.1.1 Target Rationale

The following section describes the rationale associated with the application of each target and supplemental indicator.

Type I Targets
Type I targets must be met to ensure full support of the beneficial use. The Type I target parameters include pool frequency, residual pool depth, percent fines <6mm in riffles (pebble count), and subsurface fines<6.35mm (McNeil core).

Pool Frequency and Depth

Pools provide critical habitat for cold-water fish. The frequency and character of pools in a stream channel reflect sediment transport and storage processes. The pool frequency and residual pool depth targets address excess sediment loading associated with pool infilling or reduced natural pool formation. The parameters also serve as beneficial use support objectives for habitat listings, as a loss of pools from excess sediment results in a direct reduction in fish habitat quantity and quality. Pool frequency and residual depth also address impairment due to flow alteration as the lack of pools exacerbates the negative impact of reduced flows. Flow volume affects pool formation and depth maintenance.

Fine Sediment Concentrations

Excess fine sediment, or “Sedimentation/Siltation” on Montana’s 303(d) List of impairment causes, often leads to excess subsurface fines in spawning gravels or excess surface fines in riffles. Excessive surface and substrate fines may limit fish egg and embryo survival. Excess surface fines may also reduce macroinvertebrate richness, thus limiting aquatic life and negatively affecting cold-water fish that rely on macroinvertebrates as a food source.

Increases in the percentage of < 6.35 mm fraction of fine sediment in spawning gravels correlates to a decreased success in fry emergence (Weaver and Fraley, 1991).

Fine sediment on the channel bed surface, and within the underlying substrate, is evaluated in several ways. McNeil core samples determine the fine sediment fraction in the upper several inches of substrate, usually in pool tailouts where spawning is likely to occur. For pool tailouts, McNeil coring is a consistent method for evaluating the impacts of fines on spawning success. Pebble counts are another method and typically evaluate surface fines in riffles.

Measures of substrate reflect conditions of sediment transport and its effect on channel morphology. Excessive sedimentation may be the result of excess sediment loading, or a loss in sediment transport capacity due to either altered channel morphology or reduced flows. Therefore, substrate parameters link to siltation, sedimentation, habitat, and flow alteration impairment causes.

Type II Targets

Type II targets can assist with the impairment determination, similar to Type I targets. Type II targets include: width to depth ratio, macroinvertebrate populations, percent surface fines < 6 mm in pool tailouts, surface fines < 2 mm in riffles (pebble count), and subsurface fines < .85 mm (McNeil Core).

Width to Depth Ratio

Bankfull width to depth ratio is an important indicator of stream condition. The parameter is one of several used to classify streams segments and thereby stratify datasets. If the width to depth ratio is out of the appropriate range for a given stream type, the channel may be degraded. Commonly, stream channels become over-widened due to human impacts associated with livestock trampling or riparian vegetation removal. In such cases, the increased width to depth ratio results in reduced sediment transport capacity, increased fine sediment deposition, and reduction in sediment sorting and channel complexity. As such, width to depth ratio links to siltation and habitat impairments.

Macroinvertebrates

Several macroinvertebrate metrics have documented relationships with the health of the aquatic life community. Macroinvertebrate assessment models in use by the Water Quality Planning Bureau (WQPB) of the Montana Department of Environmental Quality (DEQ) are the Multimetric Indices (MMI) for mountain and low valley landscapes and the River Invertebrate Prediction and Classification System (RIVPACS). Macroinvertebrate metrics provide a standard water quality target that applies to water bodies in Montana, as they are a direct indication of the beneficial use support for aquatic life.

Fine Sediment Concentrations

Fine sediment concentrations measured as percent surface fines < 6 mm in pool tailouts, surface fines < 2 mm in riffles, and subsurface fines < 0.85 mm (McNeil Core) can be used to support the Type I substrate targets. Reductions in macroinvertebrate richness has been associated with percent < 2 mm surface fines concentrations in excess of 20 percent as measured by pebble count (Relyea, et al, 2000). The quantitative relationships between these parameters and beneficial use support status are less clear than with the Type I substrate targets. Therefore, they are Type II targets likely linked to substrate, habitat, and flow alteration impairments.

Supplemental Indicators

Supplemental indicators provide supporting information when used in combination with the Type I and Type II targets. Supplemental indicators include woody vegetation extent, woody debris aggregate extent, woody debris aggregate frequency, pool habitat extent, and entrenchment ratio.

Woody Vegetation Extent

Riparian vegetation is an important component for fisheries and aquatic life. A significant reduction in riparian vegetation will cause reduced instream cover and woody debris contributions. Reduced riparian vegetation can also result in reduced bank integrity, causing channel over-widening and siltation. Vegetation clearing, continuous riparian grazing, or loss of base flows will reduce woody vegetation extent. Therefore, woody vegetation extent is a Type II target parameter for sediment, habitat, and flow alteration impaired streams.

Woody Debris Aggregate Extent and Frequency

Instream woody debris is an important component of stream channel complexity and habitat quality. Woody debris in a stream channel helps maintain bed stability, dissipate flow energy, create local scour pools, and sort sediment into complex habitat features. A lack of woody debris is related to sediment impairment from reduced local scouring of bed substrate. A lack of woody debris also links to habitat impairments due to reduced pool formation and lack of instream cover.

Pool Habitat Extent

Pool habitat extent can support the Type I and Type II substrate targets. However, the quantitative relationships between pool extent and beneficial use support status is not well defined; therefore, it is applied as a supplemental indicator that is likely linked to sediment, habitat, and flow alteration impairments.

Entrenchment Ratio
Entrenchment ratio is a measure of floodplain connectivity and extent. The parameter is a primary component of the channel classification scheme used for this TMDL planning effort (Rosgen, 1996). In cases where entrenchment values alone result in a reclassification of a C or E channel type to an F channel, degradation due to loss of floodplain connectivity is likely. Streams may become entrenched due to downcutting and resultant severing of the active channel from its floodplain. A loss of floodplain connectivity results in reduced flow energy dissipation on the floodplain, which can cause increased channel erosion and sedimentation. Therefore, entrenchment ratio is a supplemental indicator for siltation impairments.

Lack of floodplain access may also be caused by persistent and prolonged flow diversion that reduces bankfull depth and, therefore, the value for twice bankfull depth that is used to determine flood prone channel width and entrenchment ratio. Entrenchment ratio is therefore a supplemental indicator for impairment due to flow alteration. The lack of floodplain access also reduces the volume of water stored in the floodplain aquifer, thus lowering riparian ground water elevations and restricting the extent of riparian vegetation establishment. This linkage makes entrenchment ratio a useful indicator of impairment caused by alteration in streamside vegetative covers.

5.2 Sediment and Habitat Related Targets

This section contains the specific values developed as TMDL targets and supplemental indicator values for the Lower Blackfoot Planning area. The targets stratify by major stream type (Rosgen, 1996), and streams that primarily drain granitic source areas were stratified separately in the development of the <6mm pebble count targets. This development of separate targets for streams draining granitic source areas reflects the natural high volumes of sand-sized sediment produced by these subwatersheds. The data sources used to develop the targets include base parameter data, macroinvertebrate data, and McNeil Core data (Section 5.1). Supporting information on the development of target and supplemental indicator values for the Lower Blackfoot planning area are in **Appendix C**.

Table 5-2. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Lower Blackfoot (LBFT) Planning Area

Parameter	Target Level	Channel Type	Lower Blackfoot Target	Basis
Minimum Pool Frequency (pools/mile)	Type I	B	48	LBFT median
		C	55	Middle Blackfoot Planning Area (MBFT) Q3
		E	50	LBFT median
Minimum Residual Pool Depth (ft)	Type I	B	1.1	LBFT Q3
		C	2.0	MBFT_NC Q3
		E	1.0	LBFT Q3
		Eb	0.8	LBFT Q3
Maximum Percent Riffle Substrate Surface Fines < 6 mm (Pebble Count)	Type I	B	20	Beaverhead-Deerlodge NF Q3
		B (granitic)	20	Beaverhead-Deerlodge NF Q3
		C	22	Beaverhead-Deerlodge NF Q2
		E	36	LBFT Q3 Beaverhead-Deerlodge NF Q3
		Eb	37	LBFT Q3 Beaverhead-Deerlodge NF Q3
		Eb (grantic)_	45	LBFT Q3
		Blackfoot Mainstem	3	LBFT Q3
Maximum percent subsurface substrate fines < 6.35 mm (McNeil Cores)	Type I	C	27	Q1 All 2003-2006 Data
Maximum Percent Riffle Substrate Surface Fines < 2 mm (Pebble Count)	Type II	B	10	NV_CR reference Q3
		C	7	LBFT & NV CR Q3
		E	20	LBFT & NV CR Q3
		Eb	35	LBFT Q3
		Blackfoot Mainstem	2	LBFT Q3
Maximum percent subsurface substrate fines < 0.84 mm (McNeil Cores)	Type II	C	6	Q1[*] All 2003-2006 Data
Macroinvertebrate Populations	Type II	All	≥48	Low Valley Site Classification Multimetric Index (MMI)
			≥63	Mountain Site Classification Multimetric Index (MMI)
			≥0.8	RIVPACS

Table 5-2. Sediment/Habitat Targets and Supplemental Indicator Support Objectives, Lower Blackfoot (LBFT) Planning Area

Parameter	Target Level	Channel Type	Lower Blackfoot Target	Basis
W:D Ratio	Type II	B	12-16	B Channel definition Beaverhead-Deerlodge NF maximum Q3[**]
		C	12-19	C Channel definition MBFT maximum Q2[***]
		E	6-11	E Channel definition
		Eb	6-11	E Channel definition
Maximum percent substrate surface fines in pool tails (VB)	Type II	B	17	NV CR Q3
		C	23	NV CR Ref. Q3
		E	46	LBFT Q3
		Eb	42	LBFT Q3
Minimum Percent Woody Vegetation Extent	Supl Ind	B	88	NV CR Q3
		C	84	MBFT Q3
		E	67	LBFT Q3
		Eb	100	LBFT Q3
Minimum Percent Woody Debris Aggregate Extent	Supl Ind	B	12	LBFT Q3
		B (w/o Bel4)	12	LBFT Q3
		C	8	MBFT Q3
		E	12	MBFT Ref Q3
		Eb	12	MBFT Ref Q3
Minimum Woody Debris Aggregate Frequency (Ct./Mile)	Supl Ind	B	127	LBFT Q3
		C	74	LBFT Q3
		E	55	LBFT Q3
		Eb	73	LBFT Q3
Minimum Entrenchment Ratio	Supl Ind	C	2.2	C channel definition
		E	2.2	E channel definition
		Eb	2.2	E channel definition
Pool Habitat Extent (%)	Supl Ind	B	22	LBFT Q3
		C	35	MBFT Q3
		E	35	LBFT Q3
		Eb	10	LBFT Q3

[*] Q1 = 25th Percentile, [**] Q3 = 75th Percentile, [***] Q2 = 50th Percentile (Median)

5.3 Departure Assessment Methodology

The departure summary for each stream describes a comparison of measured site values to targets. The departure assessment identifies whether or not a target condition is satisfied, and highlights the magnitude of the difference between the site parameter value and the associated target. In the following sections, comparisons between site conditions and target values are in tabular format, with departure tables provided for each listed stream segment with relevant available data. For each listed stream segment, individual tables are presented for each of the channel types assessed on that stream, as the target values are dependent on channel type. In several cases, summaries of multiple assessment sites are in a single table. This occurs where, within a single listed stream segment, assessment data are available from multiple reaches that are of a common channel type. These compilations identify the assessment reaches by their channel type and reach name in the left most column of the table. Where there are multiple sites compiled within a single departure table, the “Site Value” listed in the table reflects the value from the assessment reach with the highest level of departure from the target. The “Target Met?” column on the table identifies whether the stream achieves the target value, and where multiple assessment sites are represented, identifies those sites that do not meet the target. Type I targets that are not meet are bolded in the “Target Met?” column. The sediment/habitat parameter values measured at each assessment site are in **Appendix C**.

5.4 TMDL Requirement Determination Methodology

The departures of current stream conditions from a target are the basis for determining the need for a TMDL. The following sections present this information in narrative form, providing a determination of any required sediment TMDLs as well as the need to address non-pollutant concerns such as flow or habitat alterations in the Water Quality Restoration Plan (WQRP) that is contained in **Section 9.0**. The determination of need for a TMDL first considers the degree to which the stream segment meets Type I parameters targets. Type II parameters and supplemental indicators are then similarly evaluated. Wherever relevant supplemental data exist, that information can support the TMDL requirement determination. A TMDL is necessary when the departure assessment does not clearly describe a fully supporting stream. As a result, the determination tends to be conservative in cases where the results are ambiguous.

5.5 Water Quality Impairment Status

The following sections identify listed stream segments needing sediment TMDL development.

5.5.1 Day Gulch

Day Gulch is a tributary to upper Elk Creek. Montana DEQ added Day Gulch to the 1996 303(d) List for flow alteration, other habitat alterations, and siltation. An assessment attempted by DEQ staff in 2004 was inconclusive due to dry channel conditions. Day Gulch is currently unassessed for any beneficial use due to a lack of sufficient credible data. Therefore, a sediment TMDL is not proposed for Day Gulch in this document. Data collected on Day Gulch as part of the 2006 Lower Blackfoot field assessment is discussed below. This information will contribute to the body of information required to meet the sufficient and credible data threshold when use support is reassessed on Day Gulch.

The base parameter and habitat unit assessment of 2006, divided the 1.2 mile long listed segment into two reaches. Reach Day1 flows through the headwaters area affected by placer mining and hillslope logging. Reach Day2 is a highly disturbed placer mine that was subsequently re-graded and reseeded. The regraded surface is now perched above the original channel location to the extent that perennial stream flow does not occur in the shallow channel constructed on the fill surface. Perennial surface flow is forced underground at the head of the fill and emerges near its base together with flow from an unnamed tributary to the south of Day Gulch. The combined flows at the base of the fill enter a rectangular retention pond that overflows to a constructed channel discharging to Elk Creek. The reach of Day Gulch assessed in 2006 is between the retention pond and Elk Creek, in an area with relatively dense riparian shrubs.

5.5.1.1 Day Gulch Departures from Target Conditions

The only sediment/habitat related parameter target met on Day Gulch is width to depth ratio. No other indicator values meet target conditions (**Table 5-3**). Pool frequencies for the assessed B channel type are less than 25 percent of the target value, and fine sediment concentrations are notably high. Residual pool depths are less than 20 percent of the target value for B channel types. No McNeil Core or macroinvertebrate data were available for Day Gulch.

Table 5-3. Sediment/Habitat Indicator Values and Targets, Day Gulch

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
B	Riffle substrate: <6mm (%)	36	≤ 20	Type I	**X**
Day2	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	11	≥ 48		**X**
	Residual Pool Depth (ft)	0.2	≥ 1.1		**X**
	Riffle substrate: <2mm (%)	25	≤ 10	Type II	X
	Width to Depth Ratio	5.1	≤ 16		√
	Maximum pool tailout surface fines < 6 mm (%)	50	≤ 17		X
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	64	≥ 88	Supp. Indicator	X
	Pool Extent (%)	2	≥ 22		X
	Woody Debris Aggregate Extent (%)	3	≥ 12		X
	Woody Debris Frequency (cts per mile)	79	≥ 127		X

* From site with highest departure from target

5.5.1.2 Day Gulch TMDL Requirements

Conditions on Day Gulch do not meet any of the Type I target values. Based on the 2006 data provided in **Table 5-3** for the stream reach below the regarded valley fill section, Day Gulch shows strong departures from substrate targets. Consideration of this information, together with a reevaluation Day Gulch that includes biological data and an assessment of headwaters channel conditions is recommended prior to development of a sediment TMDL. In this document, the channel, flow and habitat alterations observed for the lower stream reaches are addressed in the WQRP.

5.5.2 Keno Creek

Keno Creek is a second order tributary to upper Elk Creek. Montana DEQ added Keno Creek to the 1996 303(d) List for flow alteration, other habitat alterations, siltation and thermal modifications. Keno Creek is currently listed as unassessed for aquatic life, cold water fishery, and drinking water uses due to a lack of biological data. Macroinvertebrate data were collected on Keno Creek in September 2006, too late to be considered for the 2006 303(d) List.

Keno Creek is 2.9 miles long and comprises four assessment reaches. The uppermost reach, Keno1, flows through steep headwaters where upland logging is evident. Downstream, Keno2 parallels an access road, and valley walls exhibit evidence of upland logging and some historic riparian logging. Keno 3 is a relatively straight channel segment that flows closely along the south valley wall. The presence of phreatophytes, a type of aquatic vegetation, suggests spring-derived base flows. Large stumps are common in the riparian corridor, and extensive woody debris accumulations appear to reflect accumulations of slash from historic riparian logging. The lowermost reach, Keno4, shows evidence of both hillslope and riparian logging, and a gravel access road closely follows the channel. Extensive accumulations of old slash cover broad sections of channel, such that the creek is commonly not visible. Cretaceous age granitic rocks dominate the geology of the Keno Creek watershed.

5.5.2.1 Keno Creek Departures from Target Values

Of the Type I targets, Keno Creek only meets the pool frequency target (**Table 5-4**). Keno Creek does not meet substrate and residual pool depth targets. No McNeil Core data is available. The <6mm riffle substrate concentration measured on Keno Creek is 85 percent, significantly higher than the 45 percent target developed for streams that drain granitic terrain. Macroinvertebrate data available for Keno Creek do not meet Type II target values.

Table 5-4. Sediment/Habitat Indicator Values and Targets, Keno Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
Eb (gr)	Riffle substrate: <6mm (%)	85	≤ 45(gr)	Type I	**X**
Keno3 Keno4	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	69	≥ 50		√
	Residual Pool Depth (ft)	0.7	≥ 0.8		**X**
	Riffle substrate: <2mm (%)	35	≤ 35	Type II	√
	Width to Depth Ratio	6.5	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	43	≤ 42		X
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	41	≥ 48		X
	RIVPACS O/E	0.77	≥ 0.8		X
	Woody Vegetation Extent (%)	100	≥ 100	Supp. Indicator	√
	Pool Extent (%)	9	≥ 10		X
	Woody Debris Aggregate Extent (%)	8	≥ 12		X
	Entrenchment Ratio	2.0	≥ 2.2		X
	Woody Debris Frequency (cts per mile)	63	≥ 73		X

* From site with highest departure from target

5.5.2.2 Keno Creek TMDL Requirements

High concentrations of fine sediment and macroinvertebrate metrics in Keno Creek indicate the need for a sediment TMDL. Type II targets not met include macroinvertebrate indices and pool tailout fines, which also suggest the need for a sediment TMDL. The current assessment record should be updated to reflect the data collected in late 2006. These physical and biological indicators may be related to altered flow conditions and habitat alterations given as impairment causes in 1996. Potential sources of impairment include timber harvesting, road construction, and road maintenance. This document proposes a sediment TMDL for Keno Creek and the pollution-related causes are addressed in the water quality restoration plan.

5.5.3 Upper Elk Creek

Upper Elk Creek extends from its headwaters to Stinkwater Creek. It is a degraded third order tributary to the lower Blackfoot River (Montana FWP, 2002a). Upper Elk Creek supports populations of fluvial westslope cutthroat trout, rainbow trout, brown trout, and resident brook trout, which decrease in abundance downstream. Elk Creek is within the Elk Creek mining district, which was primarily a placer mining district, first discovered in 1865. The Elk Creek corridor was intensively placer mined for gold, as were several tributaries. Reynolds City and Yreka are two historic mining camps established in the Elk Creek valley.

The 8.4 mile listed segment of upper Elk Creek comprises six reaches. The uppermost reach, Elk1, flows through a confined valley bottom that supports dense conifer forest. Split flow through placer spoils is common, and visible fine sediment accumulations were present during the 2006 field reconnaissance. This reach extends to the mouth of Day Gulch. Below the mouth of Day Gulch, the valley widens, and channel sinuosity increases. Reaches Elk2 through Elk6 consist of coarse-grained channel segments that have local encroachment by the access road. The channel is locally confined to a narrow slot between the road embankment and the opposite valley wall. The road embankment commonly consists of sand-sized material at angle of repose. Valley walls are comprised of Cretaceous age granites, and the valley bottom has been placer mined near the historic town of Yreka. Elk4 is adjacent to Yreka, and in this reach, numerous beaver dams and large ponds are present in the placer mined valley bottom. Portions of this reach have been re-graded and restored. Riparian degradation is evident in the placer mined sections, and dredge ponds and spoil piles are present.

Montana DEQ lists upper Elk Creek as partially supporting of aquatic life and the cold-water fishery. Probable causes include physical substrate habitat alterations and sedimentation/siltation. Probable sources associated with these causes include forest roads and streambank modifications/destabilization.

Fisheries limitations in upper Elk Creek identified by Montana FWP (2001, 2002a) include lack of complex fish habitat (instream wood), livestock induced stream bank degradation and riparian vegetation suppression, elevated water temperature and channel instability, irrigation, and adverse effects of upstream mining and road drainage problems. Land use practices associated with these impairments include placer mining, channelization, road construction and maintenance activities, road drainage problems, and concentrated riparian livestock grazing.

Restoration projects have been completed on upper Elk Creek in several placer mined areas. In some restored areas, TSS values have declined to pre-construction levels, substrate conditions are improving, and riparian areas are beginning to recover (http://cwaic.mt.gov). Field assessment crews noted that bed scour and associated pool formation in restored sections is limited due to the coarse substrate.

5.5.3.1 Upper Elk Creek Departures from Targets

Field crews conducted assessments on both B channel types (reach Elk5), and more sinuous, lower gradient, E channel types (Elk2 and Elk3). The B channel in reach Elk5 is narrowly confined by a road embankment, and meets none of the Type I targets (**Table 5-5**). Pool frequency is notably low at less than 50 percent of the target value. Upper Elk Creek also does not meet Type II fine sediment concentration targets. The assessed E channel types on Elk Creek meet riffle substrate <6mm targets, however pool frequency and residual pool depths are low (**Table 5-6**). Elk2 and Elk3 both consist of primarily run habitat through placer spoils. Supplemental indicators related to woody vegetation and instream woody debris are consistently low in all assessed reaches.

Table 5-5. Sediment/Habitat Indicator Values and Targets, Upper Elk Creek B Channel Type

Channel Type/ Reach	**Parameter**	**Site Value***	**Target**	**Target Type**	**Target Met?** **√=Yes X=No** **ND=Not Determined**
B	Riffle substrate: <6mm (%)	22	≤ 20	Type I	**X**
Elk5	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	21	≥ 48		**X**
	Residual Pool Depth (ft)	0.8	≥ 1.1		**X**
	Riffle substrate: <2mm (%)	13	≤ 10	Type II	X
	Width to Depth Ratio	12.8	≤ 16		√
	Median pool tailout surface fines < 6 mm (%)	25	≤ 17		X
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	100	≥ 88	Supp. Indicator	√
	Pool Extent (%)	4	≥ 22		X
	Woody Debris Aggregate Extent (%)	9	≥ 12		X
	Woody Debris Frequency (cts per mile)	95	≥ 127		X

* From site with highest departure from target

Table 5-6. Sediment/Habitat Indicator Values and Targets, Upper Elk Creek Eb(gr) Channel Type

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
Eb (gr) Elk2 Elk3	Riffle substrate: <6mm (%)	32	≤ 45(gr)	Type I	√
	McNeil Cores <6.35 mm (%)	34	ND		ND
	Pool Frequency (pools/mile)	26	≥ 50		**X**
	Residual Pool Depth (ft)	0.5	≥ 0.8		**X**
	Riffle substrate: <2mm (%)	26	≤ 35	Type II	√
	Width to Depth Ratio	10.1	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	39	≤ 42		√
	McNeil Cores <.85 mm (%)	6.9	ND		ND
	MMI	49.9	≥ 48		√
	RIVPACS O/E	0.78	≥ 0.8		X
	Woody Vegetation Extent (%)	78	≥ 100	Supp. Indicator	X
	Pool Extent (%)	5	≥ 10		X
	Woody Debris Aggregate Extent (%)	3.3	≥ 12		X
	Entrenchment Ratio	2.5	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	11	≥ 73		X

* From site with highest departure from target

5.5.3.2 Upper Elk Creek TMDL Requirements

Upper Elk Creek meets the riffle substrate targets in the assessed E channel types. However, the assessment data for Elk5, which is a B channel type narrowly confined by the road and valley wall, indicates excessive fine sediment levels in both riffles and pool tailouts. Because the Type I targets related to both substrate and pool conditions are not met on the B channel type, and due to poor pool conditions in the E channel types, upper Elk Creek requires a sediment TMDL. The notably low pool frequency value for the confined B channel type, coupled with the extensive placer spoils through the reach, supports the physical habitat substrate alterations listing. The water quality restoration plan addresses this impairment.

5.5.4 Lower Elk Creek

Lower Elk Creek extends from the mouth of Stinkwater Creek to the Blackfoot River, a distance of approximately 5.6 miles. Montana FWP describes this stream as a degraded third order tributary to the lower Blackfoot River (MTFWP, 2002a). The listed channel comprises four reaches, Elk7 through Elk10. Just below Stinkwater Creek, reach Elk7 is an E channel that flows through a broad, open valley bottom. The reach supports moderate densities of a mixed willow/cottonwood riparian zone and is actively grazed. Field crews noted that undercut banks exhibited evidence of livestock trampling. Reach Elk8 consists of a largely restored channel segment, although bank trampling and widening of the restored channel has occurred. Reach Elk9 extends to the downstream end of the irrigated valley bottom near Highway 200 and has a variable channel width, and accumulations of sand in the channel bed. From the Highway 200 crossing to the mouth at the Blackfoot River, Elk Creek becomes increasingly confined and steeper as it approaches the entrenched Blackfoot River corridor. Elk10 appears to gain flow along its course below Highway 200. The bed is relatively coarse due to inputs of colluvial cobble-sized sediment from the valley walls. Elk10 also shows evidence of historic placer mining.

Elk Creek supports populations of fluvial westslope cutthroat trout, rainbow trout, brown trout, and resident brook trout; the densities of all of these species decrease in the downstream direction. Elk Creek has been described as "the only potential spawning stream (of the Blackfoot River) between Belmont Creek and Blanchard Creek, a distance of 17.7 miles" (MTFWP, 1999).

Montana DEQ lists Lower Elk Creek as partially supporting aquatic life and the cold water fishery (http://cwaic.mt.gov). The 2006 sediment/habitat related listings for Lower Elk Creek include alteration in stream-side or littoral vegetative covers, and sedimentation/siltation. Probable sources include riparian grazing and streambank modifications/destabilization. Lower Elk Creek is also on the 303(d) List for temperature.

Fisheries-related impairments on Elk Creek identified by Montana FWP (MTFWP, 1999) include elevated instream sediment loading related to extensive placer mining activity, road drainage problems, channelization, and poor riparian grazing activities. In the 1940s, one mile of Lower Elk Creek was moved from its original location to facilitate irrigation in the valley bottom. The channel was relocated to a higher elevation along the valley wall, which is comprised of fine grained lake deposits. The relocation and straightening resulted in downcutting and dramatically accelerated sediment production rates. In 1994, 8,600 ft of Lower Elk Creek were included in an erosion control project designed to improve water quality. The project involved reconstructing the channel, replanting willows from adjacent areas, adding large woody debris, and implementing a rotational grazing system. Subsequent monitoring indicated that riparian health requires further improvement to recover fish populations in Lower Elk Creek (MTFWP, 2001).

5.5.4.1 Lower Elk Creek Departures from Targets

Field crews assessed four E channel type reaches on Lower Elk Creek (**Table 5-7**) in 2006. These reaches show significant departures for all sediment/habitat related parameters. Pool frequencies are less than 50 percent of the target value, and fine sediment concentrations are high. For E channel types, width to depth ratios are higher than the target value of 11. Woody vegetation densities are low, and woody debris related parameters are well below target values. Entrenchment ratios are low on Lower Elk Creek, with all four E channel assessment sites having entrenchment ratios below the target value.

Table 5-7. Sediment/Habitat Indicator Values and Targets, Lower Elk Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
E	Riffle substrate: <6mm (%)	67	≤ 36	Type I	**X**
Elk7 Elk8 Elk9 Elk10	McNeil Cores <6.35 mm (%)	58	ND		ND
	Pool Frequency (pools/mile)	21	≥ 50		**X**
	Residual Pool Depth (ft)	0.7	≥ 1.0		**X**
	Riffle substrate: <2mm (%)	45	≤ 20	Type II	X
	Width to Depth Ratio	14.1	≤ 11		X
	Median pool tailout surface fines < 6 mm (%)	50	≤ 46		X
	McNeil Cores <.85 mm (%)	29	ND		ND
	MMI	33	≥ 48		X
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	1	≥ 67	Supp. Indicator	X
	Pool Extent (%)	12	≥ 35		X
	Woody Debris Aggregate Extent (%)	2	≥ 12		X
	Entrenchment Ratio	1.2	≥ 2.2		X
	Woody Debris Frequency (cts per mile)	11	≥ 55		X

* From site with highest departure from target

5.5.4.2 Lower Elk Creek TMDL Requirements

Assessment data indicate that high concentrations of fine sediment, over widened cross sections, poor pool conditions, and limited woody vegetation extent characterize Lower Elk Creek. The fine sediment accumulations on Lower Elk Creek indicate that a sediment TMDL is warranted for this stream segment. Similarly, limitations in woody vegetation, bedform complexity, and cross section conditions justify the habitat alterations listing. The water quality restoration plan addresses these habitat alterations.

5.5.5 Belmont Creek

Belmont Creek is a second order tributary to the Blackfoot River that originates in the northern portion of the lower Blackfoot watershed. The listed segment of Belmont Creek flows southward from the high elevations of the Lolo National Forest to the Blacktfoot River north of Potomac and is approximately 10.5 miles long. The listed stream segment comprises five reaches. Reach Bel1 is a steep channel that flows through a confined valley with historical logging. Both the valley walls and creek bottom show evidence of timber harvest. Reach Bel2 extends to the mouth of Burnt Fork Creek and consists of a lower gradient section with extensive beaver ponding. Reach Bel3 flows through a confined canyon section that supports a mixed willow/conifer valley bottom and has numerous logging road crossings. Reach Bel4 flows through a short section of unconfined valley bottom with a reduced channel gradient. Around the year 2000, a restoration project took place in the reach. Reach Bel5 extends to the Blackfoot River, and consists of a steep, confined channel that descends into the entrenched valley of the Blackfoot River.

Through the mid-1990s, the Belmont Creek watershed had 135 miles of roads (http://cwaic.mt.gov), and road drainage problems were a probable factor in accelerated fine sediment accumulations in the channel. At that time, the modeled amount of sediment being generated by the road system was about two times more sediment than would be expected under undisturbed conditions (Sugden 1994). Since that time, Plum Creek Timber Company implemented extensive sediment controls such as road closures and grazing BMPs. In the 1960s, two culverts were placed in the stream that blocked fish migrations under most flows; in 1994, a bridge was constructed to facilitate removal of the culverts. Bull trout spawning occurs in Belmont Creek, and near the mouth, a robust rainbow and brown trout fishery is present. Montana FWP considers Belmont Creek a core area bull trout stream (MTFWP, 1999).

Montana DEQ considers Belmont Creek partially supporting of aquatic life and the cold water fishery. Probable causes of impairment identified on the 2006 303(d) List consist of sedimentation/siltation, and the probable sources associated with that impairment are forest roads and riparian grazing.

5.5.5.1 Belmont Creek Departures from Targets

Field crews assessed two reaches on Belmont Creek in 2006. The uppermost reach, Bel2, is a B channel type that meets all target values with the exception of riffle substrate <6mm (**Table 5-8**). Downstream, Bel4 is a C channel type that flows through an unconfined open meadow area. Restoration activities in the reach included large woody debris placement by the BLM as well as 1995 grazing exclusion fencing and shrub and tree planting by PCTC. Although restoration has been implemented, Type I targets for McNeil Cores and residual pool depth are not met (**Table 5-9**). However, Type I targets for pool frequency and percent fines in riffles are met, potentially indicating restoration-associated improvements in channel condition.

Table 5-8. Sediment/Habitat Indicator Values and Targets, Belmont Creek B Channel Type

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
B	Riffle substrate: <6mm (%)	26	≤ 20	Type I	**X**
Bel2	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	84	≥ 48		√
	Residual Pool Depth (ft)	1.2	≥ 1.1		√
	Riffle substrate: <2mm (%)	9	≤ 10	Type II	√
	Width to Depth Ratio	11.5	12-16		√
	Median pool tailout surface fines < 6 mm (%)	5	≤ 17		√
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	100	≥ 88	Supp. Indicator	√
	Pool Extent (%)	22	≥ 22		√
	Woody Debris Aggregate Extent (%)	75	≥ 12		√
	Woody Debris Frequency (cts per mile)	491	≥ 127		√

* From site with highest departure from target

Table 5-9. Sediment/Habitat Indicator Values and Targets, Belmont Creek C Channel Type

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
C	Riffle substrate: <6mm (%)	11	≤ 22	Type I	√
Bel4	McNeil Cores <6.35 mm (%)	44	≤ 27		**X**
	Pool Frequency (pools/mile)	63	≥ 55		√
	Residual Pool Depth (ft)	1.1	≥ 2.0		**X**
	Riffle substrate: <2mm (%)	6	≤ 7	Type II	√
	Width to Depth Ratio	14.5	≤ 19		√
	Median pool tailout surface fines < 6 mm (%)	37.5	≤ 23		X
	McNeil Cores <.85 mm (%)	9	≤ 6		X
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	99	≥ 84	Supp. Indicator	√
	Pool Extent (%)	41	≥ 35		√
	Woody Debris Aggregate Extent (%)	6	≥ 8		X
	Entrenchment Ratio	3.6	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	74	≥ 74		√

* From site with highest departure from target

5.5.5.2 Belmont Creek TMDL Requirements

The confined, relatively steep B channel segment assessed on Belmont Creek does not show excessive accumulations of fine sediment. However, the lower gradient C channel type segment (Bel4) does show elevated concentrations of fine substrate in pool tailouts as measured by both McNeil Cores and surface fines counts. Because of the evidence for accumulations of fine sediment above established target values for McNeil Core data in this lower reach of Belmont Creek, a sediment TMDL is warranted for the listed stream segment.

5.5.6 Washoe Creek

Washoe Creek is a 6.1 mile long second order tributary to Union Creek. Washoe Creek is within the Coloma Mining District, and during the latter part of the nineteenth century, miners extracted gold from placer deposits in the stream corridor. The listed stream segment comprises four reaches. Reach Washoe1 is a confined, steep B channel type located in the headwaters of the drainage. Although upstream of most mining disturbances, hillslopes adjacent to the reach indicate relatively recent timber harvest. Downstream, reach Washoe2 shows more mining activity. In reach Washoe3, the valley confinement diminishes as the geology changes from Proterozoic rocks to younger Tertiary-age sedimentary rocks. Reach Washoe3 also exhibits evidence of upland logging, and the riparian corridor appears degraded on aerial photography. The lowermost Reach, Washoe4, consists of an unconfined E channel type with irrigation diversions and abrupt changes in woody riparian vegetation at fence lines. Field crews noted multiple rock and rock/log check dams in the reach.

Montana DEQ considers Washoe Creek partially supporting of aquatic life, the cold water fishery, and primary contact recreation. Sedimentation/siltation is the only sediment/habitat-related probable cause identified on the 2006 303(d) List. Probable sources associated with the sedimentation/siltation impairment include open pit mining, grazing and timber harvest. An open pit barite mine located in the upper part of the drainage is a potential source of sediment loading to the creek (http://cwaic.mt.gov).

Washoe Creek supports a resident westslope cutthroat trout population. Fisheries-related impairments on the stream identified by MTFWP (2002a) include excessive livestock access to stream banks and lack of instream complexity.

5.5.6.1 Washoe Creek Departures from Targets

The Washoe Creek assessment site consisted of an E channel segment in the lowermost reach (Washo4). Within this reach, Type I target parameters of <6mm sediment concentrations in riffles and pool frequency are met (**Table 5-10**). Residual pool depths, also a Type I parameter, are notably low, and less than half of the target value. Washoe Creek meets Type II targets, but does not achieve supplemental indicator targets for woody vegetation extent, pool extent, and woody debris.

Table 5-10. Sediment/Habitat Indicator Values and Targets, Washoe Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
E	Riffle substrate: <6mm (%)	5	≤ 36	Type I	√
Washoe4	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	53	≥ 50		√
	Residual Pool Depth (ft)	0.4	≥ 1.0		**X**
	Riffle substrate: <2mm (%)	3	≤ 20	Type II	√
	Width to Depth Ratio	9.5	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	20	≤ 46		√
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	52	≥ 67	Supp. Indicator	X
	Pool Extent (%)	10	≥ 35		X
	Woody Debris Aggregate Extent (%)	4	≥ 12		X
	Entrenchment Ratio	7.7	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	37	≥ 55		X

* From site with highest departure from target

5.5.6.2 Washoe Creek TMDL Requirements

The assessment results indicate that Washoe Creek meets some of the sediment/habitat related parameter target values; however, measured residual pool depths are less than 50 percent of the target value, indicating that fine sediment is likely limiting channel habitat for aquatic life. Since this Type I parameter shows a strong departure from the target values, a sediment TMDL is warranted for Washoe Creek.

5.5.7 East Ashby Creek

East Ashby Creek is a second order tributary to Ashby Creek, which in turn is a tributary to Camas Creek. The listed segment of East Ashby Creek is approximately 3.9 miles long, and comprises three reaches. In the headwaters area, the valley wall and an access road closely confine reach EAshby1. Downstream, reach EAshby2 is a C/E channel type with decreased confinement. This reach consists of a series of open parks separated by moderately confined sections. The lowermost portion of East Ashby Creek, EAshby3, is a moderately confined channel with road encroachment.

Montana DEQ considers East Ashby Creek partially supporting of aquatic life and the cold-water fishery. Sediment/habitat related probable causes include alteration in streamside vegetative covers, and sedimentation/siltation (http://cwaic.mt.gov). Probable sources associated with these causes are forest roads, riparian grazing, and silviculture activities. East Ashby Creek supports fluvial westslope cutthroat trout and brook trout. Fisheries-related limitations identified on East Ashby Creek include localized areas of riparian livestock overuse, and sediment impacts related to roads and riparian livestock overuse (MTFWP 2001).

5.5.7.1 East Ashby Creek Departures from Targets

The assessment site on East Ashby Creek consists of an Eb channel type in the lower most reach, EAshby3. Within this reach, East Ashby Creek meets the pool frequency and residual pool depth Type I targets (**Table 5-11**). The percent <6mm fines measured in riffles, however, is slightly elevated above the target value. This slight elevation of fine sediment concentrations above target values also occurs in the Type II <2mm size fraction for riffles. The Type II macroinvertebrate indices show significant departures from target values, and all supplemental indicators suggest poor conditions with respect to woody vegetation extent, pool extent, and woody debris parameters.

Table 5-11. Sediment/Habitat Indicator Values and Targets, East Ashby Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
Eb EAshb3	Riffle substrate: <6mm (%)	39	≤ 37	Type I	**X**
	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	69	≥ 50		√
	Residual Pool Depth (ft)	1.2	≥ 0.8		√
	Riffle substrate: <2mm (%)	36	≤ 35	Type II	X
	Width to Depth Ratio	6.4	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	ND	≤ 42		ND
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	49	≥ 63		X
	RIVPACS O/E	0.5	≥ 0.8		X
	Woody Vegetation Extent (%)	48	≥ 100	Supp. Indicator	X
	Pool Extent (%)	6	≥ 10		X
	Woody Debris Aggregate Extent (%)	5	≥ 12		X
	Entrenchment Ratio	5.0	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	37	≥ 73		X

* From site with highest departure from target

5.5.7.2 East Ashby Creek TMDL Requirements

The assessment results on East Ashby Creek indicate relatively high pool frequencies and residual pool depths compared to target values. These Type I indicators suggest that a moderate level of in-stream habitat complexity exists. However, the combination of elevated fines and low macroinvertebrate indices suggests that fine sediment accumulations are elevated, warranting a sediment TMDL for East Ashby Creek. The vegetation-related supplemental indicators also indicate altered streamside vegetative cover that is addressed in the water quality restoration plan.

5.5.8 West Ashby Creek

West Ashby Creek is a 3.1 mile long second order tributary to Ashby Creek, extending from its headwaters to the confluence with Ashby Creek. This listed stream segment comprises three reaches. Reach WAshb1 is an A/B channel type in the steep headwaters of the basin. Upland logging is evident in the area. This reach flows through Tertiary-age granites. Downstream, reach WAshb2 exits the granitic geology, and the channel slope lessens. Timber harvesting is evident on the valley walls, and access roads encroach on the channel. Valley walls and an access road encroach on the channel in reach WAshby3. Field assessment crews noted bank trampling as well as historic riparian logging.

West Ashby Creek is considered partially supporting of aquatic life and the cold-water fishery. Probable causes associated with this partial support include alteration in streamside covers, and sedimentation/siltation. Associated sources listed as probable in 2006 include forest roads (road construction and use) and silviculture activities.

5.5.8.1 West Ashby Creek Departures from Targets

West Ashby Creek originates in granitic terrain, therefore a specific Type I <6mm riffle substrate target developed specifically for granitic watersheds is applicable. Reach WAshb3 meets this target (**Table 5-12**). However, West Ashby Creek does not meet the Type I pool frequency and residual pool depth targets. The Type II targets for substrate and channel morphology are met, as is the MMI macroinvertebrate index. The second macroinvertebrate parameter shows more degraded conditions, as the RIVPACS O/E value for the site is well below the target condition.

Table 5-12. Sediment/Habitat Indicator Values and Targets, West Ashby Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
Eb (gr) WAshb3	Riffle substrate: <6mm (%)	28	≤ 45(gr)	Type I	√
	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	48	≥ 50		**X**
	Residual Pool Depth (ft)	0.4	≥ 0.8		**X**
	Riffle substrate: <2mm (%)	21	≤ 35	Type II	√
	Width to Depth Ratio	8.0	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	41	≤ 42		√
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	77	≥ 63		√
	RIVPACS O/E	0.5	≥ 0.8		X
	Woody Vegetation Extent (%)	100	≥ 100	Supp. Indicator	√
	Pool Extent (%)	5	≥ 10		X
	Woody Debris Aggregate Extent (%)	12	≥ 12		√
	Entrenchment Ratio	2.4	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	148	≥ 73		√

* From site with highest departure from target

5.5.8.2 West Ashby Creek TMDL Requirements

Measured residual pool depths on West Ashby Creek average 0.4 feet, one-half of the target value. This, coupled with significant departure for the RIVPACS O/E macroinvertebrate target, indicates that fine sediment is a likely contributor to impaired sediment/habitat conditions. Therefore, a sediment TMDL is warranted for West Ashby Creek. The altered streamside cover impairment cause is addressed in the water quality restoration plan.

5.5.9 Camas Creek

Camas Creek is a 9.2 mile long, third order tributary to Union Creek. Camas Creek supports westslope cutthroat trout, brook trout, and sculpins, with westslope cutthroat trout in the headwaters reaches (MTFWP, 2001). The listed segment of Camas Creek comprises eight reaches. The uppermost reach, Cam1, is in the steep headwaters area where logging is evident, and an access road encroaches into the valley bottom. Camas Creek then flows through a less-confined alluvial valley in Cam2, where sparse densities of woody vegetation indicate riparian degradation. Cam3 consists of a similarly unconfined section with a narrow thread of willows along the channel. In Cam4, the woody riparian vegetation thread is narrower and discontinuous, with dewatering and riparian degradation evident throughout the reach. Riparian degradation and dewatering continue downstream in Cam6, which extends to the road crossing near Potomac. Below the road crossing, Cam7 extends to the mouth of Ashby Creek. This section flows through a highly impacted valley bottom section irrigated with both flood and center pivot methods. Cam8 is the lowermost reach of Camas Creek, and is characterized by sparse woody vegetation, and significant dewatering of the stream.

Montana DEQ considers Camas Creek partially supporting of aquatic life and the cold water fishery. Sediment/habitat related probable causes identified in 2006 include low flow alterations and sedimentation/siltation. Probable sources include grazing in riparian zones, irrigated crop production, and upstream sources.

Fisheries-related limitations on lower Camas Creek identified by MTFWP (2001) include lack of a riparian overstory, lack of woody debris, and high sediment levels.

5.5.9.1 Camas Creek Departures from Targets

Field crews collected data from three reaches on Camas Creek (**Table 5-13**). These data indicate that the Type I <6mm value for riffles is approximately two times the target value, and pool frequencies and residual pool depths are notably low. The Type II width to depth ratio target is high at one of the assessment sites, indicating an over-widened condition. The values for supplemental indicators show that woody vegetation and Large Woody Debris (LWD) related parameters are low compared to targets.

Table 5-13. Sediment/Habitat Indicator Values and Targets, Camas Creek

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
E	Riffle substrate: <6mm (%)	71	≤ 36	Type I	**X**
Cam2 Cam4 Cam6	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	21	≥ 50		**X**
	Residual Pool Depth (ft)	0.6	≥ 1.0		**X**
	Riffle substrate: <2mm (%)	31	≤ 20	Type II	X
	Width to Depth Ratio	17.4	≤ 11		X
	Median pool tailout surface fines < 6 mm (%)	46	≤ 46		√
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	66	≥ 48		√
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	33	≥ 67	Supp. Indicator	X
	Pool Extent (%)	3	≥ 35		X
	Woody Debris Aggregate Extent (%)	0	≥ 12		X
	Entrenchment Ratio	1.5	≥ 2.2		X
	Woody Debris Frequency (cts per mile)	16	≥ 55		X

* From site with highest departure from target

5.5.9.2 Camas Creek TMDL Requirements

The conditions measured by field crews indicate that Camas Creek does not meet most of the water quality objectives listed above and does not provide full support of beneficial uses. Therefore, a sediment TMDL is warranted for Camas Creek. Low flow alterations, which are a type of pollution rather than a pollutant, is addressed in the water quality restoration plan.

5.5.10 Union Creek

Union Creek is a primary third order tributary to the lower Blackfoot River. The listed segment of Union Creek is 19.4 miles long, and comprises 12 reaches. The uppermost reach, Union1, is in the headwaters of the drainage, and consists of a confined, steep channel with numerous mining disturbances and road crossings. This reach is in the Copper Cliff mining district, which contains the Copper Cliff mine near the upstream end of a steep tributary to upper Union Creek. The mine was discovered in 1890 and was developed with about 1,500 feet of underground workings prior to 1916. The ore extracted from the mine was primarily copper, with some gold and silver. Field crews observed orange-colored opaque water emanating from mine tailings in the stream corridor of Union1. The headwaters area also has evidence of timber harvest. Downstream, confinement decreases in reaches Union2 through Union5, with a lower gradient. These reaches are typically bounded by a low density willow corridor in an irrigated valley bottom grazed by horses. The riparian zone in Union4 was historically used for hay production, and is currently grazed. A short, moderately confined channel segment above the Highway 200 bridge is bounded by sedimentary rock outcroppings. Below Highway 200, reaches Union7 through Union11 are minimally confined and support low density woody riparian vegetation. Two of these reaches, Union7 and Union9, show evidence of channelization. Field crews noted that reach Union8 had extensive hoof shear from livestock. The lower reaches have numerous diversions and significant irrigation return flow. Stream corridor grazing is extensive, and entrenchment into the alluvial valley fill is common. As Union Creek approaches the entrenched corridor of the Lower Blackfoot River through reach Union12, it descends steeply through a B channel type confined by both the valley wall and Highway 200.

Montana DEQ considers Union Creek not supporting of aquatic life and the cold water fishery. Probable causes related to sediment and habitat include physical substrate habitat alterations, and suspended/bedload solids. Probable sources include rangeland grazing, and streambank modification/destabilization. In addition, low flow alterations are a probable source for temperature problems on Union Creek.

Union Creek contains both brook trout and westslope cutthroat trout, with brook trout in low numbers in the middle reaches, and resident westslope cutthroat trout in low numbers in the middle and upper reaches (MTFWP, 2002a). Fisheries limitations identified by MTFWP (2002a) include poor road crossings (undersized culverts), irrigation impacts (low instream flows), lack of instream complexity, and degraded riparian vegetation resulting from excessive livestock access to stream banks.

5.5.10.1 Union Creek Departures from Targets

Field crews assessed six sites on Union Creek for sediment and habitat related parameters. The two B channel type reaches are the uppermost and lowermost reaches of the creek. At these assessment sites, Union Creek does not meet riffle substrate fines <6mm, and residual pool depths Type I targets (**Table 5-14**). Union Creek also does not meet the majority of Type II targets, and supplemental indicators are typically below water quality objectives. For the E channel types, only one target is met for the entire suite of parameters (**Table 5-15**). One reach in the upper portion of the watershed (Union4) drains an area dominated largely by granitic rocks, and falls in the granitic subset Eb channel type. This assessment reach met two Type I targets, while not meeting target residual pool depth values (**Table 5-16**). Union Creek meets one half of the Type II targets and one out of four water quality objectives developed for supplemental indicators.

Table 5-14. Sediment/Habitat Indicator Values and Targets, Union Creek B Channel Type

Channel Type/ Reach	**Parameter**	**Site Value***	**Target**	**Target Type**	**Target Met?** **√=Yes X=No** **ND=Not Determined**
B	Riffle substrate: <6mm (%)	25	≤ 20	Type I	**X**
Union1 Union12	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	48	≥ 48		√
	Residual Pool Depth (ft)	0.6	≥ 1.1		**X**
	Riffle substrate: <2mm (%)	16	≤ 10	Type II	X
	Width to Depth Ratio	19.1	≤ 16		X
	Median pool tailout surface fines < 6 mm (%)	15	≤ 17		√
	McNeil Cores <.85 mm (%)	ND	ND		X
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	100	≥ 88	Supp. Indicator	√
	Pool Extent (%)	13	≥ 22		X
	Woody Debris Aggregate Extent (%)	0	≥ 12		X
	Woody Debris Frequency (cts per mile)	0	≥ 127		X

* From site with highest departure from target

Table 5-15. Sediment/Habitat Indicator Values and Targets, Union Creek E Channel Type

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
E	Riffle substrate: <6mm (%)	36	≤ 36	Type I	√
Union5 Union8 Union11	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	26	≥ 50		**X**
	Residual Pool Depth (ft)	0.6	≥ 1.0		**X**
	Riffle substrate: <2mm (%)	29	≤ 20	Type II	X
	Width to Depth Ratio	11.9	≤ 11		X
	Median pool tailout surface fines < 6 mm (%)	50	≤ 46		X
	McNeil Cores <.85 mm (%)	ND	ND		ND
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	11	≥ 67	Supp. Indicator	X
	Pool Extent (%)	9	≥ 35		X
	Woody Debris Aggregate Extent (%)	0	≥ 12		X
	Entrenchment Ratio	1.4	≥ 2.2		X
	Woody Debris Frequency (cts per mile)	0	≥ 55		X

* From site with highest departure from target

Table 5-16. Sediment/Habitat Indicator Values and Targets, Union Creek Eb Channel Type

Channel Type/ Reach	Parameter	Site Value*	Target	Target Type	Target Met? √=Yes X=No ND=Not Determined
Eb	Riffle substrate: <6mm (%)	14	≤ 37	Type I	√
Union4	McNeil Cores <6.35 mm (%)	ND	ND		ND
	Pool Frequency (pools/mile)	53	≥ 50		√
	Residual Pool Depth (ft)	0.6	≥ 0.8		**X**
	Riffle substrate: <2mm (%)	6	≤ 35	Type II	√
	Width to Depth Ratio	5.6	≤ 11		√
	Median pool tailout surface fines < 6 mm (%)	50	≤ 42		X
	McNeil Cores <.85 mm (%)	ND	ND		X
	MMI	ND	≥ 48		ND
	RIVPACS O/E	ND	≥ 0.8		ND
	Woody Vegetation Extent (%)	33	≥ 100	Supp. Indicator	X
	Pool Extent (%)	27	≥ 10		√
	Woody Debris Aggregate Extent (%)	2	≥ 12		X
	Entrenchment Ratio	4.1	≥ 2.2		√
	Woody Debris Frequency (cts per mile)	26	≥ 73		X

* From site with highest departure from target

5.5.10.2 Union Creek TMDL Requirements

Field assessment and subsequent analysis included three channel types on Union Creek, B, E, and Eb. Each of these reach types shows significant departures from Type I and Type II water quality objectives related to sediment and habitat. As a result, Union Creek warrants a sediment TMDL. Other pollution related listings, including habitat alterations, are addressed in the water quality restoration plan.

5.6 Sediment Source Assessment

Erosion is the main source of non-point source sediment causing siltation and habitat impairments. It is mainly influenced by climate, geology, soil properties, vegetation and topography. Eroded sediment can carry nutrients, particularly phosphates, and contribute to eutrophication of lakes and streams. The two major types of erosion are geological and that caused by human activity (Ward and Trimble, 2004). Geological erosion results in the long-term development of topographic features such as stream channels, valleys, and canyons and contributes to soil formation. Tillage, road drainage and vegetation removal by humans and grazing animals may cause accelerated erosion.

The methods for assessing erosion sources in the Blackfoot River watershed were selected to consider the effects of these large scale environmental influences (climate, geology, etc.) as well as the effects of the most extensive human activities affecting the landscape. DEQ’s assessment quantifies sediment from the three most important sediment-generating processes:

1. Landscape erosion,
2. Streambank erosion, and
3. Road erosion.

Landscape and streambank erosion each have natural components influenced by large scale human land uses including agriculture, timber harvest, mining and residential and commercial land development. Though road erosion is entirely human caused, it can be mitigated by specifically applying construction and maintenance practices.

Analytical methods used to assess the sediment contribution from each of the above processes are:

- The SWAT model to quantify landscape scale hillslope erosion.
- A modified bank erosion harzard index (Rosgen 2000) based on field data collected on listed stream segments.
- Annual per crossing loading rates extrapolated from the Middle Blackfoot and Nevada Creek Roads Assessment (RDG, 2006) using the Washington Forest Practices Watershed Analysis Manual, **Appendix B**, Roads Assessment Procedure (Washington Department of Natural Resources 1997).
- Annual culvert failure loading rates extrapolated from the Middle Blackfoot and Nevada Creek Roads Assessment (RDG, 2006) using constriction ratio based failure risk.

5.6.1 Hillslope Erosion

Naturally occurring s hillslope erosion throughout the watershed can be accelerated by human land use. Hillslope erosion in the Lower Blackfoot TPA was evaluated using the Soil and Water Assessment Tool (SWAT) (Neitsch et al. 2002a) applied to the entire Blackfoot River watershed. SWAT was developed for the USDA Agricultural Research Service to predict the affects of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds. **Appendix D** describes the model's set-up, calibration, and verification in the Blackfoot River watershed.

SWAT partitioned the Blackfoot watershed into 65 subbasins that generally correspond to the watersheds of sediment listed streams. Each subbasin was divided into hydrologic response units (HRUs) of uniform soil and landcover characteristics. The model processes data describing the climate, soil properties, topography, vegetation, and land cover management practices in order to estimate long-term water and sediment movement, crop growth, and nutrient cycling. Model output of daily sediment yield per HRU for a nine-year modeling period were averaged to give mean daily sediment loading values. These values were summed to give annual yields per HRU from within each of the 65 subbasins.

Because SWAT was developed for use in low-relief agricultural settings, it uses a single mean slope value for each subbasin. However, many of the 65 Blackfoot subbasins have variable slopes. Flat ridge tops grade to extremely steep valley walls that in turn grade to relatively flat valley floors. The SWAT-assigned slope value for each subbasin is quite high and resulted in greatly exaggerated sediment yields for most subbasins, especially for low relief range and pasture HRUs. Therefore, the model could not effectively reconcile the delivered hillslope load with that being routed through the stream channel system. Thus DEQ took only the delivered loads from each subbasin and adjusted them, outside of the model, into amounts that could conceivably reach stream channels.

Table 5-17 compares SWAT sediment yield for pasture and rangeland HRUs with typical loading values for such cover types reported in the literature (Elliot and Robichaud 2001, Meeuwig 1970, USDA 2000). Note that the annual SWAT estimates in the table exceed those reported in the literature for these HRUs by a factor ranging from five to 15.

Table 5-17. Comparison of Annual SWAT Sediment Yield Estimates for Lower Blackfoot HRUs with Yield Values Reported in the Literature.

HRU Code	HRU Cover Type	Annual SWAT Sediment Yield (tons/ac/yr)	Literature Erosion Rates (tons/ac/yr)
HAY	Pasture	1.11	0.2
RNGB	Range (brush)	3.68	0.65
RNGE	Range (grass)	11.17	0.75

To address the exaggerated loading estimates, SWAT sediment results were reduced by the fraction of total subbasin area likely to deliver sheetflow erosion to stream channels. The adjustments are described in detail in **Section 8.1.1** and in **Appendix F**. **Table 5-18** contains values for the initial annual SWAT sediment yields and the reduced yields.

Table 5-18. Initial and Adjusted SWAT Sediment Yields for Hillslope Erosion in the Lower Blackfoot TPA

Stream Segment Name	SWAT Estimated Sediment Yield (tons/yr)	Adjusted Yield (tons/yr)
Keno Creek	4	1
Upper Elk Creek	279	95
Lower Elk Creek	44	14
Belmont Creek	1,727	510
East Ashby Creek	125	34
West Ashby Creek	56	21
Camas Creek	535	155
Washoe Creek	8	2
Union Creek	822	241
Totals	3,600	1,073

The SWAT model simulation for 1996-2004 predicts a mean annual total of 3,600 tons of sediment delivered from listed stream segments in the Lower Blackfoot TPA through hillslope erosion. Adjustment resulted in an estimated annual yield of 1,073 tons per year. In general, the higher elevation subbasins with higher precipitation produced the largest loads.

5.6.2 Streambank Erosion

The field investigation completed in 2006 included direct measurement of sediment from eroding banks on representative reaches of 303(d) list streams. These reaches correspond to those given in the target departure tables described in **Section 5.5** and illustrated in **Appendix A**, **Figure A-15** for each listed stream segment. For listed streams that were not directly assessed in the field, measured values from listed streams were extrapolated to similar streams. Bank erosion for unmeasured, non-303(d) list streams was modeled based upon the relationship between measured values from unlisted streams and volume of upstream precipitation. The model output is an estimate of bank erosion from typical stream conditions and is the basis for extrapolation of loads in reaches representing average conditions given current land uses. **Appendix E** describes the model development methods and **Table E-3** provides the basis for the load estimate for each reach whether based on field measurement, extrapolation or modeled values. The following tables and discussion describe the erosion assessment results for streambanks.

Table 5-19 lists the 303(d) list streams, erosion rates, and sediment loads from upstream to downstream. Erosion rates typically increase downstream and are highest in valley bottom areas where riparian vegetation has been removed. The highest erosion rates and largest sediment loads are in reaches Union10 and Union11. These two reaches produce 2,452 tons annually. This represents 55 percent of the total streambank erosion load (i.e., 4,456 tons/yr) for all assessed streams in the planning area. Day Gulch is currently unlisted due to lack of sufficient credible data, thus the total current loading from listed stream segments is 4,456 tons/yr (4460.7 minus 4.7).

Table 5-19. Streambank erosion rates and sediment loads for lower Blackfoot 303(d) streams.

Stream	Reach	Length (ft)	Erosion Rate (tons/mile/yr)	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Keno Creek	Keno1	2,357	0.5	0.2	4.4
	Keno2	6,653	2.1	2.6	
	Keno3	2,057	2.1	0.8	
	Keno4	4,685	0.8	0.7	
Upper Elk Creek	Elk1	3,389	0.5	0.3	91.6
	Elk2	9,915	2.1	3.9	
	Elk3	8,972	18.5	31.4	
	Elk4	4,354	18.5	15.2	
	Elk5	12,618	4.3	10.4	
	Elk6	8,642	18.5	30.3	
Lower Elk Creek	Elk7	15,887	67.4	202.7	449.9
	Elk8	4,496	116.6	99.3	
	Elk9	7,241	45.8	62.8	
	Elk10	6,224	72.3	85.2	
Belmont Creek	Bel1	10,606	0.5	1.0	83.0
	Bel2	23,540	2.6	11.7	
	Bel3	16,348	12.1	37.6	
	Bel4	7,962	21.7	32.7	
Washoe Creek	Washoe1	4,579	0.5	0.4	115.3
	Washoe2	22,957	18.5	80.4	
	Washoe3	6,949	18.5	24.3	
	Washoe4	1,633	32.7	10.1	
E. Ashby Creek	EAshb1	3,778	0.5	0.4	6.5
	EAshb2	8,331	1.7	2.7	
	EAshb3	10,814	1.7	3.4	
W. Ashby Creek	WAshb1	5,946	0.5	0.6	15.7
	WAshb2	3,540	1.7	1.1	
	WAshb3	7,903	9.3	14.0	

Table 5-19. Streambank erosion rates and sediment loads for lower Blackfoot 303(d) streams.

Stream	Reach	Length (ft)	Erosion Rate (tons/mile/yr)	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Camas Creek	Cam1	5,074	0.5	0.5	468.0
	Cam2	10,577	109.7	219.7	
	Cam3	4,167	82.0	64.8	
	Cam4	9,224	54.4	95.1	
	Cam5	4,971	24.0	22.6	
	Cam6	10,357	24.0	47.1	
	Cam7	4,023	24.0	18.3	
Union Creek	Union1	27,069	38.4	196.9	3,221.3
	Union2	7,513	18.5	26.3	
	Union3	7,461	18.5	26.1	
	Union4	2,576	16.5	8.0	
	Union5	7,776	159.8	235.3	
	Union6	14,080	54.4	145.1	
	Union7	4,200	24.0	19.1	
	Union8	6,487	20.1	24.7	
	Union9	4,605	99.5	86.8	
	Union10	25,840	310.7	1520.7	
	Union11	15,821	310.7	931.1	
	Union12	4,401	1.4	1.2	
				TOTAL:	4,456

A GIS based model provided an estimate of streambank erosion for streams not on the 303(d) List. The model used the relationship between measured streambank erosion and yearly upstream precipitation (a surrogate for stream power). **Appendix E** provides more information on the modeling methods. The GIS based model predicts an additional 957 tons per year of sediment derived from streambank erosion from all un-listed streams in the lower Blackfoot River watershed.

5.6.3 Sediment from Road Crossings

Surface erosion occurs when detachable soils are exposed to overland flow or the impact of rainfall (WA Forest Practices Board, 1997). Road construction, maintenance and use can expose bare soils to these processes and result in sediment delivery to streams. In addition, roads often encroach on streams, impact habitat or shade, or create fish passage barriers. **Section 2.0** of this document lists roads as one of the probable causes of sediment or habitat impairment for several of the 303(d) List streams in the Lower Blackfoot TPA.

In summer 2005, field crews assessed sediment production from a sub-sample of road crossings in the Middle Blackfoot and Nevada Creek TMDL planning areas (RDG, 2006). This assessment followed protocols adapted from the Washington Forest Practices Board Watershed Assessment Methodology (WA Forest Practices Board, 1997). The sub-sample of crossings represented typical crossing conditions. Data from surveyed crossings was summarized by road ownership, precipitation zone, and surficial geology. Mean road erosion values were calculated for broad ownership, precipitation and surface geology categories identified by GIS analysis. **Table 5-20** lists the extrapolated means for each categorical combination of ownership, precipitation zone and geology.

Table 5-20. Means for Annual Sediment Yield from Roads by Ownership, Precipitation and Geology Categories

Ownership	Precipitation	Geology	Mean of Group (tons/yr)
BLM	≤ 26 in	Alluvium-Glacial-Volcanics	2.6
BLM	≤ 26 in	Not Alluvium-Glacial-Volcanics	0.3
BLM	> 26 in	Alluvium-Glacial-Volcanics	16.7
BLM	> 26 in	Not Alluvium-Glacial-Volcanics	2.8
FS	≤ 26 in	Alluvium-Glacial-Volcanics	2.0
FS	≤ 26 in	Not Alluvium-Glacial-Volcanics	0.5
FS	> 26 in	Alluvium-Glacial-Volcanics	0.7
FS	> 26 in	Not Alluvium-Glacial-Volcanics	2.2
PCTC-TNC	≤ 26 in	Alluvium-Glacial-Volcanics	0.6
PCTC-TNC	≤ 26 in	Not Alluvium-Glacial-Volcanics	1.6
PCTC-TNC	> 26 in	Alluvium-Glacial-Volcanics	0.4
PCTC-TNC	> 26 in	Not Alluvium-Glacial-Volcanics	0.8
Other PVT	≤ 26 in	Alluvium-Glacial-Volcanics	1.6
Other PVT	≤ 26 in	Not Alluvium-Glacial-Volcanics	0.4
Other PVT	> 26 in	Not Alluvium-Glacial-Volcanics	0.7
State	≤ 26 in	Alluvium-Glacial-Volcanics	0.8
State	≤ 26 in	Not Alluvium-Glacial-Volcanics	0.3
State	> 26 in	Alluvium-Glacial-Volcanics	0.0
State	> 26 in	Not Alluvium-Glacial-Volcanics	0.1

The principal owners of roadways in the planning area include the Bureau of Land Management (BLM), United States Forest Service (FS), combined Plum Creek Timber Company (PCTC) and Nature Conservancy (TNC) ownership, other private roads (Other PVT) and Montana (State) ownership. The precipitation categories represent simplified high (> 26 in) and low (≤ 26 in) precipitation zones; the geology categories represent more erodible alluvial, glacial and Tertiary volcanic deposits as compared to less erodible Proterozoic metamorphic or Paleozoic sedimentary rocks that are common in the planning area. These mean erosion values were extrapolated to road crossings in corresponding ownership, precipitation, and geology categories in the Lower Blackfoot TPA. **Table 5-21** provides the results of the extrapolation.

Table 5-21. Estimated Lower Blackfoot Annual Sediment Loading from Road Crossings on 303(d) Listed Streams.

Stream Segment Name	Number of Crossings	Road Sediment Loading (tons/year)
Keno Creek	15	26
Upper Elk Creek	50	54
Lower Elk Creek	71	69
Belmont Creek	202	241
East Ashby Creek	30	45
West Ashby Creek	34	48
Camas Creek	105	281
Washoe Creek	4	1
Union Creek	229	249
Total	785	1,014

PCTC conducted detailed road sediment inventories in the Ashby Creek and Belmont Creek watersheds in support of Lower Blackfoot TMDL development. These inventories used methods outlined in the Washington Watershed Analysis Methodology (Washington Department of Natural Resources 1997) with refined base erosion rates applicable to western Montana described by Sugden and Woods (2007). The Belmont inventory was conducted in 2005 and Ashby in 2006. Assuming a conservatively high base erosion rate of three tons per acre per year for Belt Supergroup soil parent material based on Sugden and Woods (2007), this analysis estimated a road sediment contribution of 5.5 tons per year to Ashby Creek and 11.9 tons per year to Belmont Creek. These estimated loads are substantially lower than those in **Table 5-20** that are based on extrapolating road sediment production from the Middle Blackfoot TMDL planning area. This difference is likely a result of the lower modeled base erosion rates, and more detailed site-specific information on road BMP condition for these watersheds in the PCTC analysis. While these may be more accurate estimates of road sediment loading in these watersheds, the extrapolation of values from the Middle Blackfoot provides a more consistent approach.

Additional sediment loading from roads is possible due to culvert failure during high flow events. A single crossing failure has the potential to increase the annual stream sediment load significantly. In addition to impacts from crossings, the 2005 RDG assessment report estimated loading from culvert failure. The estimate of sediment loading from culvert failure is described below.

5.6.4 Sediment from Culvert Failure

The estimation of sediment from roadways includes an analysis of sediment from culvert failure. Sediment at risk due to culvert failure is that saturated by ponded water at the upstream inlet of undersized culverts or from overflow of ponded water onto the road surface with subsequent erosion of the fill. Estimates of the fill volumes in the Lower Blackfoot planning area that are susceptible to culvert failure were made by extrapolation of per crossing means developed from surveyed crossings in the Middle Blackfoot TMDL planning area.

Seventy-three culverts were surveyed in the Middle Blackfoot-Nevada Creek planning area during the 2005 road sediment source assessment. The analysis associated risk of failure with a ratio of culvert width to bankfull channel width (constriction ratio) of less than one. Of the 73 survey sites, 55 had constriction ratios less than one. For the 38 sites in the Middle Blackfoot with constriction ratios less than one, 4,393 tons were estimated as being at risk; a mean value of 115.6 tons per site (RDG, 2006). This mean value was extrapolated to the 785 crossings occurring on listed stream segments in the Lower Blackfoot. The estimated amount of fill at risk in the Lower Blackfoot is 90,750 tons (115.6 tons/site times 785sites).

Annual loading was estimated assuming a one percent failure rate. Thus, the annual loading estimate equals 907 tons in the Lower Blackfoot. Lacking detailed analysis of failure rates, the one percent failure per year is an estimated point of departure for calculating the at risk loads. Adjustments to this failure rate and the resulting loads are warranted when the results of more detailed culvert failure analysis are available for the planning area. **Table 5-22** gives subtotals for watersheds of listed streams.

Table 5-22. Estimated Annual Loading from Culvert Failure on 303(d) Listed Steams in the Lower Blackfoot Planning Area

Stream Name	Number of Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)
Ashby Creek, East Fork	30	3,468	35
Ashby Creek, West Fork	34	3,930	39
Belmont Creek	202	23,351	234
Camas Creek	150	17,340	173
Upper Elk Creek	50	5780	58
Lower Elk Creek	71	8,208	82
Keno Creek	15	1734	17
Union Creek	229	26,472	265
Washoe Creek	4	462	5
Totals	785	90,745	908

The naturally occurring loading is that assumed with the replacement of failed culverts with culverts passing the 100 year discharge (Q100). This long-term strategy for culvert replacement follows the guidance from the U.S. Forest Service, Inland Native Fish Strategy (INFISH) recommendations that call for all culverts on USFS land to be able to pass the Q100 flow event. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent less than loading when failed culverts were replaced with ones of similar size.

5.6.5 Sediment Source Summary

The four process components of the sediment source assessment, hillslope, bank erosion, and road surface erosion at crossings and culvert failure, combined give the gross estimated total sediment load for the planning area. Figures for the total estimated sediment loading from sediment listed stream segments is summarized in **Table 5-23**.

Table 5-23. Sediment Loading Summary for Sediment Listed Streams in the Lower Blackfoot Planning Area

Erosion Source	Sediment Load (tons/yr)	Percent of Total
Hillslope Erosion Load	1,073	14
Bank Erosion Load	4,456	60
Road Surface Erosion Load for Crossings	1,014	14
Culvert Failure Load	908	12
Planning Area Totals	7,451	

The total for hillslope erosion is the adjusted estimate described in **Appendix F** and **Section 8.1**. The adjustment reduces the SWAT estimate to account for the portion of each subbasin that is believed to actually contribute sediment and the capacity of existing vegetation conditions to reduce sediment delivery to streams.

SECTION 6.0
METALS IMPAIRMENTS

This section discusses the metals-related water quality impairments and potential impairment sources for water bodies within the Lower Blackfoot planning area. Water quality goals for metals are discussed in general terms in **Section 2.5.2**. **Section 6.1** contains a discussion of the water quality concerns based on 303(d) listings. **Section 6.2** describes the metals target values used for judging the need for TMDLs. Sampling data departures from targets are discussed and summarized in **Sections 6.3** and **6.4**. **Section 6.5** describes the metals loading source assessment and **Section 6.6** summarizes current loading conditions.

6.1 Metals Listings

This section focuses on water bodies that are, or have been, listed as impaired due to one or more metals. **Table 6-1** presents the metals-related 303(d) listings for water bodies in the planning area from the 2006 303(d) List. The primary data sources for evaluating metals-related impairment are:

1. The Assessment record database maintained by DEQ,
2. Reassessment data collected by DEQ during 2004, and
3. High and low flow synoptic sampling completed in 2006 to support TMDL development

Table 6-1. Metals-Related 303(d) Listings for Lower Blackfoot TPA and Impairments Suggested by Post-2004 Data

Water Body Segment Name	2006 Probable Metals Impairment Cause	Metals Impairments Suggested by Recent Data
Elk Creek, Upper	Cadmium	None
Union Creek	Arsenic, Copper	Iron

6.2 Metals Targets

Since some metals have established numeric standards, those numeric criteria, as defined in Circular DEQ-7 (DEQ 2008), are adopted as the water quality targets. Numeric standards apply to both human health and aquatic life protection. The numeric aquatic life criteria for some metals are water hardness dependent and their values increase as the hardness increases. Acute and chronic aquatic life criteria (and human health) for each parameter of concern are shown in **Table 6-2** at a water hardness of 100 mg/L. Where the aquatic life numeric criteria are used as targets for hardness dependent metals, the target values will vary with hardness. The evaluation of impairment status has been conducted for varying flow conditions with their respective differences in hardness.

Table 6-2. Water Quality Targets for Metals That Are Potential Impairment Causes

Parameter	**Aquatic Life (acute) (µg/L)**[a]	**Aquatic Life (chronic) (µg/L)**[b]	**Human Health (µg/L)**[a]
Arsenic (TR)	340	150	Pre- 01/23/06 – 18 Post- 01/23/06 - 10
Cadmium	2.13 @100 mg/L hardness	0.27 @100 mg/L hardness	5
Copper	14.0 @ 100 mg/L hardness	9.33 @ 100 mg/L hardness	1300
Iron (TR)	NA	1000	300

For some metals aquatic life criteria are established for both acute and chronic conditions, with the chronic standard being more stringent (lower). The water quality standards state that the acute aquatic criteria may not be exceeded in B-1 waters at any time, although the chronic aquatic criteria may be exceeded on an instantaneous basis, the average concentration measured over any 96-hour (or longer) period may not exceed the chronic aquatic criteria. Due to a lack of sufficient data with which to determine average 96-hour metals concentrations, the available data are assumed to represent such averages until such average values are available. Both the human health standards and aquatic life standards apply to surface waters and sampling results are compared to either the chronic aquatic life standard or the human health standard, whichever is more stringent.

The human health standards listed in Circular DEQ-7 for iron are not based on specific numeric values since iron is not categorized as a toxin or carcinogen. Instead, Circular DEQ-7 states that iron concentrations “must not reach values that interfere with the uses specified in the surface and groundwater standards.” Circular DEQ-7 further states that the secondary maximum contaminant level (MCL) of 300 µ/L for iron established by EPA (based on protection of aesthetic issues such as taste, odor, staining) may be considered as guidance in determining if a certain concentration interferes with the specified uses. This secondary MCL guidance value is only applicable as an indicator of an impaired drinking water use if available data suggest that they would be consistently exceeded after conventional treatment. It is assumed that the concentrations of iron present in listed water bodies in the Lower Blackfoot TPA would be removed by conventional treatment. Therefore, for the purposes of this TMDL document, the secondary MCL guidance value of 300 µg/L for iron is not applied in evaluating impairment status. The chronic aquatic life standard of 1,000 µg/L for iron is considered applicable and is used as the metals water quality goal.

6.3 Water Quality Problem Description for Metals

Table 6-3 lists the metals analysis results for water samples collected during high and low flow sampling from sites on Union Creek and Upper Elk Creek in 2006. Bolded numeric values in the table identify water quality target exceedences. The complete list of field and laboratory analysis results from the 2006 sampling effort for both water and sediment is given in **Appendix G** with a map of the sampling locations (**Figure G-1**).

Table 6-3. Water Hardness, Flow and Metals Analysis Results (mg/L) for Union and Upper Elk Creeks During Low and High Flow Sampling Events. (Target Exceedences are in Bold.)

Water body	Sample Site	Hardness (mg/L)	Flow (cfs)	Arsenic	Cadmium	Copper	Iron
Seep Adjacent to Union Creek, High Flow	USP-1	130	0.02	**0.021**	<0.00008	0.009	**12.77**
Union Creek, High Flow	UNSW-4	134	0.47	<0.003	<0.00008	<0.001	0.24
Union Creek, High Flow	UNSW-3	109	0.21	<0.003	<0.00008	0.005	0.33
Union Creek, High Flow	UNSW-2	234	8.24	<0.003	<0.00008	<0.001	0.12
Upper Elk Creek, High Flow	ECSW-4	188	1.22	<0.003	<0.00008	<0.001	<0.05
Upper Elk Creek, High Flow	ECSW-3	166	5.47	<0.003	<0.00008	<0.001	0.16
Upper Elk Creek, High Flow	ECSW-2	149	6.68	<0.003	<0.00008	<0.001	0.12
Seep Adjacent to Union Creek, Low Flow	USP-1	139	0.02	**0.021**	<0.00008	0.004	**12**
Union Creek, Low Flow	UNSW-5	169	0.25	0.005	<0.00008	0.008	**1.2**
Union Creek, Low Flow	UNSW-4	184	0.25	<0.003	<0.00008	0.002	0.3
Union Creek, Low Flow	UNSW-3	156	0.43	<0.003	<0.00008	0.004	0.28
Union Creek, Low Flow	UNSW-2	263	3.75	<0.003	<0.00008	0.001	0.31
Upper Elk Creek, Low Flow	ECSW-4	193	2.18	<0.003	<0.00008	<0.001	<0.05
Upper Elk Creek, Low Flow	ECSW-3	199	3.45	<0.003	<0.00008	<0.001	0.16
Upper Elk Creek, Low Flow	ECSW-2	180	3.19	<0.003	<0.00008	<0.001	0.11

The water quality data suggests that the 2006 303(d) listings for arsenic and copper in Union Creek and cadmium in Upper Elk Creek be re-evaluated. The assessment record for Union Creek cites elevated arsenic and copper concentrations in benthic sediment collected near the Frog’s Diner Mine in 1994 as justification for the Union Creek listing for these metals. No cadmium or copper standards were exceeded in water samples from either segment during either the high or low flow sampling. Sediment samples collected in Union Creek, near its confluence with Washoe Creek, in 2006 contained 16.2 parts per million (ppm) copper compared to a threshold effects level of 35.7 ppm (USDOC, NOAA, 2004). Arsenic concentrations in Union Creek sediment were less than the method detection limit of five parts per million (ppm).

The human health standard of 10 µg/L for arsenic in surface water was exceeded during both high and low flow sampling events for samples collected from a ground water seep (USP-1) located near the upper most Union Creek road crossing in reach Union1. The seep is adjacent to the roadway near sampling site UNSW-4. The seep at the time of sampling did not have a visible surface discharge to Union Creek. Sampling in 2006 did not confirm that arsenic from the seep causes standards exceedences in Union Creek. Although additional arsenic monitoring in Union Creek in the area of the Frog’s Diner Mine is recommended, no arsenic TMDL is proposed for Union Creek at this time.

The assessment record for Upper Elk Creek cites a 1983 water analysis result exceeding both the acute and chronic aquatic life standards for cadmium in a sample collected upstream of the Stinkwater Creek mouth. All Upper Elk Creek cadmium concentrations in the 2006 water samples were below the method detection levels. No cadmium or copper TMDLs are proposed in this document for Upper Elk Creek.

A total recoverable iron concentration of 1,200 µg/L was measured in Union Creek during low flow conditions at site UNSW-5, located about 3,800 feet downstream from site UNSW-4 (**Appendix G**, **Figure G-1**). The chronic aquatic life standard for iron is 1000 µg/L. The roadside seep labeled as site USP-1 in **Table 6-3** had an iron concentration of 12 mg/L. Although iron is not listed as an impairment cause in the 2006 303(d) List, an iron TMDL is proposed for Union Creek.

6.4 Metals TMDL Summary

New analytical results for cadmium in upper Elk Creek and copper in Union Creek do not support TMDL development for these metals. Since arsenic was not exceeded at any Union Creek sampling site during either flow regime, an arsenic TMDL is not proposed. Analytical results indicate that an iron TMDL for Union Creek is needed. **Table 6-4** summarizes the status of metals impairments in the Lower Blackfoot planning areas and identifies those selected for TMDL development.

Table 6-4. Water Bodies and Corresponding Metals Listings in the Lower Blackfoot TPA

Stream Sedment Name	Impairment Cause/s	TMDL Developed? (Y/N)
Upper Elk Creek	Cadmium	N
Union Creek	Copper	N
Union Creek	Arsenic	N
Union Creek	Iron	Y

6.5 Metals Source Assessment

Metals source assessment activities in the Lower Blackfoot TPA consisted of a review of the available GIS layers of active and inactive mines in Union and Elk creeks to identify near stream mining sources of metals. Surface water permitting records were reviewed for discharge permits located in the planning area. There are no permitted point sources of metals to either Elk Creek or Union Creek. Synoptic stream sampling occurred in 2006 during both high and low flow events. Sediment metals were sampled from selected sites during 2006. The 2006 field assessment of channel conditions for sediment transport and temperature logger placement also allowed crews to identify visible sources of near-stream metals loading.

In addition to the discrete seep described above as site USP-1, field crews documented evidence of a second more extensive seep zone along the left bank in reach Union1 downstream of sampling site UNSW-4. The zone extends for approximately 1,000 feet along the reach in the area of the Frog's Diner Mine as illustrated schematically as the red rectangle in **Figure 6-1**.

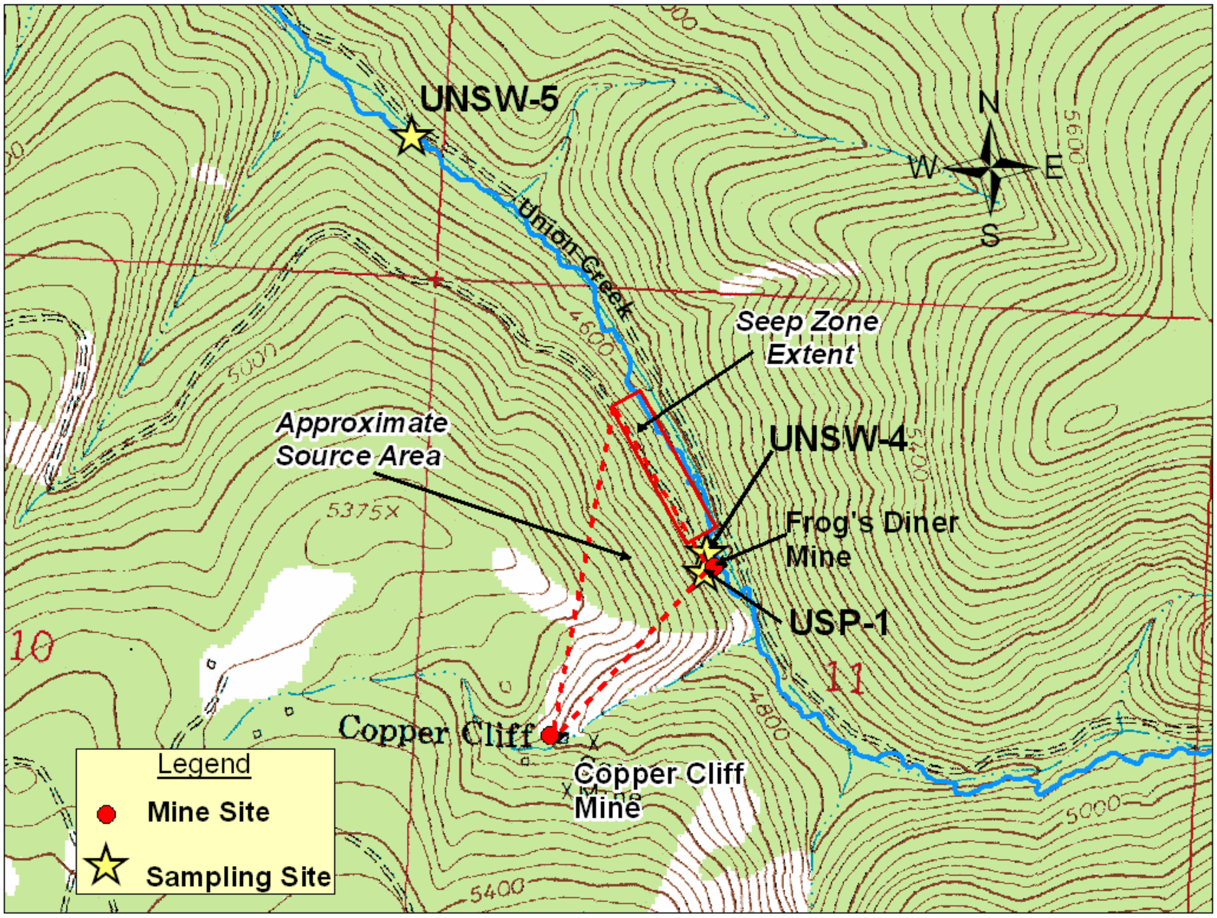


Figure 6-1. Diagram of the Seep Zone, Approximate Source Area, Sample Sites and Mine Locations in the Copper Cliff Mining District on Union Creek

The discharge from the bank line seep zone, pictured in **Figure 6-2**, is a source of dissolved iron to Union Creek.

Figure 6-2. Left bank seep in reach Union 1 in the vicinity of Frog's Diner Mine.

The assessment crew described historic mining disturbances and waste rock deposits near the stream channel in the area of the mine. Site UNSW-5, located downstream of the visible seep zone, was added during the low flow sampling to determine the effects of the seep zone on downstream water quality. Low flow sampling at this site detected the iron exceedence of 1.2 mg/L. The Copper Creek Mining District, active in the early 1900s, is located adjacent and to the west of Union Creek, directly upslope from the Frog's Diner Mine. Subsurface workings within the district are a potential source of iron loading.

In upper Elk Creek, several inactive mines occur as inclusions within the broader Coloma Mining District centered to the northwest in McGuiness Creek that drains to Lower Elk Creek. The mining camp of Reynolds City was on Upper Elk Creek near its confluence with Day Gulch. The inactive Dandy Mine is in an unnamed tributary south of Day Gulch. Elk Creek mining properties produced gold ores treated on site by amalgamation or shipped out of the drainage for smelting (DEQ 2008). Some placer mining for gold occurred in upper Elk Creek. Little mining activity has occurred in the Coloma District since 1945.

6.6 Metals Loading

An iron TMDL is proposed for Union Creek. **Table 6-5** contains the measured iron concentrations, discharge rates, and current loading rates for iron in Union Creek as well the small seep (USP-1) during high and low flow sampling events. Iron concentrations exceeding the 1.0 mg/L aquatic life standard are bolded in the table. The last column on the right contains the current iron load in pounds per day calculated from each measured concentration multiplied by the corresponding flow rate and a unit conversion factor (5.4).

Table 6-5. Iron Concentrations, Discharge, Exceedence Values (Bolded) and Current Daily Loading For Union Creek and An Adjacent Seep Discharge (USP-1) During 2006 High and Low Flow Sampling

Sample Site	Sample Date	Result (mg/L)	Discharge (cfs)	Load (lbs/Day)
UNSW-4	06/21/2006	0.24	0.47	0.61
UNSW-4	9/19/2006	0.30	0.25	0.40
USP-1	06/21/2006	**12.77**	0.02	1.38
USP-1	9/19/2006	**12.0**	0.02	1.29
UNSW-5	9/19/2006	**1.20**	0.25	1.62
UNSW-3	06/21/2006	0.33	0.21	0.37
UNSW-3	9/19/2006	0.28	0.43	0.65
UNSW-2	06/22/2006	0.17	8.24	7.56
UNSW-2	9/19/2006	0.31	3.75	6.27

Union Creek exceeded the aquatic life standard of one milligram iron per liter at site UNSW-5 during the low flow sampling. The discharge rate and the iron concentration in the seep labeled as USP-1 were similar during both high and low flow sampling. Water quality at site UNSW-4 does not appear to be affected by the discharge from USP-1. Site UNSW-4 is upstream of the more extensive left bank seep zone. The water quality standard for iron is met at site UNSW-3 approximately three miles downstream of site UNSW-5 and at site UNSW-2 about 14 miles below UNSW-5.

SECTION 7.0
TEMPERATURE IMPAIRMENTS

Fish, such as trout, need cold waters for optimum health during various life stages (Heberling, 2000). Colder water holds more dissolved oxygen; so as temperature rises, available dissolved oxygen for fish and other aquatic organisms decreases. Warm water also speeds up the growth of algae that consume dissolved oxygen, further reducing the amount available for fish. In addition, when water temperatures are above optimal levels, fish are physically stressed, their feeding habits and metabolism are affected, and they are more susceptible to fungal infections. For these reasons, temperature is a pollutant that affects the cold-water fisheries and aquatic life beneficial uses of Montana streams, and requires development of TMDLs where temperature is a cause of impairment.

The following sections describe development of temperature targets for 303(d) temperature impaired streams; examine sources of temperature impairments, and present information on the temperature impairment status of these streams. Three stream segments have been listed as impaired for temperature on 303(d) lists since 1996 in the Lower Blackfoot planning area (**Table 7-1**).

Table 7-1. Lower Blackfoot streams on the 303(d) List for temperature since 1996.

Stream Name	**Montana Water Body ID**
Blackfoot River (Monture to Belmont Creeks	MT76F001_032
Lower Elk Creek	MT76F006_032
Union Creek	MT76F006_010

Temperature loading analysis using the Stream Network Temperature Model (SNTEMP model) was conducted on the Blackfoot mainstem segment as part of temperature TMDL development in the Middle Blackfoot-Nevada Creek TPA (DTM & AGI 2006a).

7.1 Temperature Target Development and Source Assessment

The selection of temperature target parameters and appropriate values is based on a quantitative source assessment of the physical controls on stream temperature conducted as part of the bank erosion and base parameter investigation during 2006. Stream temperature data collected in the field data were assessed within the framework of a heat transport model to determine the relative contributions of target parameters to heat loading and to specify target parameter values linked to the temperature increases allowed by water quality standards for B-1 streams. Target development occurred in the following steps:

1. Collect, compile, and analyze temperature data from the field;
2. Use the temperature data to construct and calibrate a series of temperature loading models of impaired stream segments;
3. Identify the critical temperature controlling target parameters and specify their values for existing stream temperature conditions;

4. Determine numeric values for temperature controlling target parameters that represent naturally occurring conditions;

Appendix H describes the temperature modeling framework, provides maps of modeled reaches, contains model input and output tables, graphs for individual sensor data, and box plot data summary figures for listed streams. Analysis of the model output allowed an upstream to downstream assessment of temperature variability for each stream and identified the principal sources of temperature loading that serve as temperature target parameters. They include:

- Channel shade provided by riparian vegetation,
- Flow volume,
- Channel width-to-depth ratio.

In developing bank line vegetation extent as a shade parameter, background conditions along undisturbed, low gradient valley reaches was estimated as having 80 percent woody vegetation extent (**Appendix H, Figure H-1**). Within higher gradient foothill and mountain reaches, undisturbed banks exhibit 90 percent woody vegetation extent (**Appendix H, Figure H-2**). Iterative shade increases simulated within the model identified the bank line vegetation extent needed to keep human caused temperature increases to within those allowed by the standard.

Irrigation of approximately 5,345 acres in the lower Blackfoot diverts significant amounts of water from streams. Flow diversions reduce the stream capacity to absorb heat without marked temperature increases. A minimum flow augmentation of 15 percent is assumed as a naturally occurring condition for those water bodies where dewatering occurs during periods of elevated summer temperatures. Assessments of flood irrigation water delivery and application systems have demonstrated potential for greater water conservation (USDOA 1997, Anderson and Magleby 1997, Negri et al.1989). An initial flow augmentation target of 15 percent is assumed achievable in the lower Blackfoot setting.

Wide streams are inherently more susceptible to heating because more water surface is exposed to heat sources. Riparian vegetation that overhangs a narrow stream provides a higher percentage of shade than does equivalent vegetation along a wider stream. The effects of bank line vegetation extent diminish with increasing stream width. The width-to-depth ratio values selected as targets in the temperature analysis are those developed by channel type for sediment and habitat impairments (**Section 5.1**).

SNTEMP models were constructed for Lower Elk Creek and for upper and lower segments of Union Creek. Although the Union Creek temperature listing is for the entire stream, models were constructed for subreaches with similar gradient, flow, shade and channel roughness conditions. **Table 7-2** below contains the results of the SNTEMP modeling by modeled reach for current temperature conditions and simulated natural conditions **(Appendix H)**. The table lists the endpoints for mean daily and maximum daily temperatures along with the values for temperature controlling target parameters that represent the shade, flow and W:D ratio conditions that limit mid-summer temperature increases to those allowed by the standard .

Although the model output includes values for both mean daily and daily maximum temperatures, SNTEMP is less reliable for accurately assessing daily maximum temperature (Bartholow, 2004). Due to the higher uncertainty regarding simulated daily maximum temperatures, the model output for daily mean temperature is used to determine compliance with allowable increases and to quantify the values of temperature target parameters. This approach does not assume that the B-1 temperature standard applies only to mean daily temperatures or that the standard does not apply to daily maximum temperatures. The standard (See **Section 2.5.2**) does not specify a summary statistic or other value for use in determining compliance with the allowable 1.0 or 0.5 °F increases. Therefore, the standard applies to the complete range of temperatures for a given water body. In the case of the SNTEMP model, uncertainty in its predicted maximum values, acknowledged by the model developers, has prompted use of the model output for mean daily for determining the need for temperature TMDLs.

Table 7-2. Impairment Sources, Modeling Results and Targets for Temperature Impaired Streams in the Lower Blackfoot Planning Area

Stream Segment (Method)	Modeled Reach	Primacy Impairment Sources	Modeled Temperatures Mean Daily Max. Daily		B-1 Allowable Increase (°F)	Targets Reflecting Allowable Increase: a) Woody Vegetation Extent (%) b) Channel W:D Ratio c) Flow Enhancement (%)
			Current	Naturally-Occurring		
Lower Elk Creek (SNTEMP)	Cap Wallace to Rt 200	Shade Removal	71.2 79.6	66.6 72.2	0.5	a) 75 % b) B and E Channel W:D - 11-16 (Elk7, 8, 9) c) 15% (July 15th - August 15)
	Rt 200 to the Mouth	Shade Removal	71.98 77.8	67.06 74.6	0.5	a) 75% b) B Channel W:D - 11-16 (Elk10) c) 15% (July 15th - August 15)
Upper Union Creek (SNTEMP)	Headwaters to Washoe Ck	Dewatering Over-Widening	58.3 64.6	57.4 63.7	1	Current Conditions Within Allowable Increase
	Washoe Ck to Potomac Rd	Shade Removal Dewatering Over-Widening	66.4 74.9	62.9 69.6	0.5	a) 76 % b) B Channel W:D - 11-16 (Union5) c) 15% (July 15th - August 15)
Lower Union Creek (SNTEMP)	Second Hwy. 200 Crossing to Morrison Rd	Shade Removal	61.32 69.94	60.30 65.57	1	a) 35 % c) 15% (July 15th - August 15)
	Morrison Rd to the Mouth	Dewatering Shade Removal Over-Widening	73.61 85.08	70.02 83.28	0.5	a) 76 % b) B Channel W:D - 11-16 (Union5) c) 15% (July 15th - August 15)

The results indicate that temperatures within the allowable increase above naturally occurring conditions can be achieved with increases in riparian shade, increases in stream flow and decreases in channel W:D ratios.

7.2 Stream Temperature Problem Evaluation

The degree of departure between current and naturally occurring temperatures determines the magnitude of the stream temperature problem and quantifies the changes needed in temperature controlling factors such as shade. If the increase in stream temperatures under current conditions exceeds the increase above the naturally occurring temperature allowed by the standard, the temperature targets are not met and a temperature TMDL is required.

7.2.1 Elk Creek

The following SNTEMP simulations assessed the effect of riparian shade, flow augmentation, and channel form on stream temperatures:

1. Calibrated simulation of current conditions (19.9 percent bank line vegetation extent),
2. Current flow and channel form with 80 percent bank line vegetation,
3. Current vegetation and flow with target channel W:D ratio,
4. Current vegetation and channel form with 15 percent flow increase,
5. Current vegetation and channel form with 30 percent flow increase,
6. Naturally occurring conditions (80 percent bank line vegetation, 15 percent flow increase, target W:D ratios),
7. Target vegetation extent, target channel widths and 15 percent flow augmentation.

The mean daily and daily maximum temperatures for each simulation and their departures from current conditions are listed numerically in **Table 7-3** and graphed in **Figure 7-1**.

Table 7-3. Simulation results for Elk Creek at the mouth on the Blackfoot River

Model Run	Temperature (F)		Difference from Calibrated Current Condition (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	71.98	77.77	NA	NA	NA
Calibrated Temperature	71.60	81.55	NA	NA	Simulated temperature with current stream conditions
Simulation 1	67.37	74.95	-4.23	-6.60	80% Bank line Vegetation
Simulation 2	71.35	81.39	-0.25	-0.16	Target Widths Only
Simulation 3	71.28	81.19	-0.32	-0.36	15% Flow Augmentation Only
Simulation 4	70.95	80.83	-0.65	-0.72	30% Flow Augmentation Only
Natural Conditions	67.03	74.55	-4.57	-7.00	80% Bank line Vegetation Target Widths 15% Flow Augmentation
Target Conditions	67.44	75.25	-4.16	-6.30	75% Bank line Vegetation Target Widths 15% Flow Augmentation

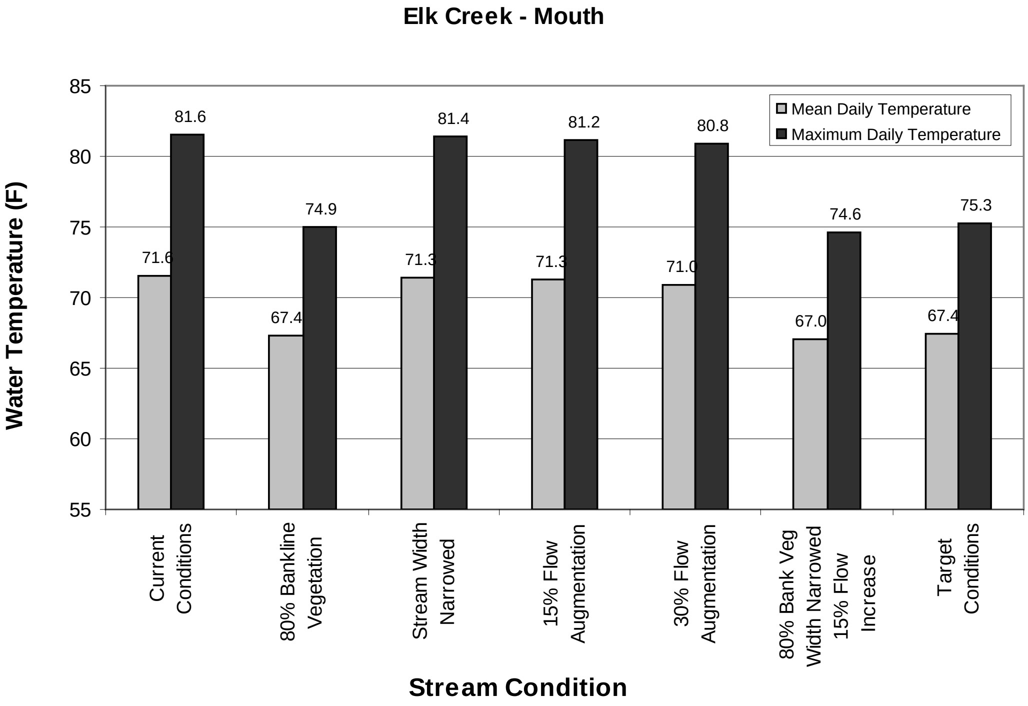


Figure 7-1. Simulated Mean and Maximum Temperature with Change in Bank line Vegetation, Flow and Stream Width for Elk Creek.

The model simulated a naturally occurring mean daily temperature of 67.03^{o} F at the Elk Creek mouth on the Blackfoot River. This is 4.57°F lower than the calibrated current conditions temperature. The magnitude of the departure between current and naturally occurring conditions indicates that current Elk Creek temperatures exceed naturally occurring temperatures by more than the allowable 0.5°F and a temperature TMDL is required.

Increasing only the woody bank line vegetation to 80 percent lowered mean temperature by 4.23° F. Target widths and target flow augmentation alone reduced mean temperature by 0.25°F and 0.32° F, respectively. Increasing woody bank line vegetation clearly has the greatest impact on reducing stream temperatures. The target simulation of 76 percent woody bank line vegetation, 15 percent flow augmentation and stream width reduction, increased the naturally occurring temperature by 0.41°F, an increase within that allowed by the B-1 standard.

7.2.2 Union Creek

Headwaters to Washoe Creek

Union Creek temperature conditions were assessed by modeling along four subreaches named in **Table 7-2**. For the reach above Washoe Creek, temperature data was collected from four Union Creek channel sites and one site on Washoe Creek above the Union Creek confluence. Graphs of the data are in **Appendix H**.

The following SNTEMP simulations assessed the effect of riparian shade, flow augmentation, and/or channel narrowing on temperatures in Union Creek above Washoe Creek:

1. Calibrated simulation of current conditions (47.2 percent bank line vegetation extent),
2. Current flow and channel form with 90 percent bank line vegetation,
3. Current vegetation and flow with target channel W:D ratio,
4. Current vegetation and channel form with 15 percent flow increase,
5. Naturally occurring conditions (80-90 percent bank line vegetation, 15 percent flow increase, target W:D ratios),
6. Target vegetation extent, target channel widths and 15 percent flow augmentation.

The mean daily and daily maximum temperatures for each simulation and their departures from current conditions are listed numerically in **Table 7-4** and graphed in **Figure 7-2**.

Table 7-4. Simulation results for upper Union Creek above Washoe Creek

Model Run	**Temperature (F)**		**Difference from Calibrated Current Condition (°F)**		**Comments**
	Mean	**Max**	**Mean**	**Max**	
Observed Temperature	57.72	63.82	NA	NA	NA
Calibrated Temperature	58.26	64.56	NA	NA	Simulated temperature with current stream conditions
Simulation 1	57.81	64.22	-0.45	-0.34	90% Bank line Vegetation
Simulation 2	58.14	64.47	-0.12	-0.09	Target Widths Only
Simulation 3	57.92	64.13	-0.34	-0.43	15% Flow Augmentation Only
Natural Conditions	57.40	63.72	-0.86	-0.84	90% Bank line Vegetation Target Widths 15% Flow Augmentation
Target Conditions	58.15	64.47	-0.11	-0.09	No Target Required: Modeled Current Conditions

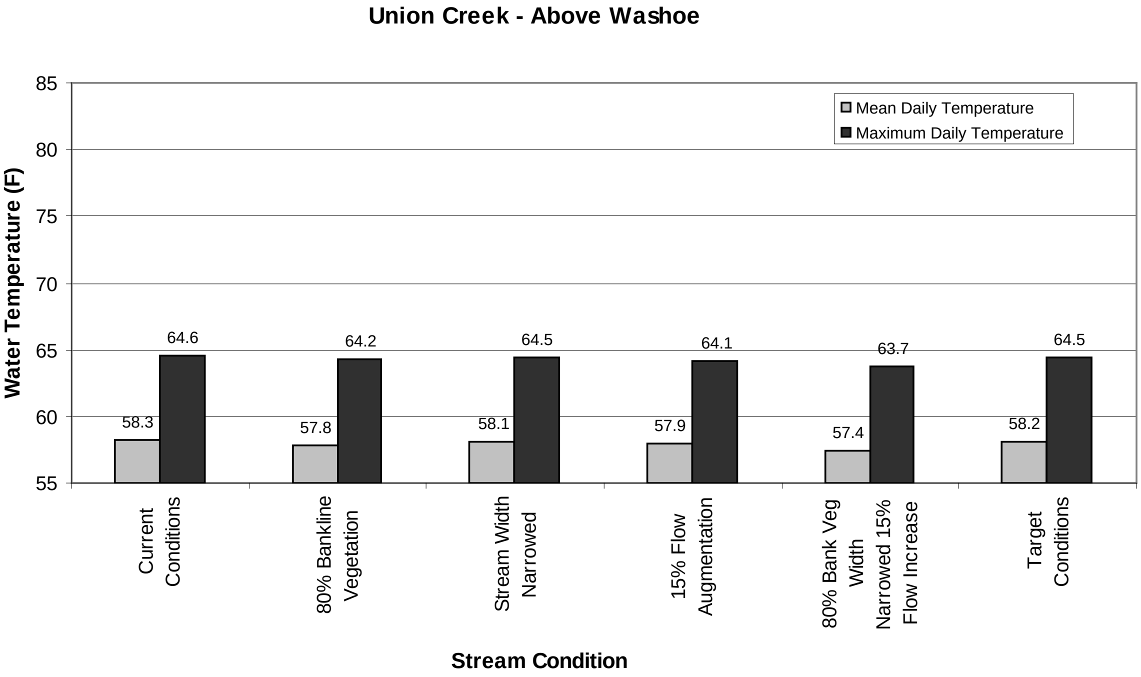


Figure 7-2. Simulated Mean and Maximum Temperature with Change in Bank line Vegetation, Flow, and Stream Width for Union Creek above Washoe Creek

The model simulated a naturally occurring mean daily temperature of 57.4°F above the Washoe Creek confluence. This value is 0.86°F lower than simulated current condition temperatures, indicating that current temperatures fall within the one-degree increase allowed by the B-1 standard for streams having a naturally occurring range of from 32°F to 66°F. Temperature conditions upstream of Washoe Creek do not reflect an impaired condition.

Washoe Creek to Potomac Road

The model simulations for this reach include:

1. A calibrated model simulation of current conditions (woody riparian vegetation extent of 47.2 percent).
2. Current flow and channel form conditions with 80 percent woody riparian vegetation,
3. Current woody riparian and flow conditions with target stream width,
4. Current woody riparian and channel form conditions with a 15 percent flow increase,
5. Naturally occurring conditions (90 percent woody bank line vegetation in upper reach; 80 percent woody bank line vegetation in valley reach)
6. Target amount of riparian vegetation, target W:D ratio and 15 percent flow augmentation

The simulations are summarized in **Table 7-5** and graphed in **Figure 7-3**.

Table 7-5. Simulation results for Union Creek, Washoe Ck to Potomac Road

Model Run	Temperature (F)		Difference from Calibrated Current Condition (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	67.01	79.68	NA	NA	NA
Calibrated Temperature	66.36	74.88	NA	NA	Simulated temperature with current stream conditions
Simulation 1	63.05	69.73	-3.31	-5.15	80% Bank line Vegetation
Simulation 2	65.34	73.31	-1.02	-1.57	Target Widths Only
Simulation 3	66.20	74.71	-0.16	-0.17	15% Flow Augmentation Only
Natural Conditions	62.94	69.64	-3.42	-5.24	80% Bank line Vegetation Target Widths 15% Flow Augmentation
Target Conditions	63.36	70.27	-3.00	-4.61	76% Bank line Vegetation Target Widths 15% Flow Augmentation

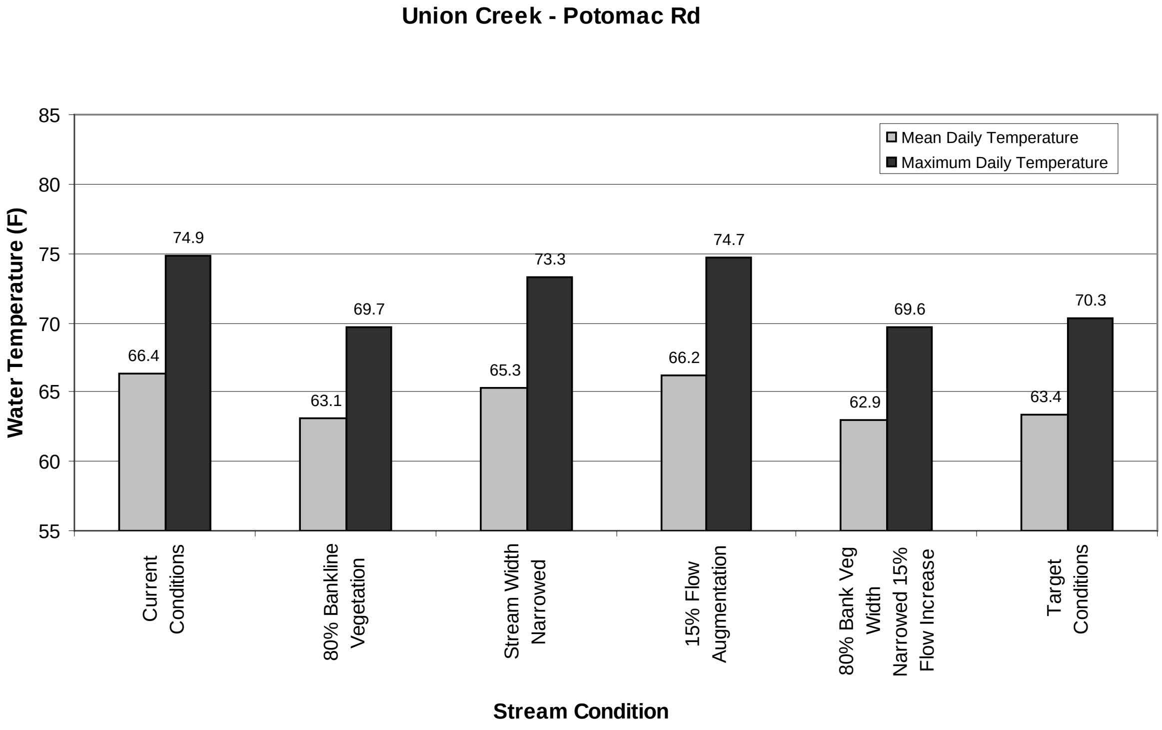


Figure 7-3. Simulated Mean and Maximum Temperature with Change in Bank line Vegetation, Flow, and Stream Width for Union Creek, Washoe Creek to Potomac Road

The model simulated a naturally occurring mean daily temperature of 62.94°F at Potomac Road. This value is 3.42°F lower than temperature simulated under current conditions and exceeds the

0.5°F allowable increase specified for streams having a naturally occurring temperature range equal to or greater than 66.5°F. A simulation increasing woody bank line vegetation to 80 percent from current conditions reduced the mean daily temperature by 3.31^{o} F. Simulations isolating the effects of meeting the W:D ratio target and the flow augmentation target showed stream temperature decreases of 1.02°F and 0.16°F respectively. Increasing woody bank line vegetation again has the greatest impact on reducing stream temperatures among the three temperature controlling target parameters. A woody bank line vegetation extent of 76 percent, along with the W:D ratio target, and the flow augmentation target, increases the naturally occurring temperature by 0.42°F, within the 0.5°F increase allowed by the standard. The magnitude of the departure between current and naturally occurring conditions indicates that Elk Creek temperatures exceed naturally occurring temperatures by more than the allowable 0.5°F and a temperature TMDL is required.

Second Highway 200 Crossing to Morrison Road

The next modeled Union Creek reach covers the channel between a private property boundary near the second Highway 200 crossing and the Morrison Road crossing. Stream temperatures were measured at four Union Creek channel sites and on a small spring located near the first node of the model. The following SNTEMP simulations assessed the effect of riparian shade, flow augmentation, and/or channel narrowing on stream temperatures in this reach:

1. A calibrated model simulation of current conditions (woody riparian vegetation extent of 25.9 percent).
2. Current flow and stream widths conditions with 80 percent woody riparian vegetation extent,
3. Current woody riparian and flow conditions with stream widths reduced to targets,
4. Current woody riparian and channel form conditions with a 15 percent increase in current flows,
5. Naturally occurring conditions (80 percent woody bank line vegetation, W:D ratio target, 15 percent flow augmentation),
6. Target riparian vegetation extent, target W:D ratio and 15 percent flow augmentation.

Table 7-6 and **Figure 7-4** show the model results for this reach.

Table 7-6. Simulation results for Union Creek from the Second Hwy. 200 Crossing to Morrison Road

Model Run	Temperature (F)		Difference from Calibrated Current Condition (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	60.78	68.36	NA	NA	NA
Calibrated Temperature	61.32	69.94	NA	NA	Simulated temperature with current stream conditions
Simulation 1	60.51	66.15	-0.81	-3.79	80% Bank line Vegetation
Simulation 2	61.32	69.89	0.00	-0.05	Target Widths Only
Simulation 3	61.02	69.21	-0.30	-0.73	15% Flow Augmentation Only
Natural Conditions	60.30	65.57	-1.02	-4.37	80% Bank line Vegetation Target Widths 15% Flow Augmentation
Target Conditions	60.80	66.61	-0.52	-3.33	35% Bank line Vegetation Target Widths 15% Flow Augmentation

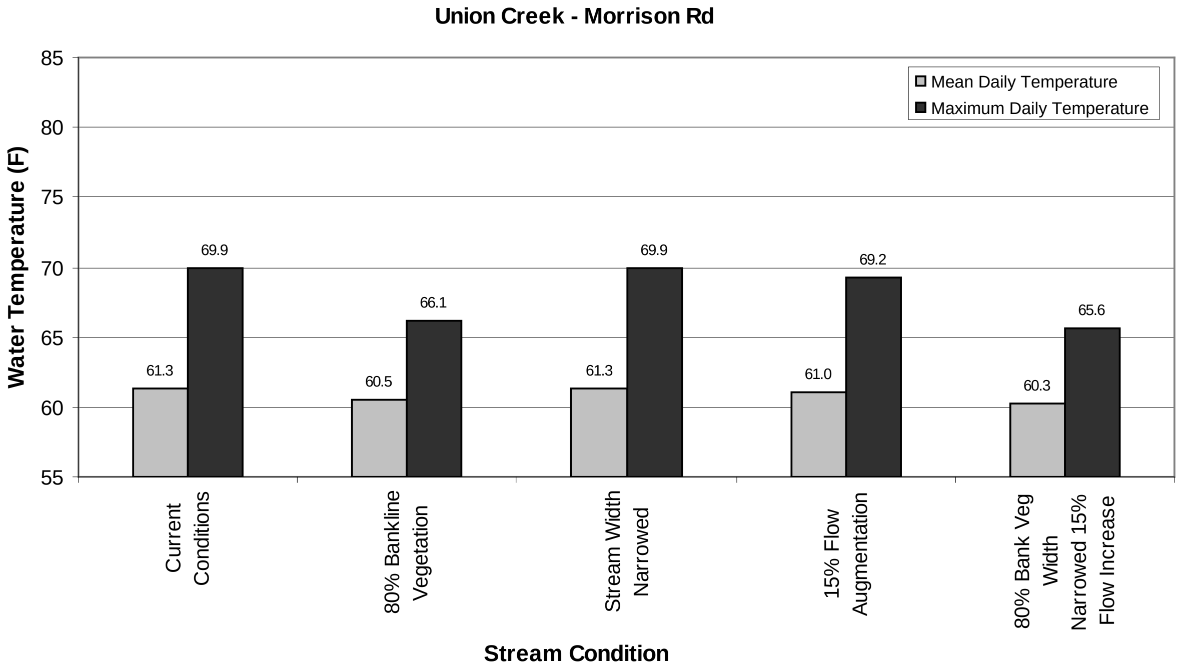


Figure 7-4. Simulated Mean and Maximum Temperature with Change in Bank line Vegetation, Flow, and Stream Width for Union Creek from the Second Hwy. 200 Crossing to Morrison Road

The model simulated a naturally occurring mean daily temperature at Morrison Road of 60.30^{o} F. The simulated current condition temperature at Morrison Road is 61.32°F, 1.02°F higher than the naturally occurring condition. Thus, this reach of Union Creek just barely exceeds the allowable increase of one degree F, indicating the need for a temperature TMDL and about a 10 percent increase in stream bank shade across the reach.

The simulation increasing woody bank line vegetation to 80 percent reduced mean temperature by 0.81° F from current conditions. Simulation of a 15 percent increase to current stream flows reduced mean temperature by only 0.30° F. Simulating only target widths did not result in any reductions in stream temperatures. Thirty-five percent woody bank line vegetation is needed, along with a 15 percent flow augmentation to reduce temperature increases to the one degree F allowed by the standard.

Morrison Road to Union Creek Mouth

The last modeled Union Creek reach covers the channel between the Morrison Road crossing and the mouth on the Blackfoot River. Stream temperatures were measured at four Union Creek channel sites and on a small spring located near the first node of the model. The following SNTEMP simulations assessed the effect of riparian shade, flow augmentation, and/or channel narrowing on stream temperatures in this reach:

1. A calibrated model simulation of current conditions (woody riparian vegetation extent of 25.9 percent).
2. Current flow and stream widths conditions with 80 percent woody riparian vegetation extent,
3. Current woody riparian and flow conditions with stream widths reduced to targets,
4. Current woody riparian and channel form conditions with a 15 percent increase in current flows,
5. Naturally occurring conditions (80 percent woody bank line vegetation, W:D ratio target, 15 percent flow augmentation),
6. Target riparian vegetation extent, target W:D ratio and 15 percent flow augmentation.

The modeling results are listed by simulation in **Table 7-7** and **Figure 7-5**).

Table 7-7. Simulation results for lower Union Creek: Morrision Road to the Blackfoot River

Model Run	Temperature (F)		Difference from Calibrated Current Condition (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	74.03	82.35	NA	NA	NA
Calibrated Temperature	73.61	85.08	NA	NA	Simulated temperature with current stream conditions
Simulation 1	70.79	83.98	-2.82	-1.10	80% Bank line Vegetation
Simulation 2	73.62	85.08	0.01	0.00	Target Widths Only
Simulation 3	73.35	84.83	-0.26	-0.25	15% Flow Augmentation Only
Natural Conditions	70.02	83.28	-3.59	-1.80	80% Bank line Vegetation Target Widths 15% Flow Augmentation
Target Conditions	70.39	83.62	-3.22	-1.46	76% Bank line Vegetation Target Widths 15% Flow Augmentation

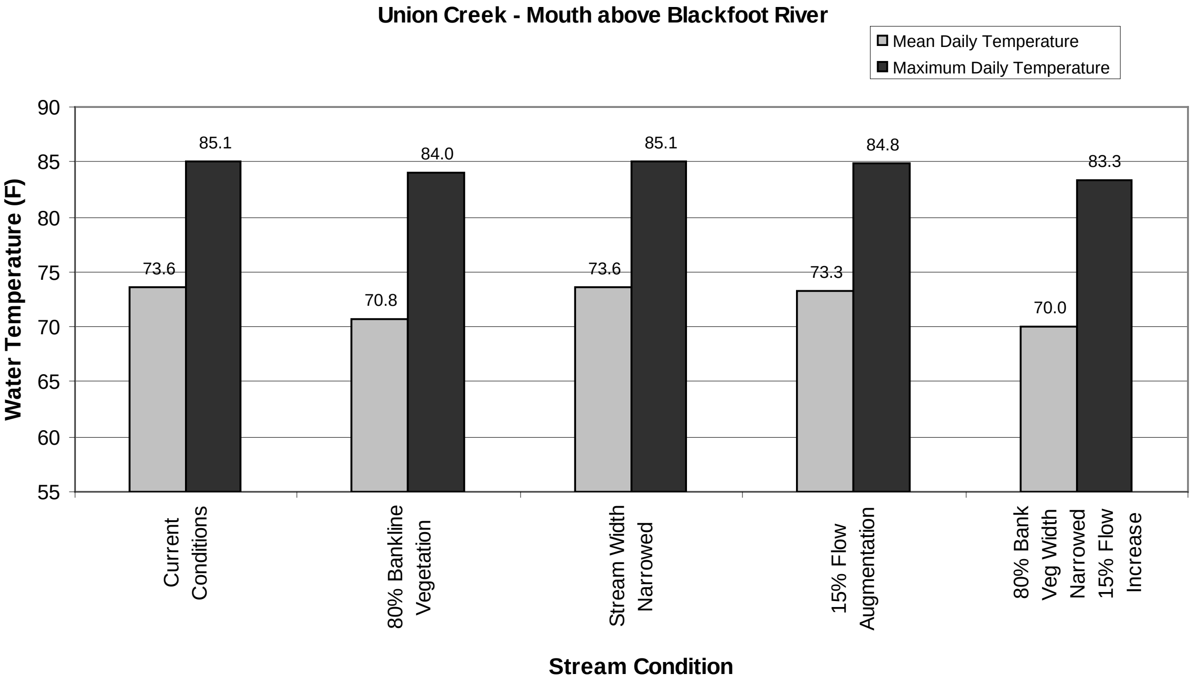


Figure 7-5. Simulated Mean and Maximum Temperature with Change in Bank line Vegetation, Flow, and Stream Width for Union Creek from Morrison Road to the Mouth.

The model simulated a naturally occurring mean daily temperature of 70.02^{o}F just above the Blackfoot River. This value is 3.59^{o} F lower than temperature simulated under current conditions. Thus, this reach of Union Creek exceeds the allowable 0.5°F increase and a temperature TMDL is needed.

A simulation that increases woody bank line vegetation to 80 percent reduced mean temperature by 2.82^{o}F. Channel width targets reduced mean temperature by only 0.01^{o}F. A simulated 15 percent increase to current flows reduced mean temperature by only 0.26^{o} F. As in other reaches, woody bank line vegetation has the greatest impact on reducing stream temperatures. Seventy-six percent bank line vegetation is needed along with a 15 percent flow augmentation and stream width reduction, where required. The simulation using these targets obtained a mean daily temperature of 70.39^{o}F, 0.37^{o}F greater than the temperature for naturally occurring conditions and falling within the 0.5°one half-degree allowable increase.

7.2.3 Blackfoot River Mainstem, Monture Creek to Belmont Creek

As explained above in **Section 7.0**, thermal loading analysis for the mainstem Blackfoot River was conducted as part of temperature TMDL development in the Middle Blackfoot planning area (DTM & AGI 2006a). **Table 7-8** contains the results for the downstream most node in the model located at the Corrick River Bend access site two river miles upstream of the Belmont Creek mouth. The SNTEMP simulations included the following:

1. A calibrated model simulation of current conditions (woody riparian vegetation extent of 63 percent).
2. Naturally occurring conditions defined as current vegetation extent along the mainstem Blackfoot River and target temperature conditions for Nevada Creek flows.

Table 7-8. Simulation results for Blackfoot River at Corrick River Bend

Model Run	Temperature (F)		Difference from Calibrated Current Condition (°F)		Comments
	Mean	Max	Mean	Max	
Observed Temperature	67.4	70.6	NA	NA	NA
Calibrated Temperature	68.6	72.9	NA	NA	Simulated temperature with current stream conditions
Natural Conditions	68.4	72.3	-0.2	-0.6	Naturally occurring temperatures in Nevada Creek

The model results indicate that with flows from Nevada Creek restored to temperature target conditions, water temperatures in the mainstem Blackfoot River are within the 0.5°F increase allowed by the B-1 temperature standard. Therefore, the model does not identify the existing temperature controlling vegetation, channel form and flow conditions along the mainstem between Monture Creek and Corrick River Bend as the source of temperature increases greater than that allowed by the standard. This result, coupled with the fact that vegetation shade increases along wide streams has minimal effect on temperature, suggests that restoration efforts to address elevated temperatures should focus on small, significantly warmed tributaries (e.g. Nevada Creek and its tributaries). Thus, a temperature TMDL is not recommended for the Blackfoot River mainstem between Monture and Belmont creeks.

As explained in **Section 7.1** above, a TMDL development conclusion based on output for mean daily temperature does not intend to ignore the importance of changes in daily maximum temperatures. Due to higher uncertainty in predicted daily maximum values, the developers of the SNTEMP tool suggest using mean daily values for interpreting the results.

7.3 Lower Blackfoot Stream Temperature Problem Summary

SNTEMP modeling of Lower Elk Creek simulated naturally occurring conditions at 80 percent woody bank line vegetation, E channel W:D ratios of 11 or less and a 15 percent increase to current streams flows. The target temperature is a maximum 0.5^{o} F increase above the naturally occurring temperatures. Comparison of naturally occurring conditions with the simulated current temperature controlling conditions (**Table 7-2**) indicates that Lower Elk Creek does not meet temperature targets and a temperature TMDL is required. Temperature modeling concluded that channel shade, as represented by the extent of woody bank line vegetation, needs to increase to 76 percent from the current 20 percent in conjunction with flow augmentation and achieving channel W:D ratio targets.

SNTEMP modeling of current Union Creek temperatures from the headwaters to Washoe Creek indicated that this reach meets temperature targets and complies with the B-1 temperature standard of a 1.0 °F allowable increase. Modeling of the stream below Washoe Creek indicated that current temperatures exceed the allowable 0.5°F increase above naturally occurring temperatures and a temperature TMDL is needed.

Union Creek temperatures increase dramatically below Morrison Road. With bank line vegetation, channel morphology and flow augmentation targets met, the temperature increase is within the 0.5°F allowed by the standard. However, elevated naturally occurring temperatures in lower Union may require additional irrigation water management BMPs to optimize conditions for salmonid fish.

SECTION 8.0
POLLUTANT LOADS AND ALLOCATIONS

This section specifies the loads and allocations for each pollutant cause addressed in the Lower Blackfoot TPA. The pollutant categories are sediment, metals, and temperature. The discussion of each major category includes the following basic components:

- Summary of the existing data or description of the computer modeling effort used to estimate loading.
- Pollutant loading quantified by either contributing process or according to a general daily loading equation.
- Allocations of allowable loads to land use sources.

The details of loading analyses may be described in appendices for the more complex loading analyses. Discussions of analytical uncertainty, margin of safety, seasonality, and adaptive management approaches for future adjustment to loading estimates are discussed at the end of each pollutant category section.

8.1 Sediment Loading

This section summarizes the current sediment load estimates from the three broad source categories of hillslope erosion, stream bank erosion, and road erosion. The details for estimating sediment loading from these sources and deriving TMDLs are described in **Appendix F** and summarized in the sections below. The sediment loads are coarse numeric estimates that may be adjusted, if necessary, through adaptive management. Until better information is available and the linkage between loading and sediment targets and use support becomes clearer, the loading estimates presented here are intended as initial points of departure.

8.1.1 Hillslope Erosion Loading Estimates and Adjustments

Sediment loading from hillslope erosion was estimated through the use of the SWAT model. **Appendix D** describes the model construction and calibration for the Blackfoot River watershed. As mentioned in **Section 5.6.1**, the SWAT output estimates of hillslope erosion required adjustments to reduce the exaggerated loading estimates caused by the model's coarse slope scale. The adjustments provide a more realistic estimate of sheetflow erosion to stream channels.

The reduction adjustment, the partitioning of loads into naturally occurring and controllable components, and the means to account for current sediment filtering conditions are further explained in **Appendix F** and summarized in the three elements below:

1. **Sheetflow Area Fraction Adjustment:** Based on literature, DEQ determined that the potential sediment delivery by sheetflow erosion occurs within 350 feet of a streambank on slopes greater than three percent. This area is the assumed source of hillslope erosion. Its numeric fraction of the entire subbasin area is the Sheetflow Area Fraction in **Appendix F, Table F-1**. Multiplied by the Initial SWAT Sediment Load Estimate, the

product is the Adjusted Sheetflow Area Load. Field and aerial photo reconnaissance of the land types suggested no need to refine C-factor values beyond those assigned globally in SWAT; therefore, SWAT's default C-factors for land types were assumed to be valid for the planning area. The factor controlling hillslope sediment delivery was assumed to be vegetative cover conditions next to the channels.

2. **Controllable Load Vs. Naturally Occurring Load:** Based on literature, healthy vegetative stream buffers are assumed to reduce the Adjusted Sheetflow Area Load by 75 percent (Castelle and Johnson 2000, Hook 2003). This is the assumed loading from developed land, where all reasonable land soil and water conservation practices are applied. This potential load reduction is called Controllable Load, while the remaining 25 percent is defined as the Naturally Occurring Load (see **Appendix F, Table F-1)**. It is assumed that the naturally occurring load will always reach the stream.

3. **Current Sediment Filtering Efficiency:** The existing condition of streambank vegetation within each subbasin was evaluated to determine the vegetation's ability to reduce the controllable sediment load. In areas with minimal human influence, only naturally occurring loads were assumed to reach the stream. The filtering efficiency of existing riparian vegetation was estimated in areas where human activities are negatively affecting riparian vegetation. Sediment removal efficiency values were multiplied by the controllable sediment load to quantify additional needed reductions in controllable loading.

Table 8-1 summarizes the results of the hillslope erosion assessment for listed portions of the Lower Blackfoot planning area after the above adjustment, partitioning and accounting for existing filtering conditions.

Table 8-1. Summary of Estimated Current, Controllable, Naturally Occurring, Needed Reduction and Percent Reduction in Hillslope Erosion Loading from (303(d) Listed Streams in the Lower Blackfoot Planning Area

Current Load (tons/yr)	**Controllable Load (tons/yr)**	**Naturally Occurring Load (tons/yr)**	**Needed Reduction (tons/yr)**	**Percent Reduction Needed in Controllable Load**
1,073	805	268	194	24

8.1.2 Stream bank Erosion Loading

The base parameter and stream bank erosion inventory project completed in 2006 included direct measurement of sediment from eroding banks on representative reaches of 303(d) listed streams. **Appendix E** of this document describes the assessment methodology and **Appendix F, Tables F-3 and F-4** give the estimates of total stream bank erosion by assessment reach and listed segment. **Appendix A, Figure A-15** illustrates the reach locations.

Table 8-2 below gives values for current segment loads, controllable segment loads, and naturally occurring segment load for each listed stream segment. The table concludes with totals for each of these categories in the Lower Blackfoot TPA.

Table 8-2. Stream Bank Erosion Inventory Results for Lower Blackfoot River TPA

Stream Name	Current Segment Load (tons/yr)	Background Segment Load (tons/yr)	Human-caused Segment Load (tons/yr)
Ashby Creek, East	6.5	4.1	2.4
Ashby Creek, West	15.7	11.1	4.5
Belmont Creek	83	59.9	23.1
Keno Creek	4.4	3.2	2.1
Elk Creek, Upper	91.6	59.4	32.3
Elk Creek, Lower	449.9	310.2	139.8
Washoe Creek	115.3	79.6	35.7
Camas Creek	468	333.5	134.5
Union Creek	3,221.3	2,268.8	952.5
Lower BlackfootTotals	4,456	3,129.7	1,326

8.1.3 Road Crossing Sediment Loading

The road sediment loading values in **Table 5-20** for the Lower Blackfoot planning area are brought forward in the second column of **Table 8-3** below as the estimated current sediment load from 785 road crossings. The amount of controllable sediment loading from road crossings was determined by assuming an achievable 30 percent reduction in loading with implementation of best management practices that minimize road erosion. The 30 percent reduction is based on Forest Service and Plum Creek Timber Company (PCTC) analyses on roads under their control after full BMP implementation (DEQ et al., 2004). Other road managers are assumed to have similar capabilities for sediment reductions via BMP applications. Where current roadway BMP implementation is extensive and properly maintained, a 30 percent reduction is probably not achievable. With the assumed 30 percent reduction, the controllable total in **Table 8-3**, equates to 304 fewer tons/year from the road system. These estimates indicate that the Camas Creek, Union Creek and Belmont Creek watersheds are the largest sources of road sediment.

Table 8-3. Road Crossing Sediment Loading and Controllable Reductions by Listed Stream Segment in the Nevada Creek Planning Area

Stream Name	Current Road Sediment Load (tons/yr)	Controllable Road Sediment Load (tons/yr)	Segment Loading with BMP Application (tons/yr)
Ashby Creek, East	45	14	31
Ashby Creek, West	48	14	34
Belmont Creek	241	72	169
Keno Creek	26	8	18
Elk Creek, Upper	53	16	37
Elk Creek, Lower	69	21	48
Washoe Creek	1	0.4	1
Camas Creek	281	84	197
Union Creek	249	75	174
Totals	1,014	304	710

8.1.4 Sediment from Culvert Failure

The estimation of sediment from roadways includes an analysis of sediment from culvert failure. Sediment at risk due to culvert failure is that saturated by ponded water at the upstream inlet of undersized culverts or from overflow of ponded water onto the road surface with subsequent erosion of the fill. Estimates of the fill volumes in the Lower Blackfoot planning area that are susceptible to culvert failure were extrapolated from per crossing means developed from surveyed crossings in the Middle Blackfoot TMDL planning area. The estimated loads are given per listed stream in **Appendix F**, **Table F-5**.

Seventy-three culverts were surveyed in the Middle Blackfoot-Nevada Creek planning area during a road sediment source assessment in 2005 (RDG, 2006). The analysis associated risk of failure with a ratio of culvert width to bankfull channel width (constriction ratio) of less than one. Of the 73 survey sites, 55 had constriction ratios less than 1. The survey of 38 sites in the Middle Blackfoot TPA estimated that 4,393 tons were at risk from culvert failure, giving a per site mean of 115.6 tons per site. This mean was extrapolated to 785 crossing in the lower Blackfoot giving a total of 90,745 tons at risk from culvert failure. Annual loading was estimated assuming a one percent failure rate in each planning area. Thus, annual loading equals 908 tons per year in the lower Blackfoot.

The naturally occurring portion of the total load is that assumed with the replacement of failed culverts with culverts passing the 100 year discharge (Q100). This long-term strategy for culvert replacement follows the guidance from the U.S. Forest Service, Inland Native Fish Strategy (INFISH) recommendations that call for all culverts on USFS land to be able to pass the Q100 flow event. Estimates of the load reduction with this culvert replacement scenario in other Montana TMDL planning areas are described in **Appendix F**. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent less than loading when failed culverts were replaced with ones of similar size.

The totals for the lower Blackfoot are given in **Table 8-4**. Lacking detailed analysis of failure rates, the one percent failure per year is an estimated point of departure for the purpose of calculating the at risk loads. Adjustments to this failure rate and the resulting loads are warranted when the results of more detailed culvert failure analysis are available for the planning area.

Table 8-4. Annual Loading from Culvert Failure on 303(d) Listed Streams for the Lower Blackfoot Planning Area

Stream Name	Total Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)	Controllable Load (tons/year)	Naturally Occurring Load (tons/yr)
Ashby Creek, East Fork	30	3,468	35	27	8
Ashby Creek, West Fork	34	3,930	39	30	9

Table 8-4. Annual Loading from Culvert Failure on 303(d) Listed Streams for the Lower Blackfoot Planning Area

Stream Name	Total Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)	Controllable Load (tons/year)	Naturally Occurring Load (tons/yr)
Belmont Creek	202	23,351	234	180	54
Camas Creek	150	17,340	173	133	40
Upper Elk Creek	50	5,780	58	45	13
Lower Elk Creek	71	8,208	82	63	19
Keno Creek	15	1734	17	13	4
Union Creek	229	26,472	265	204	61
Washoe Creek	4	462	5	4	1
Total	785	90,745	908	698	210

8.1.5 Sediment Loading Summary

Figure 8-1 summarizes the existing sediment loading in the Lower Blackfoot planning area from hillslope erosion, stream bank erosion, road surface erosion and culvert failure. Total loading to listed stream segments from the combined processes is estimated at 7,451 tons per year.

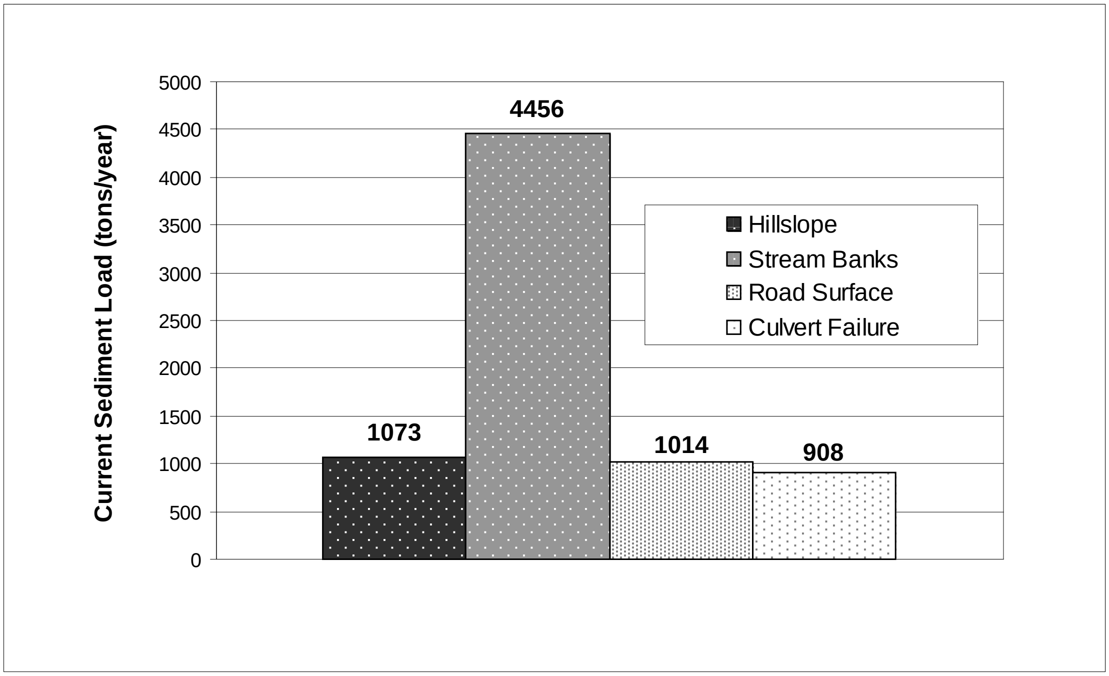


Figure 8-1. Annual Sediment Loading To Listed Streams From Process Sources in the Lower Blackfoot Planning Area

8.1.6 Sediment TMDLs

Based on the source assessment results, sediment TMDLs and allocations were developed for the listed stream segments. A TMDL is defined as the sum of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, plus a margin of safety (MOS). The MOS compensates for uncertainty in the load estimates and linkage between pollutant loads and use support. The following equation expresses the TMDL:

$$\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$$

Since there are no point sources in the planning area, the TMDLs do not include WLAs. The TMDLs are expressed as needed reductions in current sediment loading from controllable sources,plus naturally occurring sources. This approach acknowledges the uncertainty in the numeric estimates while providing useful direction for restoration efforts. The reductions are developed from literature, agency and industry documentation of BMP effectiveness, field evaluation and interpretation of aerial imagery and other geographic information. The sediment TMDLs include an implicit margin of safety described in **Section 8.1.8**.

The TMDLs are given by listed stream in **Table 8-5** both as annual load reduction percentages and estimates of those reductions in tons per year. The current loading and reductions for the Lower Blackfoot planning area are illustrated in **Figures 8-2**. **Appendix F** describes how the annual reductions for each sediment-generating process were estimated and integrated into an annual maximum and allocated to land uses.

Table 8-5. Current Sediment Loading, and Sediment TMDLs Expressed as Annual and Percent Reductions to Current Loading to Sediment Impaired Streams in the Lower Blackfoot Planning Area

Stream Name	Current Load (tons/yr)	Needed Load Reduction (tons/yr)	Percent Reduction in Current Annual Load
Ashby Creek, East	121	54	45
Ashby Creek, West	124	52	42
Belmont Creek	1068	316	30
Keno Creek	48	22	46
Elk Creek, Upper	298	96	32
Elk Creek, Lower	615	182	30
Washoe Creek	124	15	13
Camas Creek	1077	357	33
Union Creek	3976	1005	25
Total	7451	2099	Mean Percent Reduction - 28

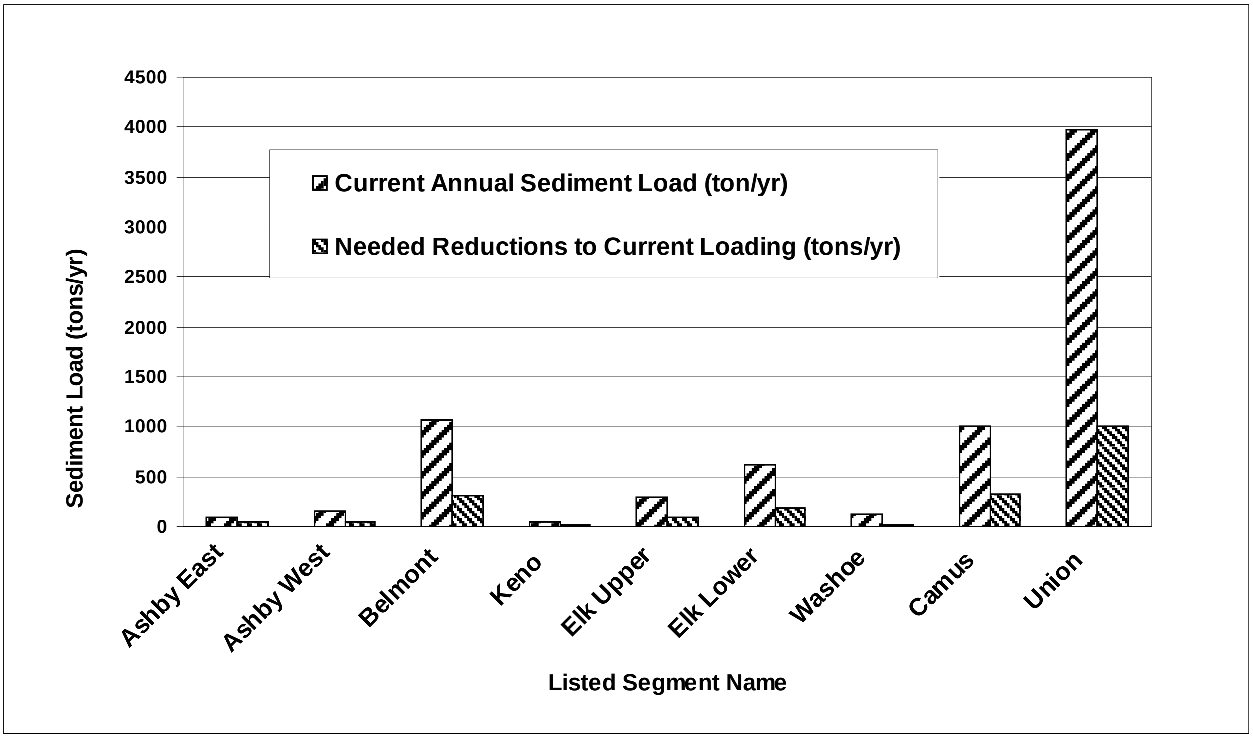


Figure 8-2. Current Sediment Loading and Needed Reductions in the Lower Blackfoot TPA by Listed Segment

Load reductions in the Lower Blackfoot TPA range from 13 percent to 46 percent of current sediment loading. Union Creek is the most significant sediment source, due mostly to stream bank loading in its lower reaches (**Table 5-18**). Low loading values for Keno and Washoe creeks reflect the lower human influence and inherent higher stability of headwaters segments.

Their comparison with Union Creek in the figure minimizes the degree to which the values for streams such as the Ashby forks, Keno Creek and Washoe Creek register on the graph.

8.1.7 Sediment Allocations

The annual loading reductions are allocated to land uses within the watersheds of impaired streams. They are expressed as a percentage of the needed annual reduction for the listed water body and converted to annual reductions in tons per year by land use source category in **Table 8-6** for the Lower Blackfoot planning Area. Details on how sediment allocations were developed are discussed in **Appendix F**.

Table 8-6. Lower Blackfoot River Sediment Loading Reduction Allocations by Contributing Land Use

Stream Name	Annual Load Reduction (tons/year)	Allocations by Land Use (tons/year)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Roads	Rural Residential
Ashby East	54	12		1		41	
Ashby West	52	4		3		44	1
Belmont	316	43	1	20		252	
Keno	22			1		21	
Upper Elk	96	1		23	11	61	
Lower Elk	182	23	60	2	12	84	1
Washoe	15	2	2	3		4	4
Camas	357	39	65	16		217	20
Union	1005	89	515	40		279	82
Totals	2,099	213	643	109	23	1003	108

Annual hillslope allocations to land uses are based upon their proportional extent within the stream buffer area assumed as the hillslope source of sediment to stream channels. Values were determined for each stream assessment reach during the 2006 field assessment and verified through interpretation of aerial imagery of 2005 conditions. The tabulated data for each listed segment is given in **Appendix F**, **Table F-6**

Similar to the hillslope allocations, those for stream bank erosion were allocated according to the percentage of the total stream bank length exhibiting a specific land use as identified during the 2006 field assessment. These percentages are given in **Appendix F**, **Table F-7**. The reduction allocations for roads are the sum of those for road surface erosion and culvert failure possible with BMP implementation. **Figure 8-3** summarizes the total sediment load reduction allocations by contributing land use category for the Lower Blackfoot planning area.

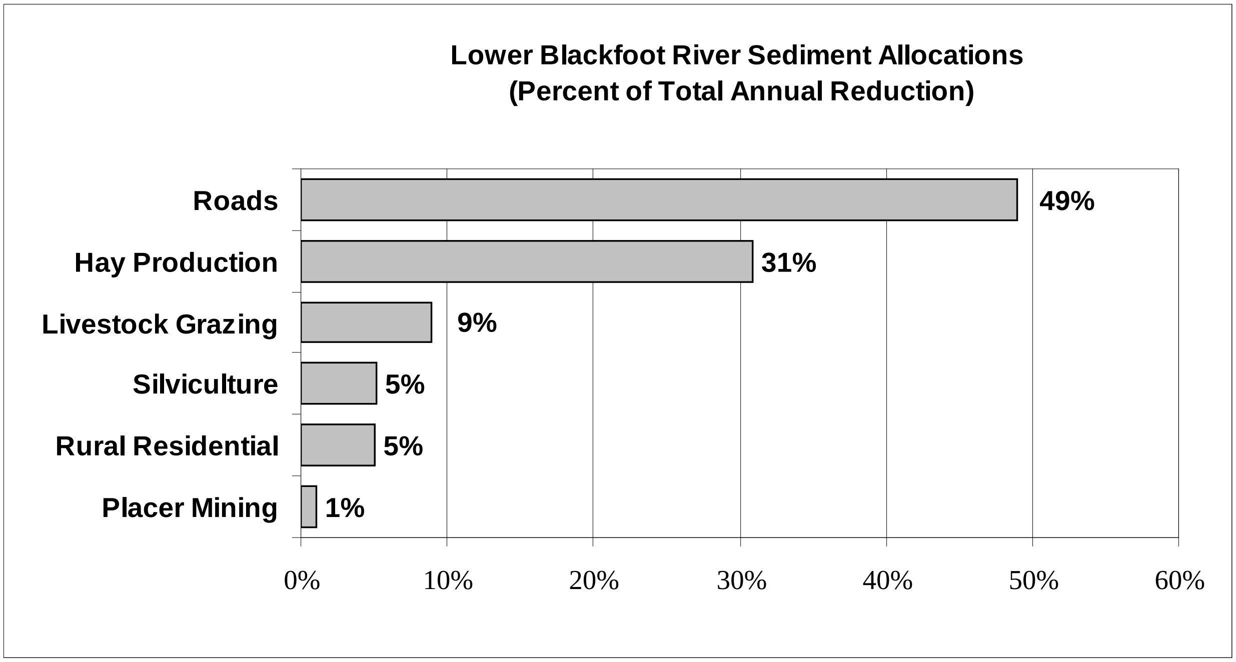


Figure 8-3. Sediment Load Allocations as a Percent of the Total Reduction by Contributing Land Use Category for the Lower Blackfoot Planning Area

The figure shows the predominant role of road erosion in sediment production. After roads, hay production and livestock grazing account for the largest reduction allocations. Silvicultural and rural residential development activities have nearly equal contributions, with a minor contribution from placer mining.

8.1.8 Daily Loads and Allocations

A nine-year period from January 1996 through December 2004 was selected for simulating water quantity and quality conditions in the Blackfoot watershed using SWAT (**Appendix D**). To calculate daily loads, the estimated mean annual sediment load and reductions were multiplied by the fraction of the SWAT generated annual sediment yield delivered during each calendar day. The model produced output files containing mean daily values for stream discharge and sediment loading (reach files) calculated for the modeling period. The annual load estimates and reductions are distributed daily according to SWAT simulations of daily loading. This approach assumes that the daily distribution of loading from all sources is equal to that in the stream reach simulations documented in the reach files for hillslope erosion. An example calculation is described below for Belmont Creek.

Belmont Creek has a total annual sediment load estimate of 1,068 tons per year (**Table 8-5**). The Belmont Creek reach file from the SWAT hillslope analysis contains estimates of mean daily sediment loads. These data were used to calculate a daily loading fraction by dividing SWAT mean daily load by the annual total. Current mean sediment daily loading in Belmont Creek is the annual total of 1,068 tons times the daily fraction for each of 365 days. The allowable annual load of 751 tons (1,068 - 317 = 751) multiplied by the daily fraction gives an allowable daily load that represents the sediment TMDL. **Figure 8-4** illustrates the current daily loading and the allowable daily sediment loading remaining after a 30 percent reduction in Belmont Creek. The time period in the graph is centered on the runoff period to better illustrate the difference between current sediment loading and the TMDL.

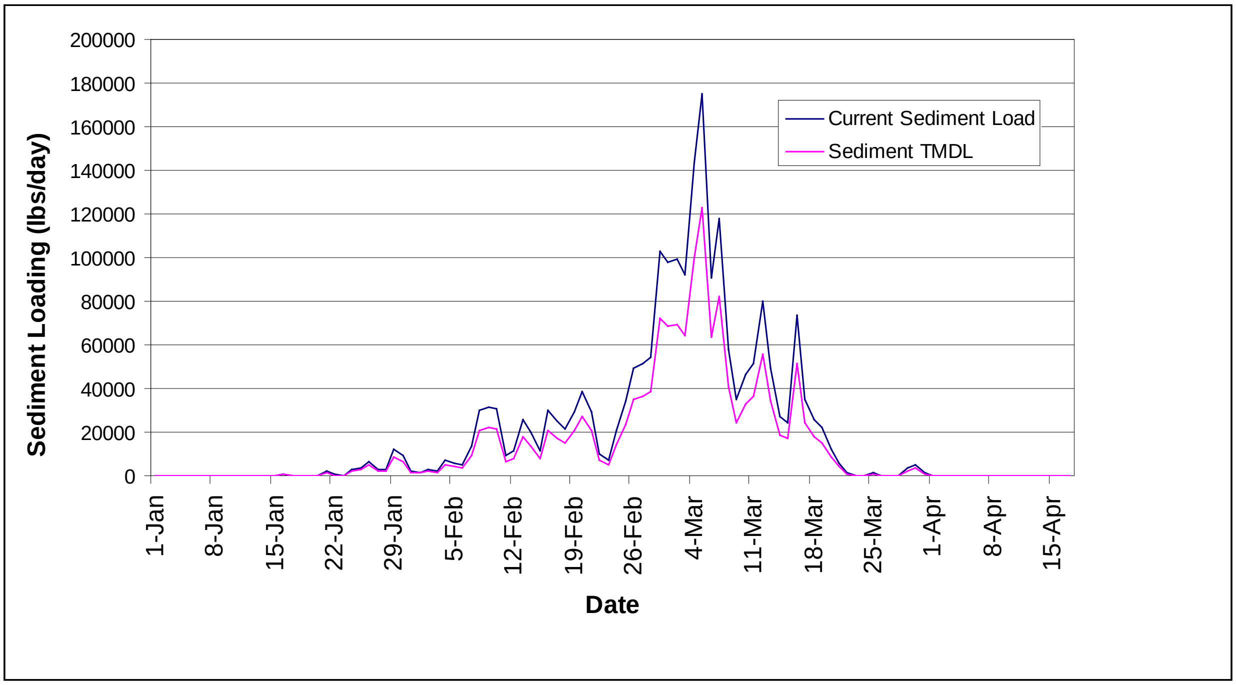


Figure 8-4. Current and Maximum Daily Sediment Loading for Belmont Creek

The large annual variability in loading due to the runoff masks the low flow load reductions. Although a logarithmic scale applied to the Y-axis in the figure would better illustrate low flow reductions, the current scale better characterizes high flow loading when actual load reductions are more achievable and would have the greatest benefit.

The daily load reductions calculated for Belmont Creek are allocated to the corresponding land use categories identified for this segment in **Table 8-6**. The daily loads allocated to these land uses are presented in **Table K-1** of **Appendix K** and illustrated in **Figure 8-5.**

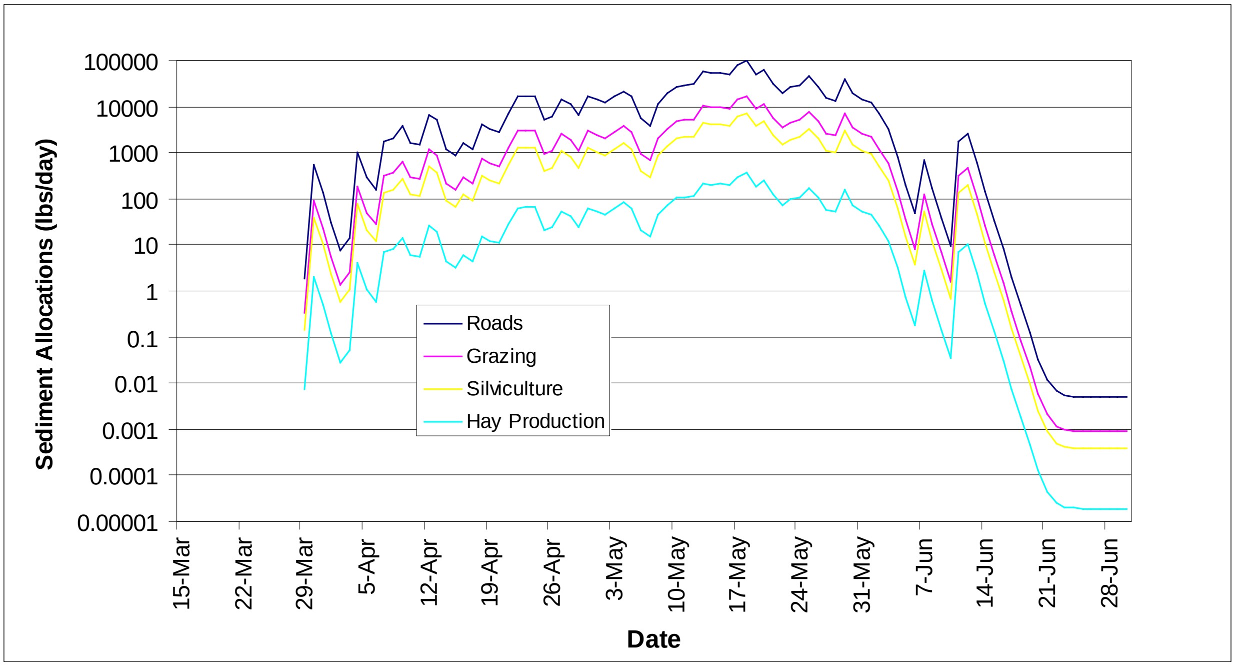


Figure 8-5. Daily Sediment Load Allocations for Belmont Creek

Table E-1 and **Figure 8-5** serve as an example of daily loads allocated to land uses. The use of the table for Belmont Creek serves as an example of the daily allocations by the process described above. An example is used in the interest of reducing the cost of tabulating and illustrating all daily data for the planning area. Example TMDLs and allocations for the remaining eight sediment impaired stream segments are tabulated in **Appendix K, Table K-2** for three separate days of the calendar year that represent: (1) mid-winter base flow loading, (2) peak runoff loading, and (3) mid-summer loading.

8.1.9 Margin of Safety and Seasonality for Sediment TMDLs

The modification of the gross hillslope loading estimates from SWAT to reflect conceivable contributing area introduces uncertainty in the hillslope loading estimates. The land cover database and management files describing sediment contributing Hydrologic Response Units (HRUs) in the SWAT model did not reflect the effects of forest fires on sediment delivery. Future revisions to the model will need to incorporate information on fire timing, duration, extent, and rate of ground cover recovery to provide more realistic sediment yield estimates for forested areas.

Uncertainty exists in the loading estimates from each of the three principal sediment generating processes of hillslopes, stream banks and road erosion. The degree of uncertainty may, in some cases, result in prescribed load reductions that would be difficult to realistically achieve where recent road improvements have been substantial and future adjustments may be warranted. The assumption of a one percent annual culvert failure rate adds significant sediment loading from roads due to the large number of forest road crossings in the lower Blackfoot. Anecdotal accounts of culvert failure frequency suggest a much lower rate of failure, thus the culvert failure analysis in this document likely results in a significant margin of safety for sediment loading.

The implicit margin of safety for sediment TMDLs has several other sources. The first is in the estimated size of the sediment contributing area used in the hillslope analysis for each stream. The slope length across which sheetflow erosion occurs is 350 feet (**Section 8.1.1**) perpendicular to the direction of channel flow. Values in the literature for this distance are quite variable, ranging from 100 feet to 400 feet. A length of 350 is conservatively high in cases where slopes adjacent to channels are nearly level. The uniform use of the 350-foot length made estimates of contributing area larger and its proportion of the entire subbasin area larger. The ratio of contributing area to total subbasin area was used to reduce the gross loading estimates generated by SWAT for hillslope erosion.

Recent research in erosion rates from forest roads in western Montana (Sugden and Woods, 2007) has concluded that base erosion rates may be an order of magnitude less than the 10 tons per acre per year assumed for this road sediment loading analysis. If the research accurately characterizes forest road erosion, an additional implicit margin of safety exists in the calculations based on the base erosion rate of 10 tons per acre.

A more generally applicable margin of safety for the sediment TMDL is its further evaluation though the adaptive management process. Several specific goals for adaptive management of sediment loading include:

- Continued refinement or redevelopment of a predictive sediment loading model with improved subbasin slope resolution, improved landcover characterization, and more accurate flow characterization.
- Monitoring of both suspended and bedload sediment transport and their relation to values for fine sediment and channel habitat targets.
- Further refinement of land use effects on hillslope and bank erosion.
- Refinement of bank retreat rates on which streambank erosion rates are based.
- Refinement of culvert failure analysis for forest roads based on an adequate length of record for a variety of culvert replacement scenarios.

The adaptive management process is an implicit margin of safety that keeps erosion control issues in focus toward finding workable solutions that protect beneficial uses.

Seasonality in the sediment TMDL is applied through the use of daily loading fractions of total annual loading contained in the SWAT generated sediment routing (reach) files for each stream segment. Use of the daily fractions distributed the total sediment load estimate over 365 days according to sediment transport capacity that varies with daily flow.

8.2 Metals TMDLs and Allocations

An iron TMDL is proposed for Union Creek. The numeric value of 1.0 mg/L is the chronic aquatic criterion for iron. Where numeric criteria are established they serve as concentration targets and TMDLs are calculated by multiplying the flow rate by the numeric target and a unit conversion factor according to **Equation 1**.

Equation 1. **TMDL = (X mg/L)(Y ft3/sec)(5.4) = (X)(Y)(5.4) lbs/day**

where:
X = the applicable numeric water quality criterion or target in mg/L,
Y = the stream flow in cubic feet per second,
5.4 = the unit conversion factor.

The upper bound on daily loading that defines the TMDL for iron is the product of flow times the numeric standard and the unit conversion factor.

8.2.1 Union Creek Iron TMDL

Water samples from Union Creek were collected during high flow on June 21 and low flow on September 19, 2006. **Table 8-7** lists the analysis results for total recoverable iron, measured flows, current iron loads for each sampling event, and the corresponding iron TMDLs calculated according to Equation 1 above for each sample site. Note that the TMDL for any specific day is equal to the stream discharge in cubic feet per second multiplied by the numeric standard of 1.0 mg/L iron and the appropriate unit conversion factor. Future TMDLs calculated from flow conditions will necessarily differ from those in **Table 8-7** due to flow differences.

Table 8-7. Measured Iron Concentrations, Discharge and Corresponding TMDLs for Union Creek Sampling Sites during High and Low Flow Sampling Dates. (Target and TMDL exceedences are in bold.)

Sample Site	Sample Date	Iron Concentration (mg/L)	Discharge (cfs)	Load (lbs/day)	Iron TMDL (lbs/day)
UNSW-4	6/21/2006	0.24	0.47	0.61	2.54
UNSW-4	9/19/2006	0.3	0.25	0.40	1.35
USP-1	6/21/2006	**12.77**	0.02	**1.38**	0.11
USP-1	9/19/2006	**12**	0.02	**1.29**	0.11
UNSW-5	9/19/2006	**1.2**	0.25	**1.62**	1.35
UNSW-3	6/21/2006	0.33	0.21	0.37	1.13
UNSW-3	9/19/2006	0.28	0.43	0.65	2.32
UNSW-2	9/19/2006	0.31	3.75	6.27	20.23
UNSW-2	6/22/2006	0.17	8.24	7.56	44.45

Figure 8-6 illustrates the line graph of the TMDL relative to the measured loads calculated from the 2006 analysis results for Union Creek.

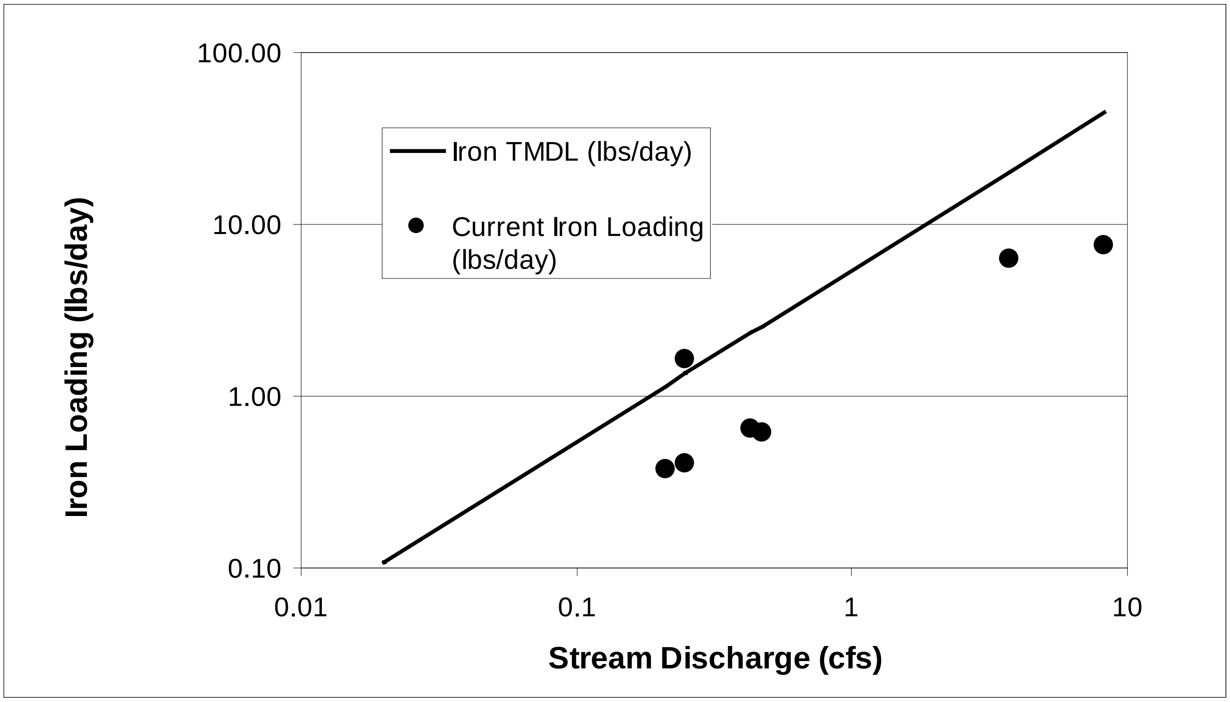


Figure 8-6. The Graph of the Union Creek Iron TMDL with Current Loads Calculated from 2006 Analysis Results

Iron loading at UNSW-5 exceeds the TMDL in Union Creek. Site UNSW-5 is about 3,000 feet downstream of the bank line seep zone that extends for about 1,000 feet below UNSW-4 (**Figure 6-1)**. Site UNSW-4 is the upstream-most sampling site and represents the background iron loading condition. Site USP-1 is a ground water seep that surfaces within the prism of an access road along the left bank of the stream and reenters the road fill a short distance downslope without clear evidence of a direct discharge to Union Creek. Sites UNSW-3 and UNSW-2 are located several miles downstream of UNSW-4. Iron loading at UNSW-2 and UNSW-3 is less than the iron TMDLs at those locations.

8.2.2 Metals Allocations

The TMDL is the sum of allocations for both natural background sources, human-caused sources, plus a margin of safety (MOS). For the Union Creek TMDL, the seep discharge to Union Creek adjacent to the Copper Creek mining district is assumed to be caused by adjacent mining sources, and is considered a point source, thus the iron TMDL for Union Creek will consist of a load allocation for the natural background sources, a wasteload allocation (WLA) for the discharge from the Copper Cliff source, plus an explicit MOS.

During 2006 the iron concentration and estimated discharge from USP-1 remained fairly constant for both the high to low flow sampling events. The discharge from USP-1 percolates into the roadway fill substrate and was not observed as a direct surface discharge to Union Creek. Judging from the consistent water quality and discharge volume at USP-1, the source of the seep appears to contribute a constant, low volume flow that is high in total recoverable iron.

A solute balance equation (**Equation 2**) used to determine the mixed iron concentration from the UNSW-4 and USP-1 discharges, calculated the same result for iron that was measured in the 2006 sample.

Equation 2 $(C_1 Q_1) + (C_2 Q_2)/(Q_1 + Q_2) = C_3$

where:
C_1 = the iron concentration at UNSW-4,
Q_1 = the discharge at UNSW-4,
C_2 = the iron concentration at USP-1,
Q_2 = the discharge at USP-1 and
C3 = the mixed iron concentration at UNSW-5.

When the low flow discharge and iron concentration data for sites UNSW-4 and USP-1 are entered into the equation as below, the calculated iron concentration for site UNSW-5 equals the measured concentration for the site.

$$\frac{(0.3\ \text{mg/L})(0.25\ \text{cfs}) + (12\ \text{mg/L})(0.02\ \text{cfs})}{(0.25\ \text{cfs} + .02\ \text{cfs})} = 1.2\ \text{mg/L}$$

This result suggests that the Copper Cliff seep discharge alone explains the standards exceedence at UNSW-5. Cleaner recharge to Union Creek below UNSW-5 further dilutes the Cooper Cliff discharge so that the TMDLs are met downstream at UNSW-3 and UNSW-2. The similarity between the calculated and measured iron concentration after mixing suggests that the more extensive left bank seep zone is possibly a downstream of expression of the USP-1 discharge.

Assuming a fairly constant seep discharge that causes instream iron exceedences only during low flow conditions, the calculated allowable seep loading for low flow is the acceptable WLA for all flow conditions. The proposed iron TMDL for Union Creek consists of the following allocations:

1. A load allocation to natural background sources of total recoverable iron,
2. A WLA to Copper Cliff mining sources, and
3. An explicit MOS that is 10 percent of the TMDL.

With these respective allocations, the Union Creek Iron TMDL, based on the total recoverable iron standard of 1.0 mg/L at low flow, is expressed as follows:

TMDL = (0.25 cfs)(1.0 mg/L)(5.4) = Background Loading + 10% MOS + Copper Cliff WLA

1.35 lbs/day. = [(0.3 mg/l)(0.25cfs)(5.4)] + [(0.1)(0.25cfs)(1.0 mg/l)(5.4)] + WLA.

= 0.40 lbs/day + 0.14 lbs/day + WLA.

By subtraction, the Copper Cliff WLA = 1.35 lbs/day – 0.40 lbs/day – 0.14 lbs/day = 0.8 lbs/day.

The acceptable seep concentration is calculated by dividing the WLA by the product of the seep discharge times the unit conversion factor (0.80/(0.02 cfs)(5.4)) =7.5 mg/L

To meet the TMDL, the current Copper Cliff concentration of 12 mg/L must be reduced by 38 percent to 7.5 mg/L total recoverable iron.

This allocation scheme assumes that naturally occurring loading does not cause the water quality standard to be exceeded and that the application of ARLSWCP to the Copper Cliff seep zone can bring about the needed 38 percent reduction in iron loading.

8.2.3 Seasonality and Margin of Safety for the Metals TMDL

Seasonality is considered through metals loading assessments that were conducted during high flow and low flow periods. The use of instantaneous flows in the TMDL equation allows for year round application of TMDLs and allocations. Seasonality is considered in the metals TMDLs in that example TMDLs were provided in **Table 8-7** for both low flow and high flow conditions. Monitoring recommendations are for seasonal sampling to determine the validity of the assumptions regarding compliance with standards from naturally occurring concentrations of iron.

The explicit margin of safety consists of 0.14 lbs/day of Union Creek capacity for assimilating iron loading. It is based on reserving 10 percent of the TMDL to compensate for uncertainty in the naturally occurring load estimate that is based on the single low flow sampling at UNSW-4 during 2006. An additional margin of safety is implicit in the use of the chronic aquatic life standard as a basis for the maximum daily loads in that maximum allowable loads are defined at the point where chronic damage to aquatic life would start to occur. Compliance with the TMDL based on the chronic metals standards should prevent the possibility of acute aquatic life damage.

Compliance with the metals TMDLs and allocations will require monitoring of water quality trends in Union Creek. Monitoring provides a feedback loop toward adjusting pollutant source control strategies with the goal of preventing standards exceedences. Once approved, the water quality restoration plan becomes a cyclic process of adapting to natural and human land management impacts on water quality by finding and implementing strategies that protect beneficial uses. The good faith engagement in this adaptive process by stakeholders provides a margin of safety against continuing or worsening damage to water quality.

Should future assessment of the sources of metals loading determine that concentration targets are not being met, restoration activities will be reviewed to determine whether they constitute all reasonable land, soil, and water conservation practices (ARLSWCP) for the control of iron loading. Should sustained application, ARLSWCP, fail to achieve restoration targets, the TMDLs may need to be adjusted. Under circumstances where water quality targets and TMDLs are not met and ARLSWCP are not being implemented, the water body would remain impaired pending the restoration effort needed to meet water quality standards.

8.3 Temperature TMDLs and Allocations

Temperature TMDLs seek to quantify the level of thermal loading that is protective of aquatic life. Loading estimates consider the actual water temperature, flow rates, existing heat sources, and the capacity of the water body to buffer heating effects. Although a loading capacity for heat (e.g. kilocal/per day and per second) is estimated in **Appendix I**, the loading capacity units cannot be readily translated into land and water management options for solving temperature problems. Therefore, surrogate measures are used in this document to focus on controllable variables that directly affect nonpoint sources of elevated stream temperature. There are no known point sources of temperature loading in the planning area.

The temperature modeling procedure described in **Section 7.0** provided the technical framework for developing a surrogate-based temperature TMDL and allocation approach by identifying the major factors influencing water temperatures and estimating their relative effects. The modeling effort identified the relative importance of channel shading, channel geometry, and flow on temperature during the mid-July to mid-August period. For all temperature impaired streams, the dominant influence on temperature loading is lack of shade.

Lower Elk Creek and Union Creek were on the 2006 303(d) List as being impaired by high water temperatures (**Table 7-1**). The applicable standards for temperature in waters classified as B-1 are:

1. A 1ºF increase above naturally occurring temperatures when naturally occurring temperatures are 66ºF or less.
2. Within the naturally occurring range of 66 to 66.5°F, no increase can cause the temperature to exceed 67°F.
3. A 0.5°F increase above naturally occurring temperatures when naturally occurring temperatures are greater than 66.5.

Thermal loading allocations in this document are expressed in terms of prescribed conditions for the dominant factors that control stream temperature because they more clearly translate to restoration options. An example of daily temperature TMDLs, in terms of instantaneous thermal loads (ITLs), are provided numerically (kilocal/day or kilocal/sec) in **Appendix I** for a location on Union Creek. The temperature variables serving as surrogates for thermal loading are listed below and described in the following paragraphs.

- Alteration of flow by diversion.
- Stream channel shade reduction through woody riparian vegetation removal.
- Alteration of channel width to depth ratio that increases water surface exposure to air and sunlight.

Mid-summer irrigation withdrawals decrease the volume of water in streams. High summer air temperature combined with decreased water volume and warmed surface return flows from flood irrigated areas result in large stream temperature increases. Tributary flow and groundwater discharge to channels reduce overall heating. Although naturally occurring low flow conditions and irrigation requirements limit opportunities for increasing stream flows, irrigation BMPs have been developed to help increase the amount of diverted water that is actually consumed by the crop. In some cases, such practices can increase the amount of water available for competing beneficial uses during the critical summer period.

Significant irrigation water delivery and application efficiency improvements for flood systems have been documented (USDA, 1997, Economic Research Station, 1997, Negri et al., 1989). In this analysis, a conservatively low expectation of 15 percent flow augmentation is assumed possible for flood irrigation systems in Lower Elk and Union creeks and is considered as a naturally occurring condition for both listed water bodies. The lack of detailed information on water supply in relation to crop demands makes it difficult to judge whether current water management on the two streams represents naturally occurring conditions, reflecting application of all reasonable water conservation practices.

For each of several woody riparian vegetation community types, naturally occurring and existing shading characteristics were translated into the percent of the stream bank covered by a particular community type (**Appendix H**). A combination of riparian vegetation mapping, photo evidence of vegetation types and channel offset, and literature values for average community height, canopy diameter, and shade density were the basis for quantifying vegetation shade. The extent of bank line vegetation was digitized for each temperature impaired reach. A weighted average value, based on the relative extent of various vegetation types was calculated for each reach. Shade from vegetation was combined with channel width and topographic shade measurements to give a single shade value for each reach.

Channel morphology can greatly influence stream temperatures. Stream bank riparian vegetation that overhangs a narrow stream provides a higher percentage of shade than does equivalent vegetation along a wider stream. The effects of this are two-fold. First, wide streams are inherently more susceptible to thermal heating simply due to their width. Second, increasing stream bank vegetation has a smaller mitigating effect on thermal gain on wider streams. As a result, the temperature target for a wide stream, based on a 1ºF allowable increase from a 95 percent stream bank vegetation natural condition, may be close to the current condition.

Over-widened streams expose more water surface to temperature loading. Restoring the characteristic width to depth ratio of C and E channel types reduces water surface expsure. The characteristic width to depth ratios defined for sediment impaired channels (**Section 5.0**) are achievable geomorphic conditions assumed as naturally occurring conditions. The appropriate width to depth ratios are currently met in some areas. Where improvements are possible, this parameter is included among the temperature allocations, and specific assessment reaches needing channel morphology improvements are given in parentheses in the allocation tables.

8.3.1 Temperature TMDL and Allocation for Lower Elk Creek

Vegetative shade removal is the main influence on thermal loading in Lower Elk Creek. **Table 8-8** gives the model output for current, naturally occurring, and restoration target temperatures. **Table 8-8** also contains the temperature TMDL stated as conditions for bank line vegetation extent, and width to depth ratio, and flow augmentation needed in Lower Elk to restrict human caused temperature increases at the mouth of Lower Elk Creek to those allowed by the B-1 standard. The TMDLs are the changes needed in the temperature controlling parameters selected as surrogates for actual thermal loading units.

Lacking specific information on the degree of influence of each current land use on shade and channel geometry, the allocation is to the composite influence of the land uses affecting shade and channel geometry conditions within the segment. Channel encroachment by irrigated hay acreage and impacts from grazing livestock, either singly or in combination, are limiting shade replacement and affecting channel morphology throughout the segment.

Table 8-8. Temperature TMDLs and Allocations for Lower Elk Creek.

Parameter	**Condition Category**			**TMDL**	**Composite Allocation to Controllable Source/s**
	Current	**Naturally Occurring**	**Restoration Goal**		
Modeled Mean Daily Temp. (°F)	72	67.1	67.6	NA	Irrigated Hay Production Livestock Grazing
Modeled Maximum Daily Temp. (°F)	78	75	75.5	NA	
Bank line Vegetation Extent (%)	20	80	75	Increase by 69% of Reference	
Width:Depth Ratio E Types (Elk7-Elk10)	14	11	11	22%Decrease	
Flow Augmentation	Unknown	≥ 15 percent flow Increase July 15 to August 15			

The Lower Elk Creek temperature TMDL stated as the maximum allowable load in thermal units of kilocalories per day is presented in **Appendix I**.

8.3.2 Temperature TMDL and Allocations for Union Creek

Thermal loading to Union Creek was assessed using the SNTEMP model with separate modeling exercises for four Union Creek reaches. These frameworks separate the stream just above its second crossing beneath Highway 200 (see **Appendix H**). Modeling concluded the following:

1. The reach upstream of the Washoe Creek Confluence currently meets the standard of a 1.0°F allowable increase,
2. The reach from Washoe Creek to the Potomac Road crossing exceeds the 0.5°F allowable increase.
3. The reach from the Hall Property to Morrison Road just barely exceeds the allowable 1.0°F increase, and
4. The current conditions for the reach from Morrison Road to the Union Creek mouth are about 3.6°F higher than the simulated naturally occurring temperature.

Table 8-9 gives the model output for current, naturally occurring, and restoration target temperatures, surrogate TMDLs and allocations for each of the three reaches where modeling determined that the standard is exceeded.

Table 8-9. Temperature TMDLs and Allocations for Union Creek

Union Creek Reach	Parameter	Condition Category			TMDL	Composite Allocation to Controllable Source/s
		Current	Naturally Occurring	Restoration Goal		
Washoe Creek to Potomac Road	Modeled Mean Daily Temp. (°F)	66.4	62.9	63.4	NA	Irrigated Hay Production Livestock Grazing
	Modeled Maximum Daily Temp. (°F)	74.9	69.6	70.3	NA	
	Bank line Vegetation Extent (%)	47	80	76	Increase by 36% of Reference	
	Width:Depth Ratio E Types (Union5 & 6)	11.9	≤ 11	11	8%Decrease	
	Flow Augmentation	Unknown	≥ 15 percent flow increase July 15th to August 15th			
Hall Property Boundary to Morrison Road Crossing	Modeled Mean Daily Temp. (°F)	61.3	60.3	60.8	NA	Irrigated Hay Production Livestock Grazing
	Modeled Maximum Daily Temp. (°F)	69.9	65.6	66.6	NA	
	Bank line Vegetation Extent (%)	26	80	35	Increase by 11% of Reference	
	Flow Augmentation	Unknown	≥ 15 percent flow increase July 15th to August 15th			
Morrison Road to Mouth	Modeled Mean Daily Temp. (°F)	73.6	70	70.4	NA	Irrigated Hay Production Livestock Grazing
	Modeled Maximum Daily Temp. (°F)	85.1	83.3	83.6	NA	
	Bank line Vegetation Extent (%)	23	80	76	Increase by 66% of reference	
	Width:Depth Ratio E Types (Union12)	11.6	11	11	5% Decrease	
	Flow Augmentation	Unknown	≥ 15 percent flow increase July 15th to August 15th			

Vegetative shade removal is the main influence on thermal loading to Union Creek. The high temperatures suggested by the modeling in Union Creek below Morrison Road indicates that water management practices in addition to channel restoration and shade replacement are needed. The Union Creek temperature TMDL varies for each of three modeled reaches that exceeded the temperature standard. The temperature TMDL for the most critical reach among the three is stated in units of kilocalories per day in **Appendix I**.

8.3.3 Temperature Impairment to the Blackfoot River Mainstem (Monture Creek to Belmont Creek).

The downstream end of the temperature listed segment of Blackfoot River mainstem is at the mouth of Belmont Creek. The SNTEMP model for the mainstem was constructed with the lowest output point at the Corrick River Bend access site located about two river miles above the Belmont Creek mouth. The conditions at Corrick River Bend are assumed to reflect those at the Belmont Creek mouth since no perennial tributaries occur within this two mile reach.

The average width of the Monture to Belmont segment is 145 feet and the average bank line woody vegetation extent is 63 percent. The wide channel prevents increases in bank line woody vegetation from having a significant influence on channel shade. Modeling an increase in bank line vegetation from the current 63 to 95 percent increased shade from 6.2 to 6.9 percent. No appreciable decrease in simulated temperature resulted from this change. Therefore, the current woody bank line vegetation extent is not a source of significant thermal loading to this segment. **Table 8-10** gives simulated current condition and naturally occurring condition temperatures at Corrick River Bend, where the naturally occurring condition is that where Nevada Creek flows meet temperature target conditions. The difference between modeled current conditions and the naturally occurring condition is within the 0.5°F increase allowed by the B-1 temperature standard.

Table 8-10. Temperature TMDLs and Allocations for the Blackfoot River Mainstem (Monture Creek to Belmont Creek)

Parameter	Current Condition	Naturally Occurring	Difference from Current Conditions
Modeled Mean Daily Temp. (°F)	68.6	68.4	-0.2
Modeled Maximum Daily Temp. (°F)	72.9	72.3	-0.6

Simulations of current temperature conditions and natural conditions differed by only 0.2°F. Since this result falls within the 0.5°F allowable increase, no temperature TMDL is required within this reach of the Blackfoot River mainstem.

8.3.4 Seasonality, Uncertainty, and Margin of Safety for Temperature TMDLs

To address seasonality the modeling analyses was focused on conditions during the period of July 15th through August 15th, when B-1 temperature standards are most likely exceeded. Targets developed to reduce stream temperatures during the most critical period provide an implicit margin of safety toward meeting temperature standards during less critical seasons.

Other implicit margins of safety are applied by using conservative assumptions in the TMDL development process (U.S. EPA, 1999). The major components are described below:

- The temperature modeling analysis and resulting TMDLs and allocations are based on actual flow mesurements and continuous instream temperature data collected during the 2006 growing season. Thus, the temperature modeling was based as geographically relevant data that realistically captured the effects of the main temperature controlling factors.

- The assumed naturally occurring percentage of bank line woody vegetation (80 percent in valley and 90 percent in upland settings) was developed from examples of optimal woody riparian vegetation within the planning area (See **Appendix H**). The examples depict abrupt woody vegetation density changes across property or land use boundaries that do not impose environmental limitations to woody vegetation growth. It is inferred from such examples that the potential for shade from woody vegetation is widespread in the planning area, but uncertainty in its extent remains. Because of natural variability in soil, climate and hydrologic conditions, the actual potential for woody vegetation may be less than 80 or 90 percent in some areas. An assumed potential of 80 to 90 percent bank line extent provides an initial margin of safety, and adaptive management allows for a future assessment and target adjustment if needed.

- Healthy streamside riparian vegetation creates a local microclimate with lower air temperatures and higher humidity. This has an additional cooling effect on stream temperatures not accounted for in the SNTEMP model. Therefore, additional woody riparian vegetation will not only provide additional shade, but will provide additional cooling through this microclimate effect.

The following elements are proposed as an adaptive management approach to future temperature assessment:

1. Continuous records of stream discharge coupled with continuous temperature records in both listed tributaries.
2. Quantify the seasonal effects of groundwater discharge and its effect on stream temperature during mid to late summer.
3. Evaluate shade restoration potential within the agricultural valley portion of Camas Creek and adjust bank line woody vegetation shade estimates if necessary .
4. Develop and execute model scenarios based upon continuous stream discharge data to improve the understanding of current temperature loading and the potential effects of flow volume in Union Creek below the second highway 200 crossing.
5. Implement targeted monitoring of the temperature effects of stream restoration projects on temperature listed segments.

SECTION 9.0
WATER QUALITY RESTORATION IMPLEMENTATION AND MONITORING PLAN

9.1 Introduction

The preceding chapters of this document describe a number of water quality problems, their sources, restoration targets, and necessary pollutant reductions for 303(d) listed streams in the Lower Blackfoot planning area. The purpose of this chapter is to outline strategies for achieving water quality targets and achieving beneficial use support on these streams. This restoration implementation and monitoring plan was written so that water quality restoration management objectives for the lower Blackfoot can be integrated with ongoing watershed management efforts in the Blackfoot as well as state-wide water quality management efforts described in Montana's Non Point Source Management Plan. It summarizes the results of the TMDL document, and serves as a guide to landowners and stakeholders concerned with the maintenance, improvement, and/or restoration of water quality in the area.

This restoration plan contains three sections; Management Recommendations, Implementation, and Evaluating Success. The Management Recommendations section addresses each impaired stream individually through a narrative of the current conditions, identified water quality problems, the sources and causes of those problems, and management actions that will contribute towards meeting water quality targets. In cases where the causes of degraded conditions are not well defined, this section provides recommendations for future monitoring.

The Implementation section draws from the "Basin-Wide Restoration Action Plan for the Blackfoot Watershed" (Blackfoot Challenge, 2005). It describes some of the key elements of successful implementation and how the water quality restoration objectives in this plan integrate with existing restoration plans. It also describes partnerships for implementation, current stakeholder management objectives, and potential funding sources for implementation.

The Evaluating Success and Adaptive Management section describes how progress towards meeting water quality restoration targets can be measured, as well as monitoring activities needed to better understand water quality in the lower Blackfoot, and monitoring activities needed to determine where adjustments to water quality restoration targets and/or management are warranted.

Appendix J contains a list and description of conservation practices or Best Management Practices (BMPs) appropriate for water quality restoration. These conservation practices are grouped into eight different categories including Stream BMPs, Riparian Area BMPs, Upland BMPs, Grazing BMPs, Water Conservation BMPs, Forestry BMPs, Road BMPs, and Other Land Uses and BMPs. The conservation practice categories correlate to management actions and water quality concerns described in the Management Recommendations section. The conservation practices under each category gives land managers several implementation options for addressing water quality issues.

9.2 Management Recommendations

This section describes sources, causes, and potential solutions to water quality impairments for each 303(d) listed stream in the Lower Blackfoot planning area. This includes descriptions and summaries of water quality issues, likely sources, and recommended management actions.

Where excess pollutant loading impairs water quality, the results of the pollutant source assessment are included in tables. These values reflect the controllable pollutant load from identified sources. The controllable pollutant load is the portion of the total pollutant load that is considered controllable through the implementation of reasonable land, soil, and water conservation practices.

Source assessment activities for sediment impairments determined that hill slopes or upland areas can be a significant source of these pollutants. The terms hill slopes, hillslope, uplands, and upland areas are used interchangeably and refer to the area within 350 feet of the stream channel with a slope greater than three percent.

For TMDL planning purposes, each listed stream has been divided into several reaches. Specific stream reaches are often referenced to describe overall water quality conditions of a listed stream. A map with stream reach delineations can be found in **Appendix A** and further information on individual stream reaches can be found in **Appendix B**.

Land uses and human activities can, and do, negatively impact water quality. It is important to note that while certain land uses and human activities are identified as sources and causes of water quality impairment, the management of these activities is of more concern than the activities themselves. This plan does not advocate for the removal of land uses or human activities to achieve water quality restoration objectives. It does, however, advocate for improving water quality and preventing degradation of water quality as a result of current or future land use management practices and human activities.

9.2.1 Day Gulch

Day Gulch drains a relatively small area in the upper Elk Creek watershed. The 303(d) listed segment of Day Gulch is 1.2 miles long (**Appendix A**). Day Gulch was listed in 1996 for flow alteration, other habitat alterations, and siltation. Subsequent 303(d) listings for Day Gulch indicated that data were insufficient to determine its impairment status.

Historic hard rock mining, placer mining, and hillslope logging have impacted the Day Gulch watershed. The Coloma Mining District is located in the Day Gulch watershed and includes the Dandy Mine, Arkansaw Mine, and Masculine Mine. These mines all had tunnels and shafts, producing mostly gold ore. The Arkansaw Mine was developed to a depth of 65 feet in the early part of the 20th century, and the Masculine Mine consisted of a short tunnel and shaft in 1916 (http://deq.mt.gov/abandonedmines/linkdocs/techdocs/143tech.asp). At the Dandy Mine site, a 40-ton amalgamation and concentration plant was constructed in 1915. In the upper part of Day Gulch, the Alabama Placer mine produced gold in 1915.

Currently, Day Gulch runs through a disturbed and/or re-graded valley bottom that supports minimal woody riparian vegetation. It appears that placer mining took place along much of the course of the gulch. It is also likely that accelerated sediment loading resulted from hard rock mining and hillslope logging. Regrading in the valley bottom has formed a wedge-shaped fill volume having a steep downstream face. As part of previous reclamation efforts, the channel on this steep face has been constructed as an armored spillway. Reclamation efforts include some revegetation and construction of two storm water detention ponds in the lower part of the gulch. Due to the coarse-grained nature of the re-graded valley fill, surface flow over the fill surface is largely intermittent. Active mining is occurring upstream of the valley fill section of the gulch.

9.2.1.1 Indicators of Habitat and Water Quality Degradation

Data collection on Day Gulch identified of excess fine sediment in pool tailouts and riffles (**Table 9-1**). Habitat parameters related to pool quality, woody debris aggregates, and woody vegetation density are all notably low (**Section 5**).

9.2.1.2 Suspected Sources

Because of the lack of data on Day Gulch, there has been no comprehensive assessment of suspected sources of impairment. However, base parameter data indicate that limitations do exist with respect to fine sediment accumulations and instream habitat complexity. Based on general land uses in the area, it is likely that the primary source of these degraded conditions is historic mining activities. Although detailed source assessments and TMDLs have not been developed for Day Gulch, restoration opportunities exist to improve sediment and habitat conditions in the lower sections of the stream.

Table 9-1. Summary of identified problems and applicable treatments, Day Gulch.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Insufficient Data, although sources are likely related to historic mining activities	Collect additional data as necessary
			Active restoration of mining impacted valley bottom
Habitat	Pool habitat conditions, woody vegetation extent, woody debris aggregate extent	Excess fine sediment	See above
		Insufficient Data, although sources are likely related to historic mining activities	Active restoration of mining impacted valley bottom
Nutrients	None Identified	None Identified	Collect additional data as necessary
Temperature	None Identified	None Identified	Collect additional data as necessary
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.1.3 Recommended Conservation Practices/BMPs

Day Gulch has a history of human disturbance due to placer and hard rock mining. In some areas, channel reclamation efforts, including retention pond construction and channel armoring followed mining. These projects do not optimize long-term aquatic habitat conditions in the reach. Further assessment of Day Gulch, with respect to overall restoration feasibility in mined reaches, or those indirectly affected by accelerated sediment loading is recommended. This will allow an evaluation of the performance of existing reclamation measures, and determination of potential benefits of additions or modifications to those projects. Any restoration efforts performed in Day Gulch should consider the feasibility of reconnecting the groundwater table to the creek to minimize flow infiltration through the disrupted and aggraded valley bottom sediments.

9.2.1.4 Monitoring Needs

The assessment record indicates a comprehensive lack of biological, chemical, physical, and habitat data describing Day Gulch. Water quality sampling during both high flow and base flow conditions, a segment-wide bank erosion assessment and macroinvertebrate and periphyton sampling are needed to meet sufficient and credible data thresholds and verify the causes and sources of water quality problems.

9.2.2 Keno Creek

Keno Creek is a second order tributary to upper Elk Creek (**Appendix A**). The 1996 303(d) Listing for Keno Creek includes flow alteration, other habitat alterations, siltation, and thermal modifications. Subsequent to this listing, Montana DEQ determined that information was lacking to verify these impairments.

Upland logging is evident in much of the Keno Creek watershed. The channel is commonly closely followed by an access road. In some areas, the riparian corridor has been logged. Large stumps are common in the riparian corridor, and extensive woody debris accumulations appear to reflect accumulations of slash from historic riparian logging. Aquatic vegetation observed in Keno Creek suggests that springs supply a significant portion of the flow.

9.2.2.1 Indicators of Habitat and Water Quality Degradation

The sediment/habitat related problem on Keno Creek measured in the base parameters assessment includes an excess accumulation of fine sediment **(Table 9-2)**. In addition, macroinvertebrate metrics indicate that use support for aquatic life may be damaged. Excess fine sediment concentrations are most evident in pebble count data, which show that the concentration of sediment <6mm in riffles is approximately twice the target value (85 percent measured vs. 45 percent target). The macroinvertebrate metrics for Keno Creek do not meet targets; however, their departures from target values are very small. The degree of entrenchment measured on Keno Creek indicates that floodplain access in the valley bottom is limited (**Table 5-4**).

In 2006, temperature measurements in lower Keno Creek did not exceed 52 ^{o}F, indicating that the thermal modifications listing of 1996 is unwarranted. However, at the mouth of Keno Creek, road construction created a pond upstream of a culvert, slowing water movement and causing increased thermal loading. This culvert is also a possible fish passage barrier.

9.2.2.2 Suspected Sources

The suspected sources of impairment on Keno Creek include road encroachment and historic logging of both the valley walls and riparian zone. These activities have resulted in degradation of the riparian corridor and accelerated delivery of fine sediment to the Keno Creek. Based on the results of the sediment source assessment, road crossings are the largest suspected sources of sediment (**Table 9-2**). This fine sediment loading is likely the primary cause of habitat degradation in Keno Creek. This degradation manifests in macroinvetebrate metrics and riffle substrate gradations indicative of impairment.

Table 9-2. Summary of identified problems and applicable treatments, Keno Creek.

Water Quality Component	**Limiting Factors/ Indicators**	**Suspected Sources**	**Applicable Treatments**
Sediment	Excess Fine Sediment	Stream bank sediment (1.2 tons/yr)	Riparian Area BMPs
		Roads (8 tons/yr)	Roads BMPs
		Hillslope sediment (0.8 tons/yr)	Upland BMPs
Habitat	Percent fine sediment <6mm in riffles, macroinvertebrate metrics	Excess fine sediment	See above
Nutrients	None Identified	None Identified	Collect additional data as necessary
Temperature	Summer temperatures consistently below 52 degrees F (2006); localized warming noted in ponded area at mouth		Reconstruct roadbed and culvert at mouth to eliminate ponding
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.2.3 Recommended Conservation Practices/BMPs

Keno Creek drains predominantly granitic terrain, which is prone to delivering relatively large volumes of sand sized sediment to stream channels. Land uses within the watershed have likely exacerbated sediment delivery rates to the stream corridor, and riparian logging has reduced the capacity of the riparian zone to trap upland sediment. As a result, land management in the Keno Creek watershed should include BMPs that limit the delivery of sediment from upland areas and roads. Field crews noted that sediment controls are in place along the roads, including berms, ditches, and culverts. These features should be maintained and expanded as necessary. The primary restoration objective on Keno Creek should be limiting the delivery of sediment from upland areas due to the propensity of the upland geology to produce high volumes of sand.

Field crews deployed temperature sensors on lower Keno Creek during the summer of 2006. Recorded temperatures in the creek did not exceed 52 degrees F, indicating that Keno Creek is not impaired for temperature. However, at the very mouth of Keno Creek, a roadbed and culvert channel impounds water, slowing it and increasing thermal loading. High water temperatures downstream in Elk Creek create water quality impairments. Therefore, reconstruction of this roadbed/culvert configuration will reduce the residence time and warming of Keno Creek waters prior to entering Elk Creek. One potential negative impact of removal of the ponded area is a reduction of the sediment trapping benefit of the pond.

9.2.2.3 Monitoring Needs

With the application of upland, road, and riparian BMPs, fine sediment accumulations in Keno Creek should be monitored to evaluate the effectiveness of BMP implementation.

9.2.3 Upper Elk Creek

Upper Elk Creek, which extends from its headwaters to Stinkwater Creek (**Appendix A**), has been described as a degraded 3rd order tributary to the lower Blackfoot River (MTFWP, 2002a). Human influences within the upper reaches of Elk Creek that have likely contributed to water quality and habitat degradation include mining, logging, and road construction. The 2006 303(d) Listings for Upper Elk Creek include metals (cadmium), nutrients, physical habitat substrate alterations, and sedimentation/siltation.

Gold was discovered on Elk Creek in 1865 by a prospecting party from Last Chance Gulch. This discovery resulted in one of the last large Montana gold rushes to the Garnet Mountains. Mining camps were created within weeks of the discovery, including Reynolds City near the mouth of Day Gulch and Yreka further downstream (http://deq.mt.gov/abandonedmines/linkdocs/techdocs/143tech.asp). This upper portion of the Elk Creek watershed is located within the Coloma Mining district. Mining in the area was most active from around 1900 to 1920, when $250,000 of ore was produced in the district. Day Gulch, a tributary to upper Elk Creek had several hard rock gold mines (Dandy, Arkansaw, Masculine) as well as placer mines (Alabama). Near the headwaters of Elk Creek, the Haparanda mine was opened in 1886 and by 1894, housed a stamp mill on the creek. The Comet mine was located near the head of Bivins Gulch, another Elk Creek tributary. This mine was developed around 1905 and had a mill on the property. At the head of McGinnis Creek, the Mammoth mine and Clemantha mine straddle the drainage divide between the Elk Creek and Washoe Creek watersheds. The mining camp of Coloma was located at the Mammoth mine.

In addition to mining within the tributary watersheds of Elk Creek, the main channel of Elk Creek itself was heavily placer mined. At the mouth of McManus Gulch, near the mouth of Keno Creek, hydraulic mining on Elk Creek removed 10-18 feet of sediment down to bedrock (http://www.deq.state.mt.us/AbandonedMines/linkdocs/techdocs/145tech.asp). Placer mining in the Elk Creek valley bottom continued following 1934, when gold prices rose during the depression. In 1939, nine placer mines in the Elk Creek district produced 1,420 ounces of gold and 131 ounces of silver. Drag line dredges were locally used in the placer mining operations as recently as 1946.

More recent barite mining in the watershed took place starting in 1951 at the Greenough (Elk Creek) mine, in Cap Wallace Gulch. Ore from this mine led to the construction of a processing mill on the Blackfoot River approximately 6.5 miles northeast of the mine (http://www.deq.state.mt.us/AbandonedMines/linkdocs/techdocs/145tech.asp). The majority of barite production from these mines took place in the early 1950s. Barite was sold to sugar refineries and for use as a drilling mud. Some mining continued in the area until 1966.

Currently, upper Elk Creek displays dramatic impacts from mining. The alluvial sediments of the valley bottom were extensively placer mined, and as a result, dredge ponds and placer spoil berms are common along the stream. The creek is straight, laterally confined by dredge spoils, and isolated from any floodplain area. Encroachment by the main road along the stream caused further channel confinement.

Upper Elk Creek supports populations of fluvial westslope cutthroat trout, rainbow trout, brown trout, and resident brook trout; the densities of all of these species decrease in the downstream direction. Fish population surveys from 1996 and 1997 on upper Elk Creek (mile 12.2) identified only brook trout (MTFWP, 1999). Fisheries-related impairments identified in upper Elk Creek include channel alterations (placer mining) and road drainage problems (MTFWP, 2002b). Between 1999 and 2002, Elk Creek tested negative for whirling disease; subsequent 2003 testing indicated a rapid escalation in infection (MTFWP, 2004).

Restoration projects have been completed on Upper Elk Creek in several placer mined areas. Two restoration projects began in 1991 (http://www.fws.gov/mountain-prairie/pfw/montana/mt5c6.htm). One of these projects, directed by the BLM, reconstructed 1,200 feet of B4 channel type in an area severely altered by placer mining activities (MTFWP, 1999). In some restored areas, Total Suspended Solids (TSS) values have declined to pre-construction levels, substrate conditions are improving, and riparian areas are beginning to recover (http://cwaic.mt.gov/). Assessment crews noted that bed scour and associated pool formation in restored sections is limited due to the coarse placer mined substrate.

9.2.3.1 Indicators of Habitat and Water Quality Degradation

Results of the base parameter assessment indicate that Elk Creek displays poor conditions with respect to fine sediment accumulations, pool habitat-related parameters, and woody debris aggregate frequency (**Table 9-3**). Excess fine sediment was measured in riffles as well as pool tailouts. Measured pool frequencies are less than half the target value for both B channel types and less confined, more sinuous Eb channel types (**Section 5**).

Recent metals data suggest no impairment due to cadmium on upper Elk Creek (**Section 6**).

Nutrient samples collected on upper Elk Creek are described as high for the region (http://cwaic.mt.gov). Data collected on upper Elk Creek in 2006 show elevated nutrient concentrations but current data is not sufficient to determine impairment or assess sources with respect to nutrients.

9.2.3.2 Suspected Sources

The suspected sources of impairments on upper Elk Creek are land uses related to mining, road construction, and silviculture. Results of the sediment source assessment indicate that hillslope areas contribute the highest controllable sediment load to upper Elk Creek. Erosion of stream banks is also a significant source of sediment loading. Physical disruption of the valley bottom as part of placer mining activities has likely contributed to habitat degradation within the stream corridor.

Table 9-3. Summary of identified problems and applicable treatments, Upper Elk Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (32.2 tons/yr)	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Roads (16 tons/yr)	Roads BMPs
		Hillslope sediment (71 tons/yr)	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
Habitat	Excess fine sediment, pool habitat conditions, woody debris aggregate frequency	Excess fine sediment	See above
		Valley bottom mining	Active Restoration
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to define sources	Collect additional data as necessary
Temperature	None Identified	Identified temperature problems are downstream	Collect additional data as necessary
Metals	None Identified	2006 Cadmium listing not indicated by recent data	Collect additional data as necessary

9.2.3.3 Recommended Conservation Practices/BMPs

Above the Stinkwater Creek confluence, upper Elk Creek shows significant degradation resulting from human influences, primarily valley bottom placer mining. Fortunately, these impacted areas provide excellent restoration opportunities through channel/floodplain reconstruction and revegetation. Due to the coarse nature of the placer spoils, any restoration activities should carefully consider the connectivity between groundwater and surface water in the disrupted valley bottom, to ensure that instream flow conditions are optimized in any restoration scenario. Valley bottom restoration efforts should also include recovery of a healthy riparian buffer to reduce delivery of hillslope-derived sediment to the stream. Roads BMPs should be applied aggressively on Elk Creek to further reduce sediment loading from either proximal roadways or culvert failures.

9.2.3.4 Monitoring Needs

Additional data should be collected on upper Elk Creek to further investigate water quality problems related to nutrients. Furthermore, any completed or future restoration efforts on Elk Creek should include monitoring of sufficient parameters so as to determine if the projects meet originally stated objectives.

9.2.4 Lower Elk Creek

Lower Elk Creek, which extends from the mouth of Stinkwater Creek to the Blackfoot River (**Appendix A**), is a degraded third order tributary to the lower Blackfoot River (MTFWP, 2002a). Lower Elk Creek is partially supporting for aquatic life and the cold water fishery (http://cwaic.mt.gov). The 2006 listings for Lower Elk Creek include alteration in stream-side or littoral vegetative covers, thermal modifications, and sedimentation/siltation. Probable sources include riparian grazing and streambank modifications/destabilization.

Elk Creek supports populations of fluvial westslope cutthroat trout, rainbow trout, brown trout, and resident brook trout; the densities of all of these species decrease in the downstream direction. Elk Creek has been described as “the only potential spawning stream between Belmont Creek and Blanchard Creek, a distance of 17.7 miles” (MTFWP, 1999). Between 1999 and 2002, Elk Creek tested negative for whirling disease; subsequent 2003 testing has indicated a rapid escalation in infection (MTFWP, 2004).

Fisheries impairments in Lower Elk Creek identified by MTFWP (2001, 2002a) include lack of complex fish habitat (instream wood), livestock induced stream bank degradation and riparian vegetation suppression, elevated water temperature, and channel instability, irrigation, and adverse effects of upstream mining and road drainage problems. Land use practices associated with these impairments include placer mining, channelization, road construction and maintenance activities, road drainage problems, and concentrated riparian livestock grazing.

In the 1940s, one mile of Lower Elk Creek (mile 1.8 to 2.8) was moved from its original location to facilitate irrigation in the valley bottom (http://www.fws.gov/mountain-prairie/pfw/montana/mt5c.htm). The channel was relocated to an upland area against the valley wall, which is comprised of fine grained lake deposits. The relocation and straightening resulted in up to 10 feet of downcutting and dramatically accelerated sediment production rates. In 1994, the channel was reconstructed as part of an erosion control project designed to improve water quality in the stream. The project involved reconstructing the channel as an 8,600 ft long E4 channel type, replanting willows from adjacent areas, adding large woody debris, and implementing a rotational grazing system with cross fences and off-site water. Post-construction monitoring efforts have shown improvements but a lack of adherence to grazing prescriptions resulted in a failure of the project to meet objectives with respect to temperature, fish populations, and suspended sediment (MTFWP, 2004).

9.2.4.1 Indicators of Habitat and Water Quality Degradation

Results of the base parameter analysis for the four assessed sites on Lower Elk Creek show significant departures relative to target values for all sediment/habitat related parameters (**Section 5**). Measured pool frequencies are less than 50 percent of the target value, and percent fines in riffles (both <6mm and <2mm size fractions) are approximately twice the target condition. The one available macroinvertebrate metric (MMI) did not meet target value, and woody bankline vegetation extents and instream woody debris aggregate frequencies are all notably low.

Temperatures on Lower Elk Creek are above the allowable level identified for that stream (**Section 7**). Above Cap Wallace Gulch, water temperatures are relatively cool. Downstream, a lack of riparian shading and dewatering due to irrigation diversions characterize the remaining 6.2 miles of Elk Creek. In this reach, measured temperatures exceed the allowable increase above natural conditions. The primary suspected source of temperature impairment on Lower Elk Creek is the lack of shade caused by degradation of riparian vegetation. Modeling results indicate that temperature targets can be met on Elk Creek with a bankline woody vegetation extent of 75 percent, a width-to-depth ratio of less than 16, and a 15 percent increase in flow.

9.2.4.2 Suspected Sources

The suspected sources of impairments on Lower Elk Creek include stream corridor grazing, valley bottom agricultural development, and diversion of flows for irrigation (**Table 9-4**). These impacts have collectively resulted in degraded physical habitat and elevated water temperatures below Cap Wallace Gulch. Results of the sediment source assessment indicate that streambank erosion contributes the largest controllable sediment load to the creek, followed by roads.

Table 9-4. Summary of identified problems and applicable treatments, Lower Elk Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (139.7 tons/yr)	Riparian Area BMPs
			Grazing BMPs
		Roads (21 tons/yr)	Roads BMPs
		Hillslope sediment (11 tons/yr)	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
Habitat	Pool habitat conditions, woody vegetation extent, woody debris aggregate extent	Excess fine sediment	See above
		Low flow alterations	Water Conservation BMPs
		Riparian Degradation	Riparian Area BMPs Grazing BMPs
Nutrients	None Identified	None Identified	Collect additional data as necessary
Temperature	Elevated temperatures below Cap Wallace Gulch	Primarily degradation of riparian vegetation and associated shade; also dewatering and channel over-widening	Riparian Area BMPs Grazing BMPs Water Conservation BMPs
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.4.3 Recommended Conservation Practices/BMPs

Results of the TMDL data collection effort indicate that conservation practices on Lower Elk Creek should focus on recovery of the woody riparian corridor and maintenance of instream flows. Comprehensive grazing and riparian BMPs should be put in place to promote riparian vegetation recovery which will increase shade, promote channel cross section narrowing and stability, reduce sediment loading from bank erosion, and improve bedform complexity through local scour and increase woody-debris related habitat elements.

The 8,600 foot long restoration project that was implemented on Lower Elk Creek in 1994 was recently revisited to determine if current land use practices are promoting channel recovery. Working with the landowners, partners have implemented a new grazing plan on Lower Elk Creek which involves the use of portable electric fencing and off-stream water developments to protect riparian areas. These practices should be monitored to assess their affects on the recovery of the channel. Continued restoration efforts in the upper watershed should serve to reduce accelerated sediment loading from upper Elk Creek.

9.2.4.4 Monitoring Needs

Monitoring of water temperature, fish populations and suspended sediment on a restored section of Lower Elk Creek has indicated that project objectives have not been met (MTFWP, 2004). These results highlight the importance of monitoring any restoration project. The primary cause for poor project performance has been described as a lack of implementation of grazing and riparian BMPs in the project area. As further restoration efforts are expended on Lower Elk Creek, and as stream corridor BMPs are implemented, additional monitoring of those projects will be critical in the ongoing assessment of project benefit. Furthermore, the results will help identify those BMPs that are most effective towards meeting overall goals of supporting the cold water fishery and aquatic life beneficial uses. Because of a lack of current data regarding nutrients on Lower Elk Creek, water quality analysis of nutrient concentrations should be included in any monitoring effort.

9.2.5 Belmont Creek

Belmont Creek is a second order tributary to the Blackfoot River, flowing southward from the high elevations of the Lolo National Forest to the Blackfoot River north of Potomac (**Appendix A**). The listed segment of Belmont Creek is approximately 10.5 miles long. Belmont Creek is considered partially supporting of aquatic life and the cold water fishery. Probable causes of impairment identified on the 2006 303(d) List consist of sedimentation/siltation and the probable sources associated with that impairment are forest roads and riparian grazing.

Belmont Creek supports bull trout, fluvial westslope cutthroat trout, and low densities of brook trout. Rainbow and brown trout thrive in lower reaches of the channel near the Blackfoot River. Belmont Creek has been described as a core area bull trout stream (MTFWP, 1999). The best wintering habitat for bull trout is located in the middle reaches, where habitat is enhanced by boulders and deep pools (Plum Creek Timber Company, 1994). Fisheries related impairments on Belmont Creek as identified by MTFWP (2002a) include elevated levels of instream sediment, and areas of low habitat complexity in lower reaches.

Through the mid-1990s, the Belmont Creek watershed had 135 miles of roads (http://cwaic.mt.gov), and road drainage problems were considered to be a primary factor in accelerated fine sediment accumulations in the channel. A watershed analysis performed in the early 1990s (Plum Creek Timber Company, 1994) indicated that the extensive road network was determined to be a primary source of sediment. Logging practices applied until the mid-1980s, which included log removal on skid trails adjacent to streams, as well as livestock access to the stream corridor, had increased sediment delivery rates. In the 1990s, hillslope erosion rates were estimated at 4 times reference conditions (http://cwaic.mt.gov). Since that time, extensive sediment controls have been implemented such as road closures and grazing BMPs. Reassessments completed in 2005 indicated that the sediment delivery rate to Belmont Creek was reduced by 80 percent, due primarily to BMP improvements to the road network (Sugden, 2006).

In the 1960s, two culverts were placed in the stream that created fish passage barriers. For over 20 years, concentrations of bull trout were documented at the downstream end of the culverts. In 1994, a bridge was constructed over Belmont Creek which allowed removal of the culverts (http://www.fws.gov/mountain-prairie/pfw/montana/mt5c.htm). Following removal of the culverts, salmonid populations increased in the stream, and in 1995, a bull trout spawning site was observed above one of the old culvert locations. Currently, bull trout spawning occurs in the middle reaches of Belmont Creek, and near the mouth, a robust rainbow and brown trout fishery exists.

In the 1990s bank trampling, due to stream corridor grazing, was identified near the mouth of the creek, and in 1995, macroinvertebrate data indicated a moderate level of impairment. In 1994, grazing was concentrated in the lower 2 miles of the stream (Sugden 1994). Some restoration has been implemented on lower sections of the creek where grazing pressure was most intense.

9.2.5.1 Indicators of Habitat and Water Quality Degradation

Data were collected from two base parameter assessment sites on Belmont Creek. The upper site, located in the middle reaches of Belmont Creek, consists of a moderately confined, relatively steep channel with some step-pool habitat elements. In this reach, all target values with the exception of riffle substrate <6mm were met (**Section 5**). Downstream, the second site flows through a relatively unconfined open meadow area that has been grazed. Some restoration activities have been undertaken in this reach. Although restoration has been implemented, the site did not meet targets with respect to fine sediment concentrations in pool tailout areas, residual pool depths, and percent of channel length comprised of woody debris aggregates (**Table 9-5**). Targets for pool frequency and percent fines in riffles are met in this reach, however, indicating that the restoration activities may have improved channel condition.

9.2.5.2 Suspected Sources

The primary suspected sources of the water quality limitations on Belmont Creek include logging, road development, and riparian grazing. However, substantial efforts have been imparted to reduce sediment loading to the stream relative to historic levels. Results of the sediment source assessment indicate that the largest controllable source of sediment along the listed stream segment is upland areas. Roads and culvert crossings also constitute a significant portion of the total controllable load.

Table 9-5. Summary of identified problems and applicable treatments, Belmont Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (23.1 tons/yr)	Riparian Area BMPs
			Grazing BMPs
		Roads (72 tons/yr)	Roads BMPs
		Hillslope sediment (383 tons/yr)	Riparian Area BMPs
			Upland BMPs
Habitat	Fine sediment concentrations in pool tailouts, residual pool depths, woody debris aggregate extent	Excess fine sediment	See above
		Riparian Degradation	Riparian Area BMPs Grazing BMPs
Nutrients	None Identified	None Identified	Collect additional data as necessary
Temperature	None Identified	None Identified	Collect additional data as necessary
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.5.3 Recommended Conservation Practices/BMPs

Sediment control measures employed on Belmont Creek, including road closures and grazing BMPs, have evidently reduced sediment loading to the stream by a significant margin. These BMPs should continue to be implemented where feasible, to further address the negative impacts of historic accelerated sediment loading to the system.

9.2.5.4 Monitoring Needs

Monitoring for elevated fine sediment accumulations should continue in Belmont Creek to determine if the BMPs that have been applied are sufficient to promote full support of aquatic life and the cold water fishery. As there is a lag time between BMP implementation and channel response, any trends in channel recovery should be identifiable as accumulated fine sediment is flushed through the system.

9.2.6 Washoe Creek

Washoe Creek is a small second order tributary to Union Creek (**Appendix A**). The listed stream segment is 6.1 miles long, extending from the headwaters to its confluence with Union Creek. Washoe Creek is considered partially supporting of aquatic life, the cold water fishery, and primary contact recreation. Probable causes of impairment on Washoe Creek identified in 2006 include sedimentation/siltation, chlorophyll-a, and nutrients (nitrate/nitrite, total phosphorus, and total Kjehdahl nitrogen). Probable sources associated with the identified impairments include open pit mining and silviculture harvesting. In 1996, probable causes included flow alteration, habitat alteration, and siltation.

Washoe Creek supports a resident westslope cutthroat trout population. Fish densities measured in 2000 (MTFWP, 2001), range from 5.1 to 5.7 fish/100. Fisheries-related impairments on the stream identified by MTFWP (2002a) include excessive livestock access to stream banks and lack of instream complexity.

Washoe Creek is located within the Coloma Mining District, and during the latter part of the nineteenth century, placer gold was prospected in the stream corridor (http://deq.mt.gov/abandonedmines/linkdocs/techdocs/143tech.asp). A stamp mill was built along upper Washoe Creek to process ore derived from the Mammoth mine which was located about a mile east on the dived between Washoe Creek and Elk Creek. An open pit barite mine located in the upper part of the drainage has been identified as a potential source of sediment loading to the creek (http://cwaic.mt.gov).

9.2.6.1 Indicators of Habitat and Water Quality Degradation

The base parameter data collected for TMDL development show that on lower Washoe Creek, target parameters of <6mm sediment concentrations, pool frequency, and residual pool depths are not met (**Section 5**). Measured residual pool depth values are notably low, and approximately one-half of the target value. Woody vegetation related parameters are also below target values on Washoe Creek.

In 2004, DEQ sampled Washoe Creek for nutrients, and all three nutrients that were tested for exceeded recommendations for aquatic life and contact recreation. Sampling in 2006 on Washoe Creek also showed elevated nutrient concentrations. Due to limitations in the dataset, however, the water quality impairment status of Washoe Creek with respect to nutrients is undetermined.

DEQ sampling for metals revealed a high concentration of mercury in a single sediment sample, however water column samples were not tested and further testing is therefore necessary. Sampling of Washoe Creek in 2006 did not show any numeric standard exceedences for metals (**Appendix G**).

9.2.6.2 Suspected Sources

The suspected causes of impairment on Washoe Creek include historic mining, livestock grazing within the stream corridor, and silviculture harvesting. An open pit barite mine in the watershed has been identified a source of sediment to Washoe Creek; the mine contains a large open pit that drains into Washoe Creek (http://cwaic.mt.gov/). The results of the sediment source assessment indicate that stream bank erosion is a primary source of the controllable sediment load delivered to the creek (**Table 9-6**). Although not included on the 2006 303(d) List, low flow alterations are also suspected as a source of fine sediment accumulations in Washoe Creek.

Table 9-6. Summary of identified problems and applicable treatments, Washoe Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (35.7 tons/yr)	Riparian Area BMPs
			Grazing BMPs
		Roads (0.4 tons/yr)	Roads BMPs
		Hillslope sediment (2.0 tons/yr)	Riparian Area BMPs
			Upland BMPs
			Grazing BMPs
		Low flow alterations	Water Conservation BMPs
Habitat	Pool extent and quality, woody vegetation extent	Excess fine sediment	See above
		Valley bottom disturbance	Stream BMPs
			Riparian Area BMPs
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to determine impairment status	Collect additional data to determine impairment status
Temperature	Warming on Union Creek at confluence suggests relatively warm water inputs from Washoe Cr.	Insufficient data to determine impairment status	Collect additional data to determine impairment status
Metals	Single sample identified high metals concentration in sediment (mercury)	Insufficient data to determine impairment status	Collect additional data to determine impairment status

9.2.6.3 Recommended Conservation Practices/BMPs

Recommended conservation practices for Washoe Creek include the application of upland BMPs, grazing BMPs, and riparian BMPs to facilitate recovery of the stream corridor with respect to woody vegetation densities, fine sediment loading, and pool habitat parameters. If the barite mine site constitutes a significant point source of sediment, mitigation measures should be applied to reduce that loading. Possibilities for the enhancement of instream flows through water conservation BMPs should be explored as a means to address fine sediment accumulations.

9.2.6.4 Monitoring Needs

DEQ noted that additional sampling of both nutrients and metals is necessary on Washoe Creek to determine its overall water quality impairment status (http://cwaic.mt.gov). Any future restoration efforts on Washoe Creek should include monitoring to determine if the projects meet stated objectives.

9.2.7 East Ashby Creek

East Ashby Creek, a second order tributary to Ashby Creek (**Appendix A**), is considered partially supporting of aquatic life and the cold water fishery. Probable causes of water quality impairment include alteration in streamside vegetative covers, sedimentation/siltation, and nutrients (total phosphorous and nitrate/nitrite). (http://cwaic.mt.gov). Probable sources associated with these causes are forest roads, riparian grazing, and silviculture activities.

East Ashby Creek supports fluvial westslope cutthroat trout and brook trout. In 2000, a fish survey conducted along a 405 foot section of creek at the mouth resulted in the capture of 23 cutthroat trout and 14 brook trout (MTFWP, 2001). Investigators noted that at that time, the East Fork of Ashby Creek appeared to support higher densities of both westslope cutthroat trout and brook trout relative to the lower mainstem of Ashby Creek. Fisheries-related impairments identified on East Ashby Creek include localized areas of riparian livestock overuse, and sediment impacts related to roads and riparian livestock overuse (MTFWP 2001).

East Ashby Creek is located in the Potomac Mining District (http://www.deq.state.mt.us/AbandonedMines/linkdocs/techdocs/143Atech.asp). The Charcoal Mine, also known as the Shawbut Mine, was opened in 1889 on the East Fork of Ashby Creek, approximately 0.5 miles upstream of its confluence with West Ashby Creek. The mine produced lead and silver through the 1950s. The Daisy mine was located within 0.5 miles to the southwest of the Charcoal Mine.

9.2.7.1 Indicators of Habitat and Water Quality Degradation

The only Type I or Type II sediment/habitat indicator that does not meet target values on East Ashby Creek is residual pool depths (**Section 5**). The average residual pool depth measured on East Ashby Creek is 0.4 ft, whereas the target value is 1.0 ft. This poor condition, with respect to pool habitat quality, is likely linked to excess siltation in the streambed. Supplemental indicator values related to woody vegetation extent and woody debris accumulations are also notably low, which will contribute to the poor pool habitat quality.

Macroinvertebrate data collected in 2004 on East Ashby Creek have been used to support the siltation listing on the creek (www.cwaic.mt.gov). Nutrient data also indicate that concentrations of nitrate and total phosphorous exceed recommendations for aquatic life and contact recreation. However, additional nutrient data have been deemed necessary on East Ashby Creek to accurately assess the status of the nutrient impairment.

9.2.7.2 Suspected Sources

Results of the sediment source assessment indicate that roads and road crossings constitute the majority of the controllable sediment load to East Ashby Creek (**Table 9-7**). Along sections of East Ashby Creek, the road corridor encroaches into the riparian zone of the creek. Livestock grazing in the stream corridor has further contributed to sediment loading and riparian degradation.

Table 9-7. Summary of identified problems and applicable treatments, East Ashby Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (2.4 tons/yr)	Riparian Area BMPs
			Grazing BMPs
		Roads (14 tons/yr)	Roads BMPs
		Hillslope sediment (7.0 tons/yr)	Upland BMPs
Habitat	Pool quality	Riparian degradation	Stream BMPs
			Riparian Area BMPs
			Grazing BMPs
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to determine impairment status	Collect additional data to determine impairment status
Temperature	None Identified	None Identified	Collect additional data as necessary
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.7.3 Recommended Conservation Practices/BMPs

On East Ashby Creek, the primary recommendations for conservation efforts that will help achieve full support of beneficial uses include effective application of BMPs on roads and within the stream corridor. The primary objectives of BMP application is the reduced delivery of sediment to the stream channel, and improved densities of woody riparian vegetation. Road BMPs should be especially focused where the stream encroaches into the riparian corridor of East Ashby Creek, as these areas will likely be especially prone to active fine sediment delivery.

In the fall of 2006, a base parameter field crew noted that in the upper portion of East Ashby Creek, a large riparian exclosure was effectively fencing livestock out of the stream corridor. Immediately downstream of the exclosure, however, the channel cross section was over-widened at a livestock crossing. The crew also noted that at the mine site on East Ashby Creek, erosion control placed at the toe of the mine spoils would help reduce localized sediment loading to the creek.

9.2.7.4 Monitoring Needs

The primary monitoring need on East Ashby Creek is for the supplementation of existing nutrient data to clearly assess the water quality condition on the listed stream segment.

9.2.8 West Ashby Creek

West Ashby Creek is a second order tributary to Ashby Creek (**Appendix A**). The listed segment of West Ashby Creek extends for 3.1 miles from its headwaters to the confluence with Ashby Creek. West Ashby Creek is considered partially supporting of aquatic life and the cold water fishery. Probable causes associated with this partial support include alteration in stream-side covers, sedimentation/siltation, and total phosphorous. Associated sources listed as probable in 2006 include forest roads (road construction and use) and silviculture activities.

Westslope cutthroat trout are considered rare in West Ashby Creek (www.cwaic.mt.gov). In 2000, a total of 20 cutthroat trout collected from West Ashby Creek and Ashby Creek fish were found to be 100 percent genetically pure.

9.2.8.1 Indicators of Habitat and Water Quality Degradation

West Ashby Creek flows primarily through granitic terrain, so the sediment-related quality targets applied on the stream reflect those considered appropriate to these granitic areas of the Lower Blackfoot Planning Area. Using targets developed for streams that drain granitic geology, the substrate targets for <6mm and <2mm fractions in riffles are both met, as are pool tailout surface fines. Although substrate targets are met, the Type I pool habitat parameters measured in the stream are below target values (**Section 5**). The average residual pool depth value is one half of the target value. Macroinvertebrate metrics are mixed, with the MMI value meeting the target value, and the RIVPACS O/E value below the target condition.

9.2.8.2 Suspected Sources

A road closely follows West Ashby Creek for several miles; this road is commonly within a few feet of the stream, and clearly encroaching into the riparian zone of the creek. Road encroachment along with extensive logging in the upper watershed are suspected sources of impairment on West Ashby Creek. Results of the sediment source assessment identify both hill slopes and roads as primary contributors of the controllable sediment load to West Ashby Creek (**Table 9-8**).

Table 9-8. Summary of identified problems and applicable treatments, West Ashby Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Roads (14 tons/yr)	Roads BMPs
		Stream bank sediment (4.6 tons/yr)	Riparian Area BMPs
		Hillslope sediment (41 tons/yr)	Forestry BMPs
			Upland BMPs
Habitat	Pool quality/extent,	Excess fine sediment	Riparian Area BMPs
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to determine impairment status	Collect additional data to determine impairment status
Temperature	None Identified	None Identified	Collect additional data as necessary
Metals	None Identified	None Identified	Collect additional data as necessary

9.2.8.3 Recommended Conservation Practices/BMPs

In order to improve water quality conditions on West Ashby Creek, efforts should focus primarily on reducing the volume of fine sediment to the channel. Current inputs of fine sediment have resulted in the degradation of instream habitat in the channel. The primary sources of this sediment have been identified as roads and hill slope areas. Forestry BMPs and Upland BMPs should both be considered to address the impacts of timber harvesting in the watershed. These BMPs will help reduce both the production of sediment from hill slopes, as well as the delivery of that sediment to the creek. Where logging or other access roads encroach into the valley bottom or riparian zone, roads/culvert BMPs should be aggressively applied to further reduce sediment loading to West Ashby Creek.

9.2.8.4 Monitoring Needs

Potential nutrient impairments for West Ashby Creek have not been determined. Limited data is available with respect to nutrients and additional sampling is recommended.

9.2.9 Camas Creek

Camas Creek is a 3rd order tributary to Union Creek, entering Union Creek approximately 7.6 miles upstream from its mouth (**Appendix A**). Camas Creek is considered partially supporting of aquatic life and the cold water fishery. Probable causes identified in 2006 include low flow alterations, sedimentation/siltation, and total phosphorous. Probable sources include grazing in riparian zones, irrigated crop production, and upstream sources.

The Camas Creek drainage supports westslope cutthroat trout, brook trout, and sculpins. Westslope cutthroat trout inhabit the headwaters reaches (MTFWP, 2001). In the listed segment of Camas Creek, westslope cutthroat trout have been noted as rare (http://cwaic.mt.gov). Fisheries-related impairments on lower Camas Creek identified by MTFWP (2001) include lack of a riparian overstory, lack of woody debris, and high sediment levels.

9.2.9.1 Indicators of Habitat and Water Quality Degradation

Camas Creek does not meet any Type I sediment/habitat related targets (**Section 5**). Concentrations of fine sediment in riffles are notably high, with 71 percent of the substrate in riffles consisting of less than 6mm sized material, and 31 percent less than 2mm. Pool habitat parameters also show poor conditions, as pool frequency is less than half the target value, and residual pool depths are 60 percent of the target condition. Other habitat related parameters such as woody vegetation extent and woody debris concentrations depict poor habitat conditions on Camas Creek.

9.2.9.2 Suspected Sources

The poor pool and substrate conditions on Camas Creek likely reflect both accelerated sediment loading and poor sediment transport conditions due to flow depletions. Results of the sediment source assessment indicates that stream banks, roads, and upland areas all contribute significant proportions of the total controllable sediment load delivered to the creek (**Table 9-9**). Land use practices in the stream corridor, including livestock grazing and crop production, are likely primary sources of these conditions. Camas Creek has locally been ditched between roads and agricultural fields. In these areas, the channel occupies a very narrow meanderbelt that allows the formation of some pool habitat. In general, however, the potential of the stream with regard to habitat complexity is not met due to its straightened course.

Table 9-9. Summary of identified problems and applicable treatments, Camas Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (134.5 tons/yr)	Riparian Area BMPs
			Stream BMPs
			Grazing BMPs
		Roads (84 tons/yr)	Roads BMPs
		Hillslope sediment (107 tons/yr)	Grazing BMPs Upland BMPs
		Low Flow Alterations	Water Conservation BMPs
Habitat	Fine sediment concentrations, pool extent/quality, woody vegetation extent	Excess fine sediment	See above
		Channelization	Active Restoration
		Riparian degradation	Riparian Area BMPs
			Grazing BMPs
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to determine sources	Collect additional data to determine impairment status
Temperature	None identified	None identified	Collect additional data as necessary
Metals	None identified	None identified	Collect additional data as necessary

9.2.9.3 Recommended Conservation Practices/BMPs

As the primary identified water quality limitations on Camas Creek are associated with both elevated fine sediment delivery and reduced sediment transport capacity, conservation efforts should focus on improving these two conditions. Sediment delivered to Camas Creek has been determined from uplands, roads, and stream banks. As a result, sediment loading can be reduced by applying appropriate BMPs to each of these sources. This includes riparian and grazing BMPs in the stream corridor, roads BMPs where access roads encroach into the valley bottom, and upland BMPs where land uses have increased sediment production and down slope transport. Furthermore, dewatering of the channel has limited the ability of the stream to flush the sediment that is currently delivered. As such, the application of water conservation BMPs on Camas Creek will help alleviate the sediment accumulation and associated habitat degradation by flushing fine material downstream.

Where Camas Creek has been straightened due to encroachment by roads and agricultural fields, there may be opportunity to widen the meander belt available to the channel. Any opportunity to widen the stream corridor will facilitate the recovery of a woody riparian corridor, and improve instream habitat complexity.

9.2.9.4 Monitoring Needs

Recent data collected on Camas Creek indicate excessive or elevated concentrations of several nutrient parameters. Due to the limited number of samples, however, additional nutrient data are necessary to accurately assess nutrient-related water quality limitations on Camas Creek.

9.2.10 Union Creek

Union Creek is a primary 3rd order tributary to the lower Blackfoot River (**Appendix A**). The listed segment of Union Creek is 19.4 miles long. Union Creek is considered not supporting of aquatic life and the cold water fishery, and partially supporting of primary contact recreation. Probable causes include arsenic, copper, total phosphorous, physical substrate habitat alterations, suspended/bedload solids, and temperature. Probable sources include impacts from abandoned mine lands, animal feeding operations, rangeland grazing, streambank modification/destabilization, and flow alterations from water diversions. Recent metals sampling data suggest no impairment due to arsenic or copper, but did identify concentrations of iron that exceed target levels. As such, a TMDL for iron has been proposed for Union Creek.

Union Creek contains both brook trout and westslope cutthroat trout; brook trout have been identified in low densities in the middle reaches, and resident westslope cutthroat trout have been sampled in low numbers in the middle and upper reaches (MTFWP, 2002a). Fisheries impairments identified by MTFWP (2002a) in the middle and lower reaches of Union Creek include poor road crossings (undersized culverts), irrigation impacts (low instream flows), lack of instream complexity, and degraded riparian vegetation resulting from excessive livestock access to stream banks. In general, the fishery in Union Creek has been described as “extremely depressed” (http://cwaic.mt.gov).

The headwaters area of Union Creek is part of the Copper Cliff mining district. The Copper Cliff mine was located near the upstream end of a steep tributary to upper Union Creek. The mine was discovered in 1890 and was developed with about 1,500 feet of underground workings prior to 1916 (http://deq.mt.gov/abandonedmines/linkdocs/techdocs/144tech.asp). The ore extracted from the mine was primarily copper, with some gold and silver. The mining district continued some ore production through the 1950s. Some ore within the district reached 22 percent copper, however the average copper concentrations were probably less than 1 percent. The Frog's Diner Mine is located downslope from the Copper Cliff Mine, adjacent to the Union Creek channel. The headwaters area of Union Creek has been harvested for timber. Downstream, confinement decreases through a low density willow corridor within an irrigated valley bottom that is typically grazed by horses. Elevated metals concentrations have been associated with historic mining in the upper watershed.

9.2.10.1 Indicators of Habitat and Water Quality Degradation

A total of six base parameter sites were assessed on Union Creek in 2006 in support of TMDL development. At virtually all of the assessed sites, which include relatively steep, confined channels (B-types), moderately steep, sinuous channels (Eb-types), and low gradient, narrow and deep channels (E-types), conditions related to pool habitat quality and fine sediment accumulations are poor (**Section 5**). Residual pool depths do not meet target values in all channel types. Although the percent fine sediment concentrations measured in riffles are met in the Eb channel types, pool tailout surface fines are above target values. In the low gradient E channel types within the Potomac Valley, pool frequencies measured at one assessment site is approximately one half of the target value. Woody vegetation extents are typically low in these reaches, and none of the assessed E channel type reaches meet targets with respect to entrenchment ratio. This entrenched condition in much of lower Union Creek reflects a systemic lack of floodplain access through the Potomac Valley.

On upper Union Creek, temperature data collected in the summer of 2006 document relatively cool temperatures near the headwaters and at the Plum Creek property boundary approximately 6 miles downstream. From the Plum Creek boundary to Washoe Creek, groundwater influx and abundant shading vegetation keep temperatures relatively low. Within this reach, Union Creek currently meets TMDL-associated water quality objectives for temperature (**Section 7**). Downstream of the Washoe Creek confluence, however, temperatures measured in Union Creek increase significantly. At Potomac Road, measured diurmal fluctuations in water temperature were 20^{o} F to 25^{o} F a day (summer 2006), indicating large thermal gains from daytime heating downstream of Washoe Creek. The maximum water temperature measured at Potomac Road briefly exceeded 80^{o} F in late July of 2006. Below Potomac Road, gains in water temperature are tempered by inputs of relatively cool groundwater and tributary surface flow until Morrison Road. Below Morrison Road, temperatures increase in Union Creek. At the mouth of the creek near the Blackfoot River, average daily water temperatures in late July 2006 approached 75^{o} F, and instantaneous measurements exceeded 80^{o} F during six consecutive days in late July 2006. Results of SNTEMP modeling indicate that to meet the target temperature condition on lowermost Union Creek (below Morrison Road), seventy-six percent woody bankline vegetation is needed, along with a 15 percent increase in flows, as well as channel narrowing in areas of inappropriately high width to depth ratios.

With regard to nutrients, previous data collection efforts have identified elevated nutrient values in lower Union Creek (http://cwaic.mt.gov). However, in order to determine the current water quality impairment status with respect to nutrients on Union Creek, additional data needs to be collected.

A total recoverable iron concentration of 1,200 µg/L was measured in upper Union Creek during low flow conditions, which exceeds the chronic aquatic life standard of 1000 µg/L. A roadside seep in the upper watershed had an iron concentration of 12 mg/L (**Section 6**).

9.2.10.2 Suspected Sources

The results of the sediment source assessment indicate that fine sediment loading into Union Creek is predominantly the result of accelerated bank erosion (**Table 9-10**). This bank erosion can be linked to land use practices in the stream corridor.

The gains in Union Creek water temperature downstream of Washoe Creek are attributed to warm tributary inflows from Washoe Creek, as well as due to a lack of shading vegetation on Union Creek below the confluence. Substantial gains below Morrison Road are attributed to a lack of riparian shading, degradation of channel morphology, and dewatering due to flow diversions.

High iron concentrations in Union Creek were measured in the upper reaches of the watershed, in areas of active seepage on the channel margin at the Frog's Diner Mine. The suspected source of this high iron concentration is mine seepage from hard rock mining areas.

Table 9-10. Summary of identified problems and applicable treatments, Union Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess Fine Sediment	Stream bank sediment (952.5 tons/yr)	Riparian Area BMPs
			Grazing BMPs
		Roads (75 tons/yr)	Roads BMPs
		Hillslope sediment (181 tons/yr)	Upland BMPs
			Riparian Area BMPs
Habitat	Pool frequency, residual pool depth, woody vegetation extent	Excess fine sediment; riparian degradation	Riparian Area BMPs
			Grazing BMPs
Nutrients	Limited dataset suggests elevated nutrients	Insufficient data to define sources	Collect additional data as necessary
Temperature	Elevated temperatures below Washoe Creek	Degradation of riparian vegetation and associated shade, dewatering, and channel overwidening	Riparian Area BMPs
			Active channel restoration
			Water Conservation BMPs
Metals	Iron	Seepage from hard rock mines/waste rock	Reclamation

9.2.10.3 Recommended Conservation Practices/BMPs

Fine sediment loading and elevated water temperatures are key problems that should be addressed by the application of conservation practices on Union Creek. The application of Riparian BMPs and Grazing BMPs will facilitate the recovery of woody vegetation within the reach. Due to the degraded nature of the corridor, however, any passive BMP application such as riparian fencing should be accompanied by intensive willow revegetation to facilitate the recovery of streambank stability, and to improve shading. Bioengineered erosion control measures would be appropriate in grazed pasture areas that contain high eroding banks. Because of the impacted cross section on much of lower Union Creek, active reconstruction of the channel to reduce width to depth ratios and improve floodplain connectivity would further contribute to system recovery.

The application of water conservation measures on Union Creek and its tributaries is recommended, as increased instream flows will help improve overall health of the stream by supporting woody vegetation growth, lowering stream temperatures, and flushing fine sediment from the streambed.

The reclamation of areas prone to seepage discharge of iron-rich waters is an important component of water quality management in upper Union Creek. This reclamation should include a thorough evaluation of water treatment/seepage reduction alternatives to maximize the cost/benefit of any such work and to ensure that beneficial uses on Union Creek are met.

9.2.10.4 Monitoring Needs

Recent data collected on Union Creek indicate excessive or elevated concentrations of several nutrient parameters. Due to the limited number of samples, however, additional nutrient data are necessary to accurately assess nutrient-related water quality limitations on Union Creek.

9.2.11 Mainstem Blackfoot River

Two listed segments of the mainstem Blackfoot River are within the Lower Blackfoot Planning Area. The upper segment extends from Monture Creek to Belmont Creek. Only the portion of this segment extending from the Clearwater River to Belmont Creek is within the planning area. This reach was listed for nutrients and siltation in 1996; subsequent listings in 2000, 2002, and 2004 include nutrients and thermal modifications. The listed causes of impairment in 2006 include nutrients (nitrogen and phosphorous) and water temperature.

The listed segment of the Blackfoot River extending from Belmont Creek to the Clark Fork River is entirely within the Lower Blackfoot Planning Area. Pre-2006 listings on this segment included nutrients, siltation, and toxics; in 2006, the segment was listed for ammonia. Probable sources for the ammonia listing included contaminated sediments, riparian grazing, and silviculture. In 2006, the Johnsrud section, which extends from Belmont to Union Creeks, was described as having minor impairment (http://cwaic.mt.gov). Further downstream, at the USGS gaging station approximately 7 miles above the mouth, the river was described as having moderate impairment due to potential metals impacts (iron, lead, and copper) observed in the

1990s. At the lowermost end of the reach, sediments near Milltown were elevated in ammonia. Data collected post-2000 indicate that metals were no longer elevated, although ammonia levels remained relatively high.

Results of TMDL assessments within all Blackfoot River watershed planning areas suggest that pollutant problems in the mainstem Blackfoot River can be in part addressed through the application of appropriate conservation measures on contributing tributaries. If successful conservation measures are put into place on contributing streams, the loadings delivered to the mainstem will be commensurately reduced. The recommended approach to improving water quality on the mainstem Blackfoot is to focus on these tributary inputs and carefully monitor the mainstem with respect to metals, nutrients, temperature, and sediment, to determine if conservation measures are effective, and if undocumented sources of impairment on the mainstem itself have not been identified.

9.3 Implementation Strategy

Successful implementation of this restoration plan and achievement of water quality targets will depend on many factors. This section outlines key elements, strategies, resources, and tools for implementation. Implementation will ultimately depend on the ability, willingness, and priorities of landowners, land managers, and restoration partners.

9.3.1 Key Elements and Approaches

Section 9.2 of this plan describes recommended management actions specific to water quality causes and sources for each impaired water body. The following are key elements to be considered during the implementation of this water quality restoration plan as part of larger watershed efforts.

Partnerships are a primary reason for the success of restoration and conservation efforts in the Blackfoot watershed and continuing this approach is crucial to successful implementation of this plan. Partnerships allow organizations to pool resources, meet multiple management objectives, and reduce duplicative efforts. Equally important is the continued cooperation and involvement of local landowners as a number of water quality impairment issues and much of the restoration needed will occur on private lands. Implementation and achievement of water quality targets will depend largely on the cooperation and support of private landowners and watershed stakeholders and a willingness to work across ownership and management boundaries.

Whenever possible, water quality restoration objectives should include or be included in comprehensive management plans. Comprehensive management is a holistic approach in which a number of resource concerns are addressed through a series of management actions. Comprehensive management allows multiple resource objectives to be met while meeting landowner objectives. It also ensures that benefits from implementation of conservation practices are not offset by failures elsewhere.

Similarly, water quality restoration objectives should integrate or be integrated into existing management directives. In 2005, the Blackfoot Challenge and its partners developed the “Basin-wide Restoration Action Plan for the Blackfoot Watershed." This plan examines the three primary programs currently driving stream restoration in the Blackfoot (native fisheries restoration, water conservation, and water quality restoration) and their relationships. The results of this analysis show a strong correlation between streams needing some level of restoration as identified by these three programs. When restoration projects are being developed, this document can serve as a valuable resource for identifying multiple programmatic objectives.

Selection of conservation practices should be site specific. The effectiveness of conservation practices can vary from site to site. Water quality restoration objectives, other resource management objectives, and landowner needs should be evaluated when developing comprehensive management plans to achieve all potential benefits.

Once conservation practices have been implemented, it is important that the practices be maintained and properly managed. To avoid failure and further degradation, implemented practices should be monitored regularly by the lead partner or landowner (**Section 9.4**).

It is essential to protect or maintain areas where water quality targets and objectives are being met. Current management practices should be maintained in areas where restoration has already occurred or areas that are trending towards recovery. If disturbance is necessary, steps should be taken (BMP implementation) to ensure impacts are minimal.

The TMDL process cannot possibly identify all impaired streams or water bodies. There are a number of streams not assessed during this process where water quality could be improved. These un-assessed streams are also likely to contribute to water quality concerns at a watershed scale. Streams not included on the 303(d) List or not assessed during TMDL development should not be excluded from water quality restoration efforts.

9.3.2 Partners and Priorities

The Blackfoot watershed has a long history of restoration, conservation, cooperation and partnerships. Organizations such as the Blackfoot Challenge and the Big Blackfoot Chapter of Trout Unlimited (BBCTU) have facilitated public-private partnerships in an effort to address natural resource issues on a watershed-wide scale. These partnerships have led to a tremendous amount of successful on-the-ground restoration and conservation projects. While this plan recognizes that partners will pursue restoration projects based on organizational priorities and management directives, it strongly encourages partnerships as a means of implementation. The following describes water quality related management activities, directives, and priorities of major stakeholders in the Blackfoot watershed.

The Blackfoot Challenge is a landowner based watershed group whose mission is to "enhance, conserve and protect the natural resources and rural lifestyle of the Blackfoot River Valley for present and future generations." The Blackfoot Challenge is involved with a number of natural resource related programs including weed management, wildlife and wildlife habitat management, conservation of large landscapes, drought and water conservation, and education. The Blackfoot Challenge has also served as the primary facilitator of stakeholder involvement in the water quality restoration planning and TMDL development process in the Blackfoot watershed and will continue to work with all partners and private landowners on implementation of this plan and restoration of water quality.

For the past 20 years, the Big Blackfoot Chapter of Trout Unlimited (BBCTU) has lead native fish recovery efforts in the Blackfoot watershed. With their partners, BBCTU has completed hundreds of projects that have improved fish habitat, fish migration, wetlands, riparian areas, and water quality throughout the watershed. In the future, BBCTU will continue to develop and implement projects that aid in the recovery of native fisheries on both private and public lands. These projects will undoubtedly have positive impacts on water quality.

Much of the success of the Blackfoot Challenge and BBCTU has been due to the participation and support of private landowners. Private landowners have played a critical role in the development of this water quality restoration plan by allowing access to lands, sharing knowledge of streams and management practices, and participating in public forums during its development. Their support and participation will become even more important as this plan is implemented.

The Natural Resource Conservation Service (NRCS) focuses primarily on agricultural land (grazing land and cropland), and the predominate use of private land in Montana. NRCS emphasizes voluntary, science based assistance, partnerships, and cooperative problem solving at the community level through the locally-led conservation process. NRCS offers numerous programs to private landowners and agricultural producers for the implementation of conservation practices. Sustainable agriculture as well as the improvement and protection of streams, riparian areas, water quality – specifically sediment and nutrient reduction, and water quantity are primary program objectives of the NRCS.

Missoula Conservation District promotes sustainable resource management for all natural resources in Missoula County. Their goals (in order of priority) are to improve and protect water quality, stream corridors and stream and riparian habitats; improve and protect water availability; mitigate resource impacts of suburban development in rural areas; promote wise land use practices; and increase public awareness of the conservation district's role and responsibilities. Missoula Conservation District administers the State 310 Law (Natural Streambed and Land Preservation Act of 1975) within Missoula County on private landowner projects. The purpose of the 310 Law is to insure that projects on perennial streams will be carried out in ways that are not damaging to the stream or to adjoining landowners. In addition to the 310 Law administration, Missoula CD offers technical assistance and funding to private landowners both through their staff and programs and through partnership with NRCS to implement natural resource conservation practices.

Plum Creek Timber Company owns and manages approximately 108,473 acres in the Lower Blackfoot planning area. The Plum Creek Native Fisheries Habitat Conservation Plan (PCNFHCP) describes primary restoration objects for basins within the Blackfoot watershed. The PCNFHCP includes specific timeframes for upgrading roads in all drainages by 2010 and 2015 of which substantial work has been done to date. Fish passage barrier removal is being done in conjunction with road improvements. Riparian protection, research and monitoring, grazing leases, range management plans are also included in this plan.

The U.S. Forest Service manages approximately 20,248 acres in this planning area. The primary focus of the Lolo National Forests, with respect to water quality, is reducing sediment delivery from roads through implementation of Road BMPs and general road improvements. Many of these road improvements will also include replacement of undersized culverts allowing for fish passage, improved flow conveyance, and improved stream channel form and function.

The Montana Department of Natural Resources and Conservation (DNRC) manages lands in the Lower Blackfoot planning area. DNRC's on-going projects include implementation of Road and Forestry BMPs and enforcement of Montana's Streamside Management Zone (SMZ) Law to reduce erosion, sedimentation, and to protect water quality. Projects may include road inventory maintenance and road improvements/removal such as the upgrade of existing roads and stream crossings constructed prior to BMP to improve water quality and allow for fish passage. DNRC also utilizes extended SMZ widths on sites with high erosion risk or on streams supporting cold-water fish species to protect fish habitat. DNRC is, and will continue to be an active partner with landowners and agencies for restoration activities to improve water quality, conservation activities, and fish habitat.

The Bureau of Land Management (BLM), Missoula Field Office, oversees approximately 11 percent of the acreage in the Lower Blackfoot Planning Area. Water quality management is guided under a Memorandum of Understanding with Montana DEQ. The main focus at the field-level is identifying actual pollutant sources, evaluating cause and effect, and designing and implementing cost-effective restoration and/or ongoing pollutant control measures including Best Management Practices (BMPs). Recent activities in the planning area which addressed water quality concerns include reducing road erosion and hazards on thirty three sites in the Blackfoot River Corridor between Gold Creek and Belmont Creek, improving riverbank trails and floating access sites, revegetation, exclosure fencing, fish habitat enhancement on Belmont Creek, and the application of Road BMPs in the Keno, Kennedy, and Washoe watersheds in 2007.

Montana Fish, Wildlife and Parks (FWP) is responsible for the management of rivers and streams in Montana. The primary focus of Montana FWP will continue to be native fisheries recovery and management. Montana FWP has been a significant partner in efforts to date.

The Montana Department of Environmental Quality (DEQ) is charged with oversight and implementation of the Non-Point Source (NPS) Program. DEQ has provided technical and financial assistance to the development of TMDLs in the Lower Blackfoot planning area. Through the 319 program, DEQ will also be able to provide technical and financial assistance to the implementation and monitoring activities described in this restoration plan.

The U.S. Geological Survey (USGS) collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. This is evident in the Blackfoot as USGS maintains five continuous flow and temperature gages and has provided assistance to multiple organizations in the collection and analysis of water quality data. USGS will continue to aid in the understanding of water quality issues and solutions through future monitoring.

The water quality related management activities and directives described above offer numerous opportunities for implementing this restoration plan through partnerships. The Blackfoot Challenge and BBCTU will continue their partnership to implement projects that lead to improved water quality, native fish recovery, and water conservation. Much of the work needed to achieve water quality targets and objectives will occur on private lands. The Blackfoot Challenge, BBCTU, local Conservation Districts, and the Natural Resource Conservation Service (NRCS) have a long history of private lands restoration and conservation and working together will likely be the lead organizations developing and implementing water quality restoration projects in cooperation with private landowners. The Blackfoot Challenge and BBCTU have also worked extensively with other private organizations and public agencies to implement restoration projects and conduct monitoring. These are just a few examples of the partnerships at work in the Blackfoot. Strengthening these partnerships and forming new partnerships will allow partners to meet internal water quality management objectives as well as those of this plan.

9.3.3 Water Quality Restoration Projects

Section 9.2 of this plan provides specific management recommendations for achieving water quality targets for impaired streams in the Lower Blackfoot planning area. Numerous projects and opportunities are possible based on these recommendations but will require further development prior to implementation. **Table 9-11** presents a list of projects on listed and non-listed streams in the Lower Blackfoot planning area that are under development or slated for implementation in the near future by various partners.

Table 9-11. Water Quality Restoration Projects

Stream/Watershed	Project Partners	Project Description	Water Quality Component	Status
Blackfoot River (Clearwater River to Belmont Creek)	BBCTU/Private Landowner	Fencing, off-stream watering facilities; and grazing management plan	Improve riparian area vegetation and bank stability; reduce erosion	Under development

9.3.4 Funding

A number of funding sources are available for implementation of water quality restoration projects and monitoring under this restoration plan. **Table 9-12** contains a list of funding opportunities including state, federal, and private sources. The funding limits, funding cycle, eligible applicants, and a description are provided for each grant source. While this is a fairly comprehensive list of potential funding sources for project implementation, there are numerous other funding sources that could support implementation of this restoration plan which are not listed and further research will be required.

Table 9-12. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
DEQ 319 Program	1.5 million annually	Annual	Government Entities and Non-profit Organizations	Funds must be used for water quality protection, improvement, or planning; 4 categories of applications - Watershed TMDL Planning, Watershed Restoration, Groundwater, and Information/Education
MT FWP Future Fisheries	~$750,00 annually	6 months	Anyone, but coordination with local fisheries biologist recommended	Projects that restore or enhance habitat for naturally reproducing populations of wild fish.
DNRC RRGL Planning Grant	$300,000 this biennium	Biannual	Government Entities	Must be for the conservation, management, development, or protection of a renewable resource in Montana. 50% cash match required unless sponsored by a non-revenue producing entity such as a CD
DNRC RRGL Grant	4 million biennial	Biennial	Government Entities	Must be for the conservation, management, development, or protection of a renewable resource in Montana.
DNRC RDGP	4 million biennial	Biennial	Government Entities	Projects that reclaim lands damaged by mining; activities that address crucial state needs. Projects must provide benefits in one or more of the following: reclamation, mitigation, and research related to mining and exploration; identification and repair of hazardous waste sites, research to assess existing or potential environmental damage.
DNRC Private Grants	$100,000 biennial	Biennial	An individual association, for-profit corporation or non-profit corporation	Projects relating to water where the quantifiable benefits exceed the costs
NRDP - Large Grants	6.5 - 8.5 million annually	Annual	Government Entities, Privates, Non-profits	Projects must restore, replace, or acquire the equivalent of injury natural resources and/or lost services covered in Montana v. ARCO lawsuit
NRDP - Project Development Grants or Small Projects	$200,000 annually	Annual	Government Entities, Privates, Non-profits	Projects must restore, replace, or acquire the equivalent of injury natural resources and/or lost services covered in Montana v. ARCO lawsuit

Table 9-12. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
USFWS Fish & Habitat Conservation - Fish Passage	Nationally 3.6 million in 2005	Annual	Unrestricted	Project funding is for fish passage restoration by removing or bypassing barriers to fish movement such as dam removal, culvert renovation, designing and installing fish ways, installing fish screens, and barrier inventories to identify additional fish passage impediments.
USFWS Partners for Fish & Wildlife Program	Nationally 16.8 million in 2005	Annual	Some restrictions	This program provides technical and financial assistance to private landowners for habitat restoration on their lands. A variety of habitats can be restored to benefit federal trust species (for example migratory birds and fish and threatened and endangered species).
USFWS Private Stewardship Grants Program	Nationally 6.5 million in 2005	Annual	Some restrictions	This program provides grants and other assistance to individuals and groups engaged in private, voluntary conservation efforts that benefit species listed or proposed as endangered or threatened under the ESA. Eligible projects include those by landowners and their partners who need technical and financial assistance to improve habitat or implement other activities on private lands.
USFWS Cooperative Endangered Species Conservation Fund (Section 6)	Not specified	Annual	State governments that have a current cooperative agreement with the Secretary of the Interior	This program funds a wide array of voluntary conservation projects for candidate, proposed, and listed endangered species.
USFWS Cooperative Conservation Initiative	Not specified	Annual	Not specified	Support efforts that restore natural resources and establish or expand wildlife habitat
USFWS Fisheries Restoration & Irrigation Mitigation Act (FRIMA)	Not specified	Annual	Local and state governments, partnerships, and Conservation Districts. Landowner is often a co-applicant	Design, construction, and installation of fish screens, fish ladders, or other fish passage devices associated with water diversions. Projects may also include modifications to water diversion structures that are required for effective functioning of fish passage devices.

Table 9-12. Funding Programs

Agency/Grant Program	Amount	Funding Cycle	Who Can Apply	Description
USFWS Dingell-Johnson Sport Fish Restoration	Nationally ~293 million in 2005 & 2006	Annual	State fish & wildlife agencies	Support activities designed to restore, conserve, manage, or enhance sport fish populations and the public use benefits from these resources; and to support activities that provide boating access to public waters. Projects supported include fish habitat improvement, research on fishery problems, surveys and inventories of fish populations, provision for public use of fishery resource, and lake and stream rehabilitation.
USFWS Landowner Incentive	Nationally 18 million in 2005; 34 million in 2006	Annual	State fish & wildlife agencies	These grants are available for conservation efforts to be carried out on private lands, to provide technical or financial assistance to private landowners for the purpose of benefiting Federally listed, proposed or candidate species.
USFWS North American Wetlands Conservation Fund (NAWCA)	61 million in 2005; 75 million in 2006	Annual	Public and private organizations or individuals who have developed partnerships to carry out wetland conservation projects	Funds may be used to restore, manage, and/or enhance wetland ecosystems and other habitat for migratory birds and other fish and wildlife. Lands and waters must have as their primary purpose long-term water conservation for the benefit of migratory birds and other wildlife.
NRCS Environmental Quality Incentives Program	Not specified - varies from national to state level	Annual	Private landowners that are agricultural producers (can be assisted by conservation groups, consultants, etc.)	Provides voluntary conservation program for farmers and ranchers that promote agricultural production and environmental quality as compatible national goals.
NRCS Wildlife Habitat Incentives Program	Not specified - varies from national to state level	Annual	Private landowners (can be assisted by conservation groups, consultants, etc.)	Voluntary program for people who want to develop and improve wildlife habitat primarily of private lands. This program provides both technical and cost share assistance to establish and improve fish and wildlife habitat.

Table 9-12. Funding Programs

Agency/Grant Program	**Amount**	**Funding Cycle**	**Who Can Apply**	**Description**
FSA Conservation Reserve Program	Acreage capped program - currently 39.2 million acres nationally	Annual	Private landowners that are agricultural producers (can be assisted by conservation groups, consultants, etc.)	Program offers annual rental payments, incentive payments, and cost-share for establishment of grasslands, riparian habitat, and wetlands on marginal cropland and pastureland.
NRCS Wetlands Reserve Program	Not specified - varies from national to state level	Annual	Private landowners (can be assisted by conservation groups, consultants, etc.)	Voluntary wetland conservation program that offers perpetual easements, 30-year easements, and 10-year restoration cost-share agreements. NRCS holds CEs; private landowner controls access and performs management.
BOR Water Conservation Field Services Program	$450,000	Annual	Unrestricted	Financial assistance for demonstration programs and pilot projects to promote and implement improved water management and conservation. Also for planning, designing, and construction improvements that will conserve water, increase water use efficiency, or enhance water management through measurement or automation, at existing water supply projects within the 17 western states.
Columbia Basin Water Transaction	Not specified	Not specified	Qualified Local Entities (Trout Unlimited)	Improve flows to streams and rivers in the Columbia Basin through water acquisitions, boosting efficiency, conserving habitat, rethinking the source, pools, and banks.
Tri-County Resource Advisory Council	Varies - designated by counties each fiscal year. $100,000 was available for the 2005 fiscal year	Annual - The SRSCSDA expires on September 30, 2006. Congress will need to re-approve this Act for funding past this date	Unrestricted - preference is for projects with several partners	Projects must be located within one of the three counties covered by the Tri-County RAC (Deer Lodge, Granite, or Powell). Funds must be spent on projects that benefit federal land, although projects do not have to be located on federal land. Eligible projects include watershed restoration and maintenance; restoration, maintenance, and improvement of wildlife and fish habitat; or reestablishment of native species.

9.4 Evaluating Success and Adaptive Management

This plan acknowledges the uncertainties and limitations associated with setting water quality restoration targets and timelines for achieving those objectives. Stakeholders recognize that this plan is only the first step in a cyclical process that will be employed to restore water quality in the Lower Blackfoot planning area. Water quality restoration targets and objectives as well as the expectations for achieving them will likely need to be modified over time as implementation occurs, natural conditions change, and new knowledge is gained.

In order to determine whether the causes and sources of water quality impairment have been properly identified, whether water quality restoration targets are being achieved as a result of implementation, where additional work is needed, and if adjustments to the plan are necessary it will be important to establish a program for measuring success. This section describes key elements needed for evaluating the restoration of water quality in the Lower Blackfoot planning area and strategies for adaptation based on experiences and new knowledge.

9.4.1 Tracking Implementation

A system for tracking completed projects and monitoring is necessary to evaluate the local and cumulative effects of restoration on water quality. The “Basin-Wide Restoration Action Plan” proposes such a tracking system but it has not yet been developed. An integral part of evaluating the success of this water quality restoration plan will be to develop, implement, and maintain this tracking system. The Blackfoot Challenge maintains a small internal database of completed projects and monitoring in which it has been a partner. The Blackfoot Challenge will continue to update and maintain this database with projects it implements under this restoration plan. The Blackfoot Challenge will also pursue the development of a watershed project database in which partners can regularly update information.

9.4.2 Monitoring

Monitoring at various scales will be critical to evaluating the success of this restoration plan. Monitoring is required to assess the effectiveness of restoration activities both locally and at the watershed scale. Monitoring will also help to assess whether water quality restoration targets are being met as a result of restoration activities; provide justification to modify restoration strategies, numeric targets, load allocations, or timelines for achieving water quality restoration objectives when appropriate; and to identify or better delineate additional causes and sources of water quality impairment. The following describes four levels of monitoring that are recommended under this plan.

9.4.2.1 Restoration Effectiveness Monitoring

Site specific restoration monitoring should be used to evaluate the effectiveness of restoration in achieving water quality restoration targets for a given stream or stream reach. Monitoring parameters will vary based on the 303(d) listed stream and its associated impairments and specific monitoring plans will need to be developed based on the project. The Restoration Effectiveness Monitoring Protocol of the “Basin-Wide Restoration Action Plan” was written to provide restoration planners with a common reference for determining the appropriate monitoring parameters/activities to utilize on a given project. **Table 9-13** comes directly from the Restoration Effectiveness Monitoring Protocol and shows suggested monitoring parameters to be used for restoration projects depending on the restoration goals and/or the particular water quality impairment.

Table 9-13. Restoration Monitoring Matrix

METRICS	RESTORATION PROJECT OBJECTIVES/IMPAIRMENT CAUSES							
	In-Stream Flow Maintenance	**Habitat Restoration**	**Reduce Substrate Siltation**	**Reduce Thermal Modification**	**Reduce Ag Runoff**	**Riparian Area Restoration**	**Reduce Elevated Metals**	**Reduce Elevated Nutrients**
BIOLOGICAL METRICS								
Fish Population Surveys	X	**X**	X	X	X	X		
Redd Counts	X	**X**	X	X	X	X		
Macroinvertebrate Sampling	X	X	X	X	X	X	X	X
Periphyton Sampling	X	X	X	X	**X**			X
Chlorophyll-a					**X**			X
PHYSICAL PARAMETERS								
Habitat Assessments	X	**X**				**X**		
Riparian Assessment		X	X	X	X	**X**		
Water Temperature	X	X	X	**X**	X	**X**		
Flow Monitoring	**X**			X			**X**	**X**
Photo Points	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
WATER CHEMISTRY								
TSS Samples			**X**		**X**		X	X
Nutrient Sampling					**X**			**X**
Metals Sampling							**X**	
STREAM SUBSTRATE COMPOSITION								
McNeil Core Samples		X	**X**			X		
Percent Fine Sediment Content		X	**X**			X		

X – Metrics marked in bold should be given primary consideration for monitoring
TSS- Total Suspended Sediment

The Blackfoot Challenge has recently been involved with site specific project monitoring for projects in which it is a partner. The Blackfoot Challenge has used the Restoration Effectiveness Monitoring Protocol to determine appropriate monitoring parameters. The Blackfoot Challenge will continue to conduct site specific restoration monitoring on projects where it is a partner and will continue to track these data collection efforts. Other partners often collect site specific restoration data. Data collected by various partners should be viewed collectively when evaluating the project effectiveness. A variety of methodologies for data collection are also utilized. Whenever possible, site specific restoration monitoring on previously assessed locations will utilize previous assessment methods to ensure consistency.

9.4.2.2 Status and Trends Monitoring

Over the past 15 years, hundreds of stream related projects have been implemented by various partners in the Blackfoot watershed (Blackfoot Challenge, 2005). These projects have improved conditions locally and have undoubtedly had a cumulative impact on water quality and fisheries resources throughout the watershed. In addition to measuring the effectiveness of individual projects, monitoring will need to occur at the watershed scale. In 2004, partners in the Blackfoot developed and implemented the Blackfoot Watershed Status and Trends Water Quality Monitoring Program. The purpose of this program was to “develop a fixed set of locations to evaluate and describe the status, spatial patterns, and time trends in water quality in the Blackfoot watershed” (Land & Water 2002). In 2004 and 2005 water quality data was collected at 12 stations in the Blackfoot providing baseline conditions. Of these 12 stations, one is located within the Lower Blackfoot planning area (Land and Water, 2004). Monitoring at this scale is important to understanding water quality in the Blackfoot. Due to the expense of this monitoring program, it is not feasible to perform this monitoring on an annual basis. However, monitoring at these stations at least every 3 to 5 years is recommended.

9.4.2.3 Additional TMDL Assessments

Several cases arose during the development of TMDLs for the Lower Blackfoot planning area where additional assessments or monitoring are needed to better understand conditions, better delineate, quantify, or identify water quality impairment sources including natural or anthropogenic sources; or identify additional water quality impairments or impaired streams. The following describes additional TMDL assessment needs.

- The scale of the SWAT model used to determine the sediment load from hill slope sources was broad and coarse. Continued refinement or redevelopment of a predictive sediment loading model with improved sub-basin resolution, improved landcover characteristics, and more accurate flow characterizations is recommended. The refinement of the SWAT model should also be supplemented with field measured hill slope sediment loading rates and volumes.
- Based on recent studies conducted by Plum Creek Timber Company and the University of Montana, base erosion rates (10 tons/acre/year) chosen to calculate road sediment loads should be reevaluated during the five-year TMDL review. Sugden and Woods (2007) found that the estimated base erosion rate of 10 tons/acre/year are three to ten times higher than actual measured values.

- An effort is needed to compile and summarize existing road data from major stakeholders, review road management activities and plans, identify roads and road-crossings with high sediment load contributions, identify road-crossings that present barriers for fish passage, identify road related management efforts beyond BMP implementation, and prioritize road related water quality restoration activities.
- Due to limited datasets and a need of better refine modeling tools, TMDLs were not developed for nutrients in the lower Blackfoot. Additional monitoring is needed to determine nutrient impairments, to identify potential nutrient sources, and to identify possible management actions. Streams requiring additional nutrient sampling in the lower Blackfoot include West Fork Ashby Creek, East Fork Ashby Creek, Camas Creek, Upper Elk Creek, Union Creek, Washoe Creek, and the Blackfoot River.
- Similar to nutrients, the current dataset for metals is limited and additional monitoring is recommended. Metals sampling should include streams previously listed for metals impairments (Upper Elk Creek, Union Creek, and the Blackfoot River) and in areas where extensive mining has occurred. Additional metals sampling will lead to a better understanding of impacts to water quality from historic mining and identify possible restoration activities in these areas.
- Sediment from potential culvert failures represents a substantial portion of controllable sediment load and necessary sediment load reduction. An assessment of culverts in the Lower Blackfoot planning area is recommended to identify those culverts most at risk for failure and to develop a prioritized list of culvert upgrades.
- High, naturally occurring concentrations of arsenic in groundwater that exceed drinking water standards has been found locally in the Potomac valley. Though not a wide-spread occurrence, this plan makes note of it to raise awareness of the issue and to encourage residents of the Potomac valley to test groundwater wells for arsenic, nitrate, and bacteria concentrations for their own health and well-being. More information on testing groundwater wells can be obtained by contacting the Missoula County Environmental Health Department.

9.4.2.4 Five-Year Review

Five years following TMDL development, Montana DEQ evaluates the Watershed Restoration Plan and all other available sources of information for BMP implementation, criteria attainment, beneficial use support, and the degree to which TMDL objectives have been met (Montana DEQ Framework for TMDL Five-Year Review, December 2006). The Blackfoot Challenge and its partners will assist DEQ as needed on any future evaluations of this plan.

SECTION 10.0
PUBLIC AND STAKEHOLDER INVOLVEMENT

Five individuals/organizations submitted formal written comments. Their comments have been summarized/paraphrased and organized below by primary topic headings corresponding to document sections. Responses prepared by DEQ follow each of the individual comments. The original comment letters are located in the project files at DEQ and may be reviewed upon request. Where specific modifications to the document have been made in responding to comments, they are noted in the responses.

In addition to the comments below, several general comments that mainly included grammatical errors and missing or mistaken references were addressed by modifying the final document. These comments were addressed and are not summarized below.

10.1 Executive Summary, Introduction, Regulatory Framework and Watershed Characterization (Sections 1.0 - 3.0)

Comment 10.1.1

The size of the watershed areas for each listed stream should be given in **Section 3.0** to help the reader normalize the sediment data into tons/acre.

Response 10.1.1

The following table has been inserted into **Section 3.0.**

Streams Name	Drainage Area (Square Miles)	Drainage Area (Acres)
West Ashby Creek	4.5	2,866
East Ashby Creek	6.0	3,781
Belmont Creek	29.3	18,733
Camas Creek	40	25,839
Upper Elk Creek	28	18,063
Lower Elk Creek	23	14,652
Keno Creek	2.6	1,640
Union Creek	51	32,533
Washoe Creek	8.5	5,422

Comment 10.1.2

Despite nutrient listings for several streams on the 1996 and 2006 lists, DEQ cites the pending development of numeric nutrient standards does not develop nutrient TMDLs in the Lower Blackfoot planning area. This decision is inconsistent with the agency’s decision to develop nutrient TMDLs for two streams in the upper Big Hole River watershed. The decision to postpone nutrient TMDL development in the Lower Blackfoot has implications for the threatened bull trout (*Salvelinus confluentus*). Nutrient related accumulations of benthic algae decreases the suitability of habitat for benthically-oriented bull trout, constraining an imperiled species that is highly selective of clean substrates.

The presence of whirling disease in the lower Blackfoot River watershed provides an additional justification for addressing nutrient enrichment. *Tubifex tubifex*, the intermediate host to the protozoan causing whirling disease, is highly tolerant of eutrophication that can be caused by nutrient enrichment. The assessment record for nutrient impaired Camas Creek noted high numbers of tubificid worms in benthic samples. The delay in nutrient TMDL development is counter to the interests of westslope cutthroat trout occupying this stream.

Response 10.1.2

There are basic differences between the Blackfoot and Big Hole watersheds that have prompted DEQ to take more time to develop Lower Blackfoot nutrient TMDLs. The higher potential for significant residential development in the Lower Blackfoot requires a more complex means of assessing the effects of septic discharges. Nutrient transformations in effluent between the drainfields and surface water recharge zones require a modeling tool that accounts for processes such as denitrification in groundwater and instream biological consumption. The modeling tool applied in the Big Hole (Generalized Watershed Loading Functions or GWLF) has no routing component, is not spatially explicit and uses simple export coefficients to quantify loading.

Discrete, numeric nutrient standards are in effect on the Clark Fork River below the mouth of the Blackfoot. The need to balance Blackfoot river nutrient loading to achieve Clark Fork standards also calls for improvements to the simulation tool applied in the Blackfoot. Numeric standards are not being applied below the mouth of the Big Hole River. Point source nutrient dischargers of in the Clark Fork basin are in need of a more precise nutrient accounting tool to plan for affordable future upgrades to their treatment systems. This is less of a concern in the Big Hole that has fewer such dischargers.

An improved and more complex nutrient loading simulation tool typically requires more data describing existing conditions and their seasonal variation. A delay in nutrient TMDL development will also allow time to improve the nutrient database in many headwater reaches and help to better define the relationship between the lower Blackfoot sediment TMDLs and nutrient loading in the lower Blackfoot.

Comment 10.1.3

The statement on page 14, **Section 2.3** of the document that “DEQ must address all pollutant/water body combinations appearing on the 2006 303(d) List” is misleading and erroneous. The order requires establishment of TMDLs for water quality limited segments identified on the 1996 303(d) List.

Response 10.1.3

Section 2.3 of the document has been edited to clarify the relationship between the 1996 303(d) List and the use support determinations contained in the Water Quality Integrated Report for Montana (DEQ 2006). The TMDLs developed in the Lower Blackfoot document integrate water quality problems identified on the 1996 303(d) List and verified since that time.

10.2. TMDL Assessment Projects and Data Sources (Section 4.0)

Comment 10.2.1

In **Table 4-2**, Plum Creek Timber Company (PCTC) is cited as providing temperature data for Belmont Creek, though Belmont Creek is not listed as impaired for temperature. The table does not mention that Plum Creek provided stream temperature data for upper Union Creek and Camas Creek.

Response 10.2.1

Table 4-2 is intended to be a catalog of data sources regardless of the pollutant causes for which TMDLs are developed. The table will be edited to reflect that Plum Creek Timber Company provided DEQ with temperature data for upper Union and Camas creeks.

Comment 10.2.2

The data assessment record for the Blackfoot River suggests DEQ reviewed nutrient data from the outdated STOREASE database while apparently overlooking the more modern STORET database. STORET contains over 2,000 records of nutrient analyses conducted from samples collected along the mainstem of the lower Blackfoot River over the past two decades. DEQ collected a large portion of these samples. DEQ should incorporate STORET data into its assessment record for the Lower Blackfoot.

Response 10.2.2

The information sources referenced in the Blackfoot River assessment record reflect those considered at the time of the most recent update of that record by staff of the Monitoring and Assessment Section at DEQ. The assessment record for the Blackfoot River on which the STOREASE database is listed as a source is that for segment MT76F001_033, the Blackfoot River from Belmont Creek to the mouth. This record was last updated on June 5th, 2006. Therefore, it does not contain data collected specifically for TMDL development during the field assessment of September 2006 or water quality data collected from lower Blackfoot tributaries in June and September of the same year. Current versions of the assessment record for any water body will rarely catalog all data used to develop TMDLs for that water body due to the time lag between assessment record updates and scheduled TMDL development. Regarding use of the EPA STORET database, downloading and analysis of STORET data for a listed water body are routine components of TMDL planning at DEQ and any future formal assessment activities documented within DEQ assessment record files will include STORET information as appropriate. The data sources used for the lower Blackfoot TMDL development are listed in **Table 4-2** of the document and include STORET.

10.3 Sediment and Habitat Impairments (Section 5.0)

Comment 10.3.1

PCTC has major concerns about the accuracy of the SWAT model predictions of hillslope erosion, as previously expressed regarding the draft Middle Blackfoot – Nevada Creek TMDL. As a forest hydrologist, a long-time member of the state forestry BMP audit team, and someone who has inspected hundreds of timber harvests, I have found that where BMPs are applied, even to a modest level, it is exceedingly rare for hillslope erosion to occur. This is supported by measured sediment yield data in the lower Blackfoot for Johnson Creek and West Fork Gold Creek (see Sugden 1994). The only exception to this is following wildfire. Simply stated, I don't believe the model results and, from the level of post-processing, it appears that DEQ has reservations about the estimates as well.

Given a lack of field evidence to support this being included in the TMDL as a significant source, my recommendation would be for DEQ to remove hillslope erosion from the sediment budget altogether. If DEQ is not willing to do this, then at a minimum, the "adjusted" values should be reported in **Sections 5.6.1** (**Table 5-17**) and **5.6.5** (**Table 5-22**) rather than the unadjusted estimates.

Response 10.3.1

As evidenced by the level of post-processing of the SWAT hillslope erosion estimates, DEQ acknowledges the need to modify model input files to improve future hillslope erosion estimates for the entire Blackfoot River watershed. Refinement or redevelopment of the modeled sediment loading estimates is a stated goal in **Section 8.1.9** of the document that describes the margin of safety for sediment TMDLs. Adjustments to model inputs are currently underway with the application of SWAT in other TMDL planning areas. Despite the high level of uncertainty in the Blackfoot estimates, DEQ prefers that hillslope erosion remain as an acknowledged source of sediment loading as iterative improvements are made to the modeling framework. Model refinement or redevelopment is preferred to the complete removal of the hillslope erosion portion from the sediment loading estimate. However, the adjusted hillslope estimates will be added to the tables referenced above to emphasize the degree of needed post processing.

Comment 10.3.2

In **Section 5.5.5**, paragraph 2, the Belmont Creek Watershed Analysis (Sugden 1994) is incorrectly cited as stating "*…estimated hillslope erosion rates were twice those of reference conditions*." The study found that modeled road erosion rates were about twice the estimated natural background erosion rate. Current rates of hillslope erosion were deemed de minimis based on an examination of recent harvest units and a lack of any observed erosion features. **Section 5.5.5** should be corrected to be consistent with the above statements.

Response 10.3.2

After further review of the Sugden (1994) publication, the sentence in **Section 5.5.5** will be edited to read as follows: "At that time, the modeled amount of sediment being generated by the road system was about two times more sediment than would be expected under undisturbed conditions."

Comment 10.3.3

The first paragraph of **Section 5.5.5.1** cites restoration activities undertaken by BLM in the meadow reach of lower Belmont Creek. The document should be revised to mention that PCTC took restoration actions on this same reach in 1995, which involved excluding the meadow from livestock grazing, planting hardwood shrubs, and conifers.

Response 10.3.3

The lower Belmont Creek restoration description will be rewritten as follows: "Restoration activities in the reach included large woody debris placement by the BLM as well as 1995 grazing exclusion fencing and shrub and tree planting by PCTC."

Comment 10.3.4

PCTC is disappointed that DEQ elected to not incorporate Plum Creek site-specific road erosion inventories available in the lower Blackfoot. This included data PCTC provided for East Ashby, West Ashby, and Belmont Creeks. PCTC also provided data for two unlisted tributaries: Johnson Creek and West Fork Gold Creek. Several of these inventories were undertaken with the express intent of supporting the Lower Blackfoot TMDL process. These data were communicated to DEQ on 1-21-08 and again on 7-2-08. While extrapolating data from the Middle Blackfoot will probably yield reasonable average results, it is difficult to understand why DEQ would not use site-specific watershed data when it is readily available. PCTC asks that the PCTC site-specific data for East Ashby, West Ashby, and Belmont be cited and included as an additional column in **Table 5-20**. Additionally, this data should be mentioned in **Section 4.5**, as well as in **Table 4-2**.

Response 10.3.4

The method for estimating sediment loading from road erosion has frequently been discussed since the field survey crews returned with their results for the Middle Blackfoot-Nevada Creek planning area in 2005. At the request of PCTC, the assumed base erosion rate used in that planning area was lowered from 30 to 10 tons per road prism acre per year. A method of extrapolating Middle Blackfoot road erosion results to the Lower Blackfoot was devised to greatly reduce the cost of estimation as well as to limit the methodology debate in an atmosphere of approaching document deadlines. The extrapolation plan, based on road ownership, precipitation zone and underlying geology was described to and discussed by the technical TMDL advisory committee working on the Lower Blackfoot. General consensus was reached on using the simplified extrapolation method.

DEQ reviewed the road erosion survey results provided by PCTC for the drainages mentioned above and discovered that the assumed annual base erosion rate was, in most cases, significantly less (from one to six tons per acre) than the 10 ton figure used in the Middle Blackfoot. A second departure from the Middle Blackfoot methodology appeared in the assumed cover percentages for road prism surfaces. PCTC cover values were notably higher and were more uniformly applied than those returned by the field survey crews in 2005. Higher cover percentages translate to lower sediment delivery. These departures suggested fundamental differences between PCTC field survey practices and those used by the contractor developing the road erosion estimate for the Middle Blackfoot that was extrapolated to the Lower Blackfoot. To avoid an "apples and oranges" comparison in **Table 5-20** and more explanatory text, DEQ preferred to use only the results derived from the planned extrapolation.

Comment 10.3.5

The methodology used to estimate sediment loading from culvert failure is similar in some aspects to culvert loading calculations used by the Lolo National Forest hydrologic NEPA assessments. While the Lolo National Forest has no assumed rate of annual failure, extrapolating data from culvert surveys and applying a 1 to 2 percent failure rate has been used in the past. Perhaps exceptionally high culvert failure estimates could be adjusted by using a single median value or culverts could be stratified by road design or topography. Forest road engineering standards call for larger fill volumes as both road width and topographic slope increases. Several values stratified by channel gradient may yield a better estimate.

Response 10.3.5

Channel gradient was not one of the parameters measured at surveyed crossings in the Middle Blackfoot, but such a stratification is an option for future culvert failure estimates.

Comment 10.3.6

The natural range of variation for sediment target parameters for each stream system has not been adequately derived to justify their use to identify sediment related water quality problems.

Response 10.3.6

The accuracy of selected sediment targets is inherently limited by available data. Target development typically follows a review of the existing record with one to two years of focused data gathering to describe current conditions. The results are then stratified by stream type and summarized by examining percentile statistics. This approach was used due to the fact that appropriate reference streams that could represent naturally occurring conditions could not be located within the watershed of interest and generally do not exist in comparable watersheds. Notwithstanding the small datasets, some knowledge of parameter variability is considered, along with value ranges reported in relevant literature, in setting targets. Improving the degree to which targets represent the true "natural" range of variation will depend upon the outcome of targeted and sustained monitoring to make needed adjustments. The TMDL process requires specified targets, but also provides the possibility for future adjustments when more is known about natural variability within specific systems. Comprehensive knowledge of each affected stream channel system prior to setting sediment targets is improbable within the legal timeframe of the TMDL program.

Comment 10.3.7

The hillslope erosion estimate from SWAT modeling should not be a substitute for identifying actual cause and effect relationships for sediment sources.

Response 10.3.7

In developing and applying the SWAT hillslope information, knowledge gained from field observations and stream assessment work concerning land uses and riparian health were incorporated into the hillslope modeling work. Also see **Response 10.3.1** above.

10.4. Pollutant Loads and Allocations (Section 8.0)

Comment 10.4.1

The 30 percent reduction goal for roads is a reasonable TMDL target for a road network that is not up to a rigorous BMP standard, but not for a road network that is largely improved. In Belmont Creek, PCTC began major road improvements in the watershed in 1995. At the time, roads were in very poor condition, with few BMPs in place. In a 2006 road sediment re-assessment, PCTC actions since the baseline 1994 inventory were found to have reduced sediment delivery by 80 percent. PCTC does not believe an additional 30 percent is attainable in the Belmont Creek watershed. Best estimates of current loading from roads in the Belmont Creek watershed (using validated base erosion rates) suggest that roads are contributing less than 5 percent in excess of natural background watershed erosion rates. PCTC asks that the document note that TMDL targets for roads may not be attainable for road systems that are already up to a high BMP standard. This could be mentioned in **Section 8.1.3**.

Response 10.4.1

The comment brings up a valid point that is implicitly addressed in the fourth paragraph of **Section 8.1.9**, Margin of Safety and Seasonality for Sediment TMDLs. The paragraph will be edited to more explicitly discuss the situation where extensive, existing BMP implementation may limit the potential for additional sediment load reductions. In addition the discussion of road sediment allocations in **Section 8.3.1** will be edited to explain that in areas of extensive road BMP implementation, the potential for future reductions are limited.

Comment 10.4.2

The USGS recently released a publication documenting annual suspended sediment yields from the Blackfoot River for the period 2004-2007 (Lambing and Sando 2008). Combining these data with other available USGS daily load data, the annual sediment yield for a 14 year period can be plotted (1989-1997, 2004-2008). During these years, the average annual yield was 51,600 tons/yr. Given that the Lower Blackfoot TMDL largely completes the TMDL process for the Blackfoot, it is important that this TMDL document summarize the previous "upstream" sediment TMDLs and compare results with the measured sediment yield at the mouth of the Blackfoot. This would be a good "reality check" and something that is critically important to document. It would be helpful to compare this annual measurement with estimated yields by source for the previous TMDLs (Blackfoot Headwaters, Nevada, and Middle-Blackfoot), along with the Lower Blackfoot.

Response 10.4.2

The comment assumes that the annual sediment loading estimates contained in the TMDL documents are reflected directly in the measured annual suspended sediment load at the downstream most station above the Milltown impoundment. More realistically, the hillslope modeling, stream bank assessments and road erosion estimates attempt to quantify loading to the channel of the affected water body. A significant proportion of this total load can be expected to be deposited on point bars and floodplains, settle in pools and interstitial substrate spaces or simply covers the channel substrate where flow volumes needed to pass it downstream are not available. Simply stated, the average annual suspended load is only a portion of the sediment load that modeling and field surveys attempt to quantify. A closer estimate of annual loading throughout the watershed may more closely reflect suspended sediment loading during peak flow events. A much more rigorous, basin wide monitoring network would be required before the calculated suspended load above Milltown could be expected to provide a clear picture of stream health and use support within sediment affected tributaries. Attempting to balance modeled and survey based loading estimates with the suspended load at a single downstream station would be an interesting academic exercise but is of little use in judging the accuracy and utility of model results and field erosion surveys.

In their current form, the TMDL documents developed for Blackfoot planning areas are more useful as a means to identify relative source contributions and assign to each a reasonable reduction rather than as a realistic mass balance methodology.

Comment 10.4.3

The margin of safety discussion in **Section 8.1.9** rightfully mentions the significant uncertainty in the loading estimates, and the expected conservative predictions that overstate the level of loading.

Response 10.4.3

The discussion in **Section 8.1.9** will be expanded per the response to **Comment 10.4.1** above to more explicitly address situations where significant local application of BMPs may limit possible loading reductions in the future.

10.5 Water Quality Improvement Plan (Section 9.0) and Appendices

Comment 10.5.1

The Prescribed Grazing BMP (#528) described in **Appendix J** should allow setting of grazing targets per vegetation goals rather than specify that no grazing unit be grazed more than half of the growing season of key species. Item number 3 under Stream BMPs should be worded to recognize the importance of vegetation cover in controlling stream temperatures.

Response 10.5.1

The sentence containing the no grazing specification has been removed from the grazing BMP description and the stream BMP wording edited to include vegetative cover as a control on stream temperature

Comment 10.5.2

The total maximum daily loads given in **Appendix K** should not be based on model output but rather on actual identifiable pollutant sources.

Response 10.5.2

All model outputs are based on identified pollutant source categories per field observations, assessment activities in the watershed consistent with identified pollutant sources in similar watersheds in Montana and the Western U.S. Models are necessary to provide a watershed scale cumulative approach of capturing loading inputs from sources across a watershed, particularly when source loading is often episodic and extremely resource intensive to measure each specific source contribution. This approach provides a fair balance between resources expanded to study a problem versus resources needed to fix the many obvious pollutant loading problems identified in the watershed.

Comment 10.5.3

The sheet erosion and overland flow processes referred to in **Appendix F** are extremely rare in forested areas. Root throw, burrowing, colluvial processes and freeze-thaw effects are more typical soil movement agents acting on forest soils. There should be some rationale for linking stream bank erosion loading to adjacent land use. The inherent error in determining the Q100 flows for upper watershed streams may prevent accurate sizing of replacement culverts. Fish passage criteria may be more easily applied to culvert replacement.

Response 10.5.3

See **Response 10.3.1** above regarding forest hillslope erosion. The implicit rationale for apportioning the allocations according to land use extent is that the land use adjacent to stream banks directly affects their stability, and thus their tendency to contribute sediment to the channel. For example, woody stream bank vegetation removal to increase the acreage and ease of equipment operation for hay production decreases the stream bank root depth and density. These factors are recognized as important controls on bank stability. It is rational to conclude that the length of stream bank affected by this common hay production practice is proportional to sediment loading from stream banks. It is important to focus on areas where load reductions are possible and apply the BMPs that can achieve loading reductions versus focusing on the specific load values derived from modeling or other approaches. Though the actual loading values may always be an area of debate, the potential for loading reductions or improved land management conditions that go into evaluating potential load reductions is an area of much greater certainty and provide an area of focus for future land management activities and water quality improvements.

Fish passage criteria may be more easily applied to culvert replacement, but their application to upper watershed road crossings was not commonly observed during the road crossing survey. The Q100 criterion, although over-protective in some cases, has been suggested as a workable replacement BMP for forest roads.

Comment 10.5.4

Appendix C does not contain a clear explanation of the statistical justification for sediment target selection.

Response 10.5.4

The statistical parameters used to derive sediment targets by channel type are contained in a series of tables within the appendix. These tables were not correctly referenced in the Public Review Draft of **Appendix C** discussions of the targets and the corrections have been made in the **Appendix C** text for the final document. Note that some of the sediment targets are, as stated in the **Appendix C** discussion, based on values that define channel type, rather than on statistical percentile values. Also see **Response 10.3.6** above regarding sediment target selection.

Comment 10.5.5

The description of Day Gulch regrading in **Section 9.2.1** needs clarification.

Response 10.5.5

The discussion in **Section 9.2.1** has been edited to clarify the nature of the fill structure and mention that active mining is occurring in Day Gulch upstream of the structure.

Comment 10.5.6

Section 9.2.1.4 asserts that there is a water quality problem in Day Gulch, but no data is presented to explain it.

Response 10.5.6

Section 9.2.1.4 identifies that additional monitoring recommendations to help evaluate multiple aspecs of water quality in Day Gulch from a comprehensive use support perspective. Nevertheless, **Sections 9.2.1.1** through **9.2.1.3** provide sufficient data and analysis to identify a likely aquatic life habitat problem in this stream.

Comment 10.5.7

Section 9.2.2.1 contains mistaken references to **Table 9-2**.

Response 10.5.7

The discussion in the section has been edited to correct the table and document section references.

REFERENCES

Alt, D., 2001. Glacial Lake Missoula and Its Humongous Floods. Missoula, MT: Mountain Press Publishing Company.

Alt, D. and D. Hyndman, 1986. Roadside Geology of Montana. Missoula, MT: Mountain Press Publishing Company.

Anderson, M., and R. Magleby. 1997. Agricultural Resources and Environmental Indicators, 1996-1997. U.S. Department of Agriculture Economic Research Service Agricultural Handbook No. 712. Washington, D.C.

ARM, 2005. Administrative Rules of Montana. Title 17 – Environmental Quality, Chapter 30 – Water Quality, Sub-Chapter 6 – Surface Water Quality Standards and Procedures. http://arm.sos.state.mt.us/17/17-2501.htm

Bartholow, J.M., 1989. Stream Temperature Investigations: field and analytic methods. Instream Flow Information Paper No. 13. U.S. Fish and Wildlife Service Biological Report 89(17). 139p.

Bartholow, J.M., 2004. Stream Segment Temperature Model (SSTEMP), Version 2.0 (June 2004). Fort Collins, CO: U.S. Geological Survey. 24p.

Bengeyfield, P., 2006. Unpublished Channel Morphology Data. Beaverhead-Deerlodge National Forest, Dillon, MT.

Blackfoot Challenge, 2005. A Basin-Wide Restoration Action Plan for the Blackfoot Watershed: Report prepared for Montana DNRC Renewable Resource Grant and Loan Program and the Blackfoot Watershed restoration and monitoring partners, August 2005, 63p.

Castelle, Andrew, A.W. Johnson. 2000. Riparian Vegetation Effectiveness: Technical Bulletin No. 799. National Council for Air and stream Improvement. Research Triangle Park, NC.

DEQ, 2006a. Standard Operating Procedure, Water Quality Assessment Process and Methods. DEQ Guidance for Montana Water Use Classification, Assessment Process, Sufficient Credible Data Assessment, , and Beneficial Use Support Determinations. Available at: http://www.deq.state.mt.us/wqinfo/QAProgram/SOP%20WQPBWQM-001.pdf

DEQ. 2006b. Circular WQB-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality (DEQ).

DEQ 2008. Abandoned Mine Program. Abandoned Mine Information, Historical Narrataives, Coloma Mining District. Avaiable at:
http://www.deq.state.mt.us/AbandonedMines/linkdocs/techdocs/143tech.asp

DEQ, 2008. Middle Blackfoot-Nevada Creek Total Maximum Daily Loads and Water Quality Improvement Plan. Sediment, Nutrient, Trace Metal and Temperature TMDLs.

DTM, 2006. SWAT Model Development for the Blackfoot River Watershed, Montana. Preliminary Report for Montana DEQ, January, 2006.

DTM and AGI, 2006. Quality Assurance Project Plan and Sampling and Analysis Plan (QAPP/SAP) Lower Blackfoot TMDL Planning Area. Prepared for Montana DEQ and Blackfoot Challenge by DTM Consulting, Inc. and Applied Geomorphology, Inc., September 2006.

DTM and AGI, 2006a. Temperature Analysis and Modeling of 303(d) List Streams in the Blackfoot River Watershed, Montana. Report for the Blackfoot Challenge and Montana DEQ prepared by DTM Consulting, Inc. and Applied Geomorphology, Inc., July 2006.

Elliot, William J. and Peter R. Robichaud. 2001. Comparing Erosion Risks from Forest Operations to Wildfire. The International Mountain Logging and 11th Pacific Northwest Sklyine Symposium 2001.

Heberling, P., 2000. Umpqua Basin Update: Stream Temperature. State of Oregon Department of Environmental Quality, Fact Sheet. Available online at: www.deq.state.or.us/wq/wqfact/UmpquaStreamTemp.pdf

Helsel DR, and Hirsch RM. 1995. Statistical Methods in Water Resources. *Studies in Environmental Science* (49): 7356-7363.

Hook, Paul B., 2003. Sediment Removal in Rangelands Riparian Buffers. Journal of Environmental Quality. 32:1130-1137.

Land & Water Consulting Inc. 2002. Design Considerations and a Framework for Improving Water Quality Monitoring Programs in the Blackfoot Watershed. Missoula, Montana: Land & Water Consulting Inc.

Land & Water Consulting, Inc. 2004. Big Blackfoot Watershed Water Quality Monitoring Program Quality Assurance Project Plan. Helena, Montana: Land & Water Consulting, Inc.

Lewis, R.S. 1998. Geologic Map of the Butte 1o X 2 o Quadrangle, Southwestern Montana. Montana Bureau of Mines and Geology Open File Report MBMG 363.

McBain and Trush, 2001. Spawning gravel composition and permeability within the Garcia River Watershed, California: Report prepared for Mendocino County Resource Conservation District, Ukiah, CA, 35p.

McCuen, Richard H. 1998. Hydrologic Analysis and Design, Second Edition. Prentice Hall, Upper Saddle River, New Jersey.

Meeuwig, Richard O. 1970. Sheet Erosion on Intermountain Summer Ranges. Intermountain Forest and Range Experiment Station, 25 p.

Montana Department of Environmental Quality (DEQ), 2004. Blackfoot Headwaters Planning Area Water Quality and Habitat Restoration Plan and TMDL for Sediment, April 2004.

Montana Department of Environmental Quality (DEQ), 2006. 2006 Integrated 305(b)/303(d) Water Quality Report. Assessment Record available at http://www.deq.mt.gov/CWAIC/wqrep/2006/assmtrec/MT76F003_120.xls

Montana Department of Fish, Wildlife and Parks. 1997. Montana Warm Water Fisheries Management Plan, 1997-2006.

Montana Fish, Wildlife and Parks (MFWP), 1999. Blackfoot River Restoration Project: Monitoring and Progress Report 1997-1998; March 1999, 51p.

Montana Fish, Wildlife and Parks (MFWP), 2001. Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2001; February, 2001, 95p.

Montana Fish Wildlife and Parks (MFWP), 2002a. The Blackfoot River Fisheries Inventory, Restoration and Monitoring Progress Report for 2001; March, 2002, 81p.

Montana Fish Wildlife and Parks (MFWP), 2002b. A hierarchical strategy for prioritizing the restoration of 83 impaired tributaries of the Big Blackfoot River: Report submitted to The Blackfoot Challenge and the Big Blackfoot Chapter of Trout Unlimited, March 2002, 70p.

Montana Fish, Wildlife and Parks (MTFWP), 2004. The Big Blackfoot River Restoration Progress Report for 2002 and 2003: MTFWP, Missoula, Montana, 107p.

Mudge, M.R., Earhart, R.L., Whipple, J.W. and Harrison, J.E. 2001. Geologic and Structure Map of the Choteau 1o X 2 o Quadrangle, Western Montana: A Digital Database.

Negri, Donald H., and John J. Hanchar (1989). Water ConservationThrough Irrigation Technology. USDA., Econ. Res. Serv., AIB-576, Nov.

Neitsch, et al, 2002a. Soil and Water Assessment Tool Theoretical Documentation. Grassland, Soils, and Water Research Laboratory and Blackland Research and Extension Center, Temple, Texas. Published by Texas Water Resources Institute, College Station, Texas TWRI Report TR-191. Available online at: http://www.brc.tamus.edu/swat/doc.html

Neitsch, et al, 2002b. Soil and Water Assessment Tool User's Manual. Grassland, Soils, and Water Research Laboratory and Blackland Research and Extension Center, Temple, Texas. Published by Texas Water Resources Institute, College Station, Texas TWRI Report TR-192. Available online at: http://www.brc.tamus.edu/swat/doc.html

Omang, R.J., 1992. Analysis of the Magnitude and Frequency of Floods and the Peak-Flow Gaging Network in Montana. US Geological Survey Water-Resources Investigations Report: 92-4048

Pierce, R. and C. Podner. 2000. Blackfoot River Fisheries Inventory, Monitoring and Restoration Report 2000. Missoula, Montana: Montana Fish, Wildlife and Parks.

Pierce, R., C. Podner and J. McFee. 2002. A Hierarchical Strategy for Prioritizing the Restoration of 83 Impaired Tributaries of the Big Blackfoot River. Missoula, Montana: Montana Fish, Wildlife and Parks.

RDG, 2006. Field-Updated Implementation Report and Data Analysis and Results Summary Middle Blackfoot and Nevada Creek TMDL Planning Areas Roads Assessment. Report to Montana DEQ and the Blackfoot Challenge by River Design Group, Inc.

Redmond, R.L., M.M. Hart, J.C. Winne, W.A. Williams, P.C. Thornton, Z. Ma, C.M. Tobalske, M.M. Thornton, K.P. McLaughlin, T.P. Tady, F.B. Fisher, S.W. Running. 1998. The Montana Gap Analysis Project: final report. Unpublished report. Montana Cooperative Wildlife Research Unit, The University of Montana, Missoula. Available at http://nris.mt.gov/nsdi/nris/gap90/mtgapveg.pdf.

Relyea, C.D., G.W. Minshall, and R.J. Danehy. 2000. Stream insects as bioindicators of fine sediment. Idaho State University, Boise Cascade Corp & Water Environment Federation.Pocatello, ID.

Rosgen, D. L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L., 2000. A Practical Method of Computing Streambank Erosion Rate. Wildland Hydrology, Inc. Pagosa Springs, CO.

Sugden, Brian D., 1994. Belmont Creek Watershed Analysis. Plum Creek Timber Company, Clearwater Unit, Missoula, Montana. 73p.

Sugden, B, 2006. Net sediment reduction from roads managed under the native fish HCP through 2005- Adaptive Management Trigger C Assessment: Plum Creek Timber Company, March 31, 2006.

Sugden, B.D. and S. Woods. 2007. Sediment production from forest roads in western Montana. Journal of the American Water Resources Association (JAWRA) 43(1):193-206.

Suplee MW. 2004. Wadeable Streams of Montana’s Hi-line Region: An Analysis of Their Nature and Condition, with an Emphasis on Factors Affecting Aquatic Plant Communities and Recommendations to Prevent Nuisance Algae Conditions. Helena, MT: Montana Department of Environmental Quality.

Theurer, F.D., Voos, K.A., and Miller, W.J., 1984. Instream Water Temperature Model. Instream Flow Inf. Pap. 16 Coop. Instream Flow and Aquatic System Group, U.S. Fish & Wildlife Service. Fort Collins, Colorado, approx. 200pp.

U.S. Department of Agriculture (USDA) (1997). National Engineering Handbook, Part 652, "Irrigation Guide", Natural Resources Conservation Service.

USDA. 2000. Summary Report: National Resource Inventroy (Revised December 2000), Natural Resource Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa, 89 p.

United States Department of Commerce, National Oceanic and Atmospheric Administration. 2004. Screening Quick Reference Table for Inorganics in Solids. HAZMAT Report 99-1. February 2004.

United States Environmental Protection Agency. 1998. Garcia River Total Maximum Daily Load. Environmental Protection Agency, Region IX.

USEPA, 1997. Climate change in Montana. EPA230-F-97-0082.

USEPA, 1999. Draft Guidance for Water Quality-based Decisions: The TMDL Process (Second Edition). EPA 841-D-99-001.

USEPA. 2000. Nutrient Criteria technical Guidance Manual, Rivers and Steams. United States Environmental Protection Agency, EPA-822-B00-002. Washington, D.C.

Ward, A.D, and Trmble, S.W., 2004. Environmental Hydrology. CRC Press LLC, Boca Raton, FL. Second Edition.

Washington Department of Natural Resources. 1997. Washington Forest Practices Board. 2001. Board Manual. Seciton 11 Standard methodology for conducting watershed analysis. http://www.dnr.wa.gov/forestpractices/board/manual/

Weaver, T. and J. Fraley, 1991. Fisheries Habitat and Fish Populations, IN: Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program, Flathead Basin Commission, Kalispell, Montana, June 1991.

ERRATA SHEET FOR THE "LOWER BLACKFOOT TOTAL MAXIMUM DAILY LOADS AND WATER QUALITY IMPROVEMENT PLAN – SEDIMENT, METALS AND TEMPERATURES"

This TMDL was approved by EPA on December 23, 2009. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version has a minor change that is explained and corrected on this errata sheet. If you have a bound copy, please note the correction listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

Appropriate corrections have already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

The following table contains corrections to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the "Lower Blackfoot Total Maximum Daily Loads and Water Quality Improvement Plan – Sediment, Metals and Temperatures" document.

Location in the TMDL	Original Text	Corrected Text
Table EX-1, Pollutants of Concern by Water Body, Keno Creek, Water Body ID	MT76F002_018	MT76F006_040
Table 2-1, Section 2.3, Page 16, Stream Assessment Unit column, Keno Creek	MT76F002_018	MT76F006_040
Table 2-1, Section 2.3, Page 16, Stream Assessment Unit column, Washoe Creek	MT76F006-901	MT76F006-090

APPENDIX A
FIGURES AND MAPS

Watershed Characterization

All boundaries are approximate and should not be used for legal purposes.
Data Source: NRIS

Figure A-1. Location of the Blackfoot River Watershed

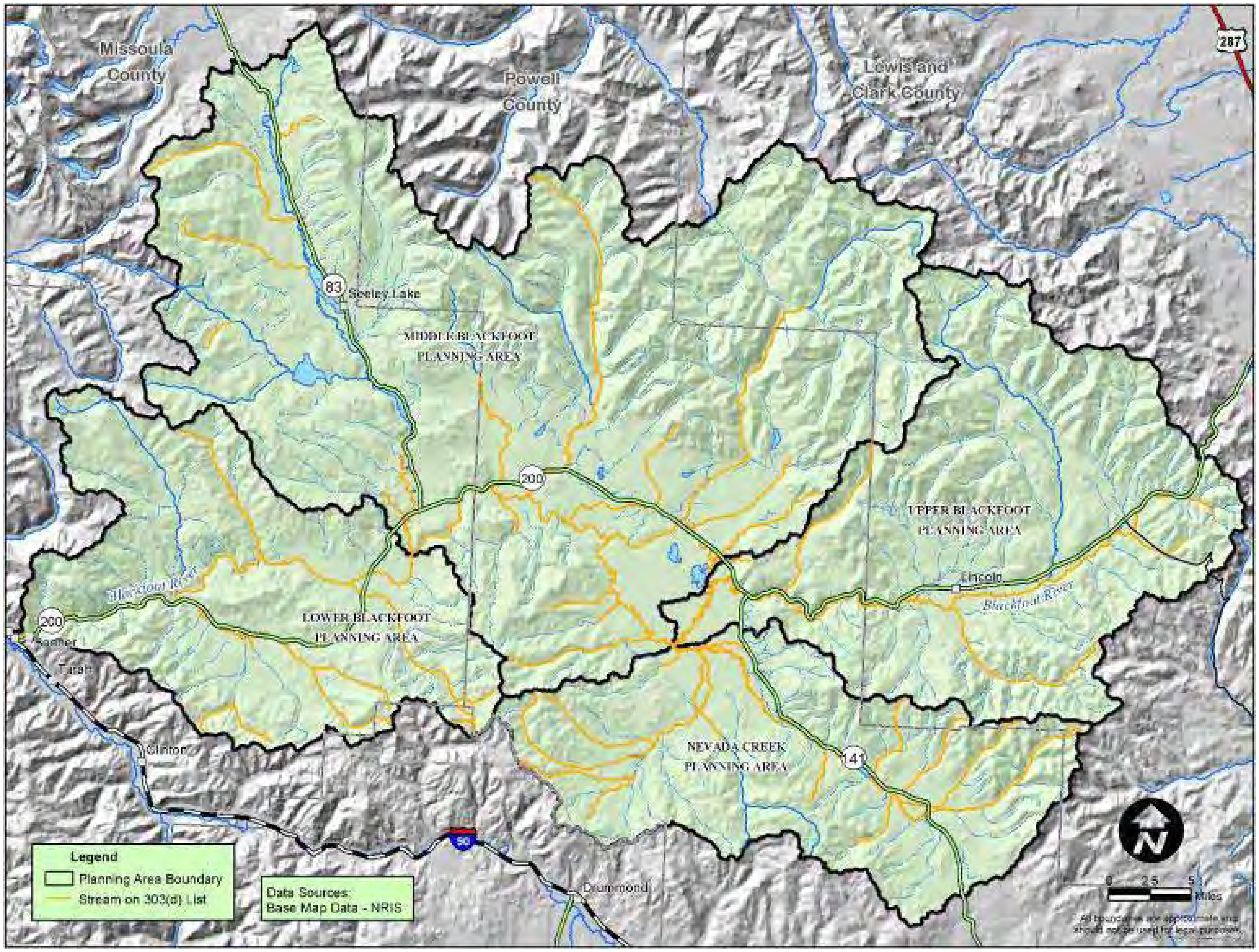


Figure A-2. TMDL Planning Areas in the Blackfoot River Watershed

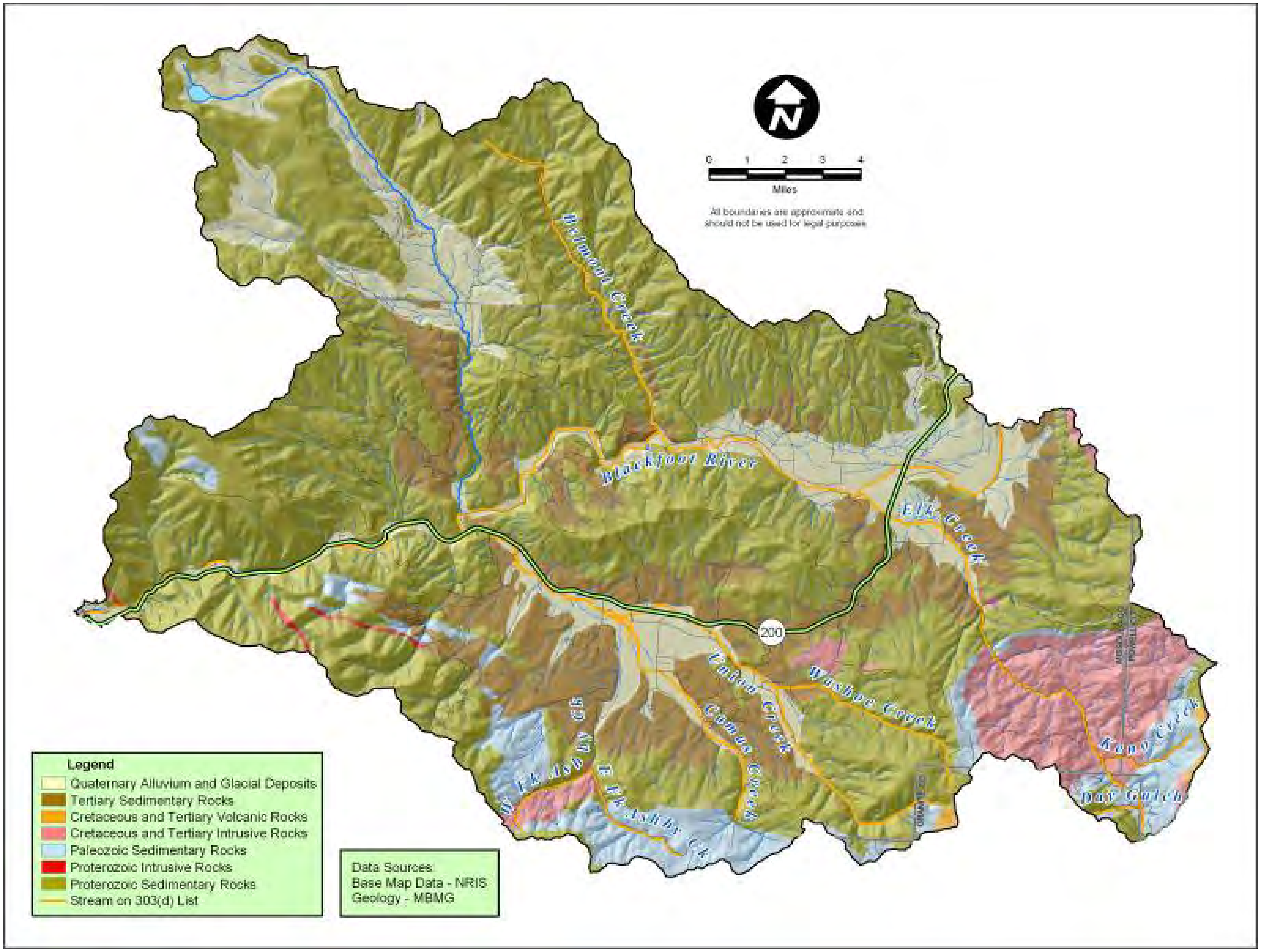


Figure A-3. Geology of the lower Blackfoot planning area.

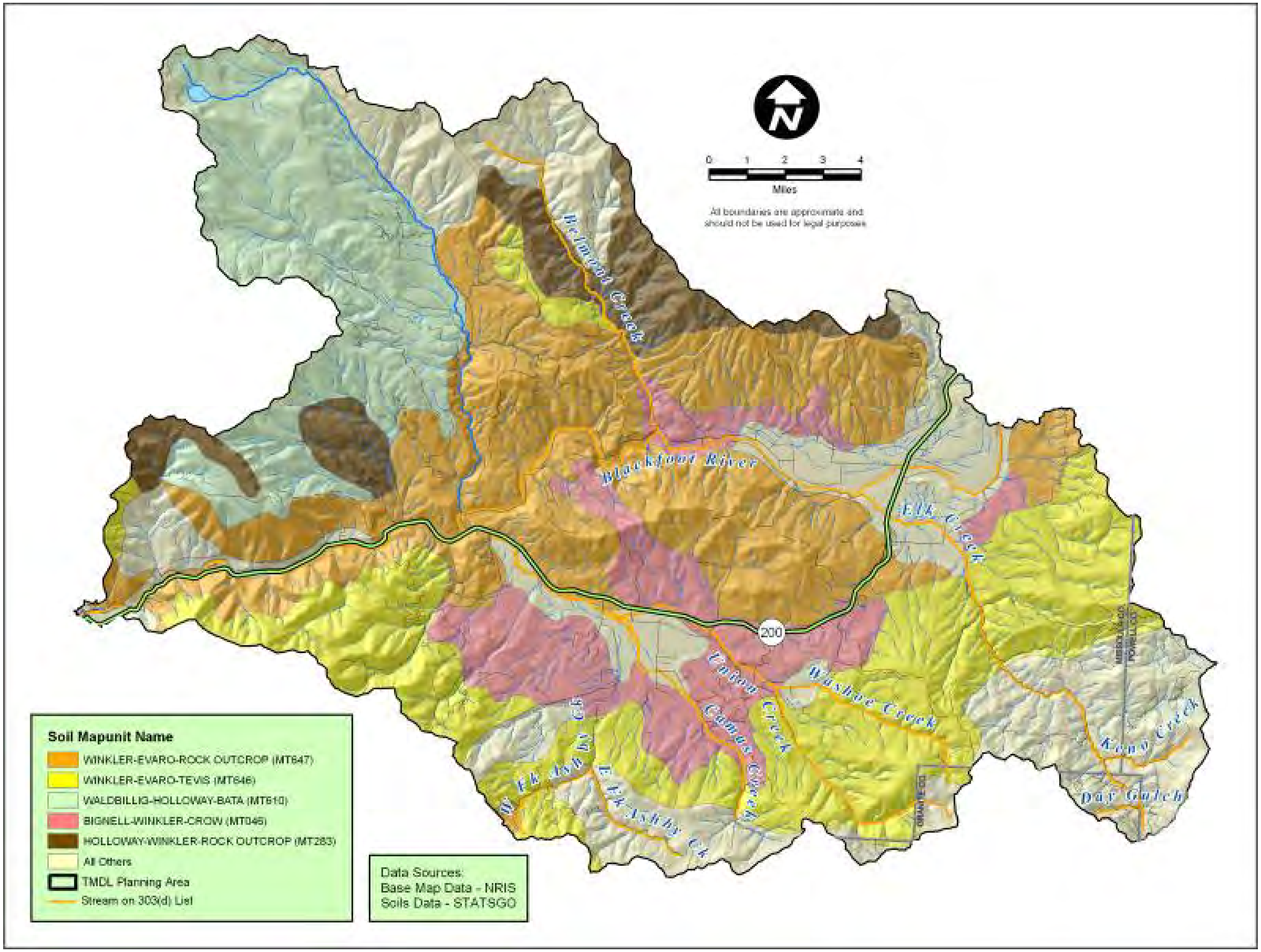


Figure A-4. Soils in the lower Blackfoot planning area.

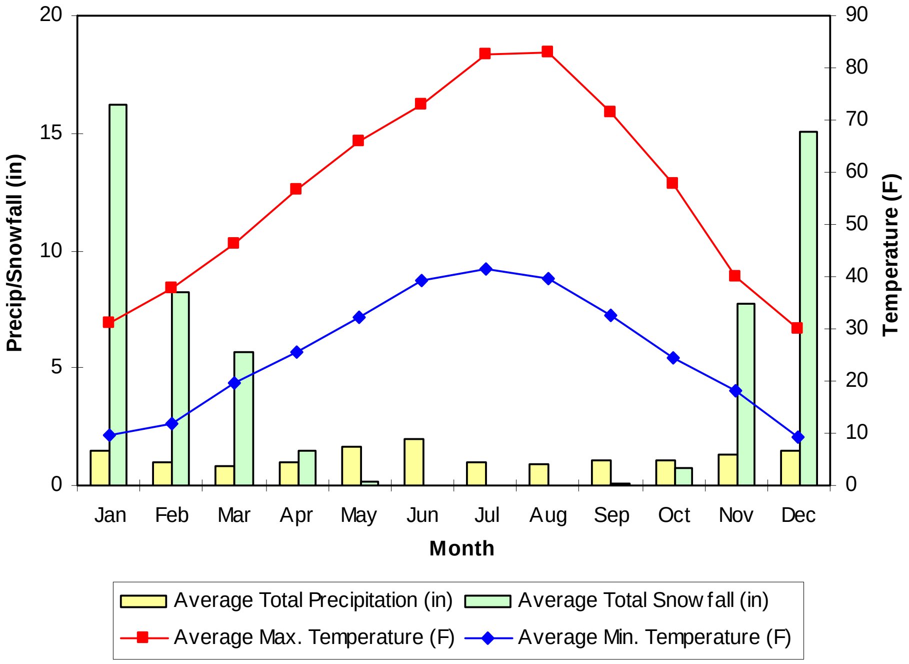


Figure A-5. Average total precipitation, total snowfall, average maximum temperature and minimum temperature at NOAA Potomac Station #246685.

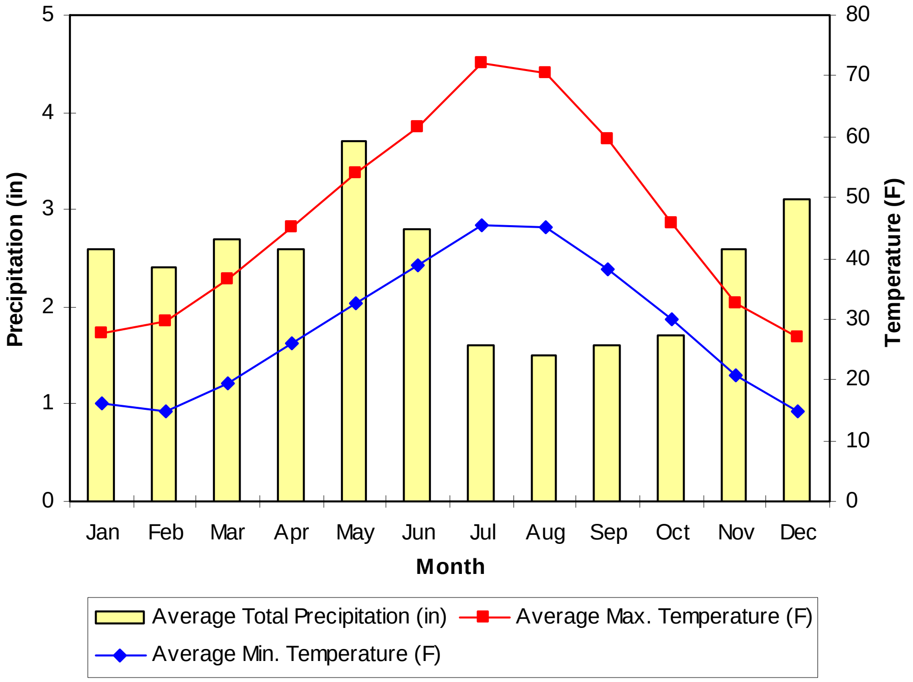


Figure A-6. 30-year (1971-2000) average total precipitation, average maximum temperature and minimum temperature at NRCS North Fork Elk Creek Snotel #657.

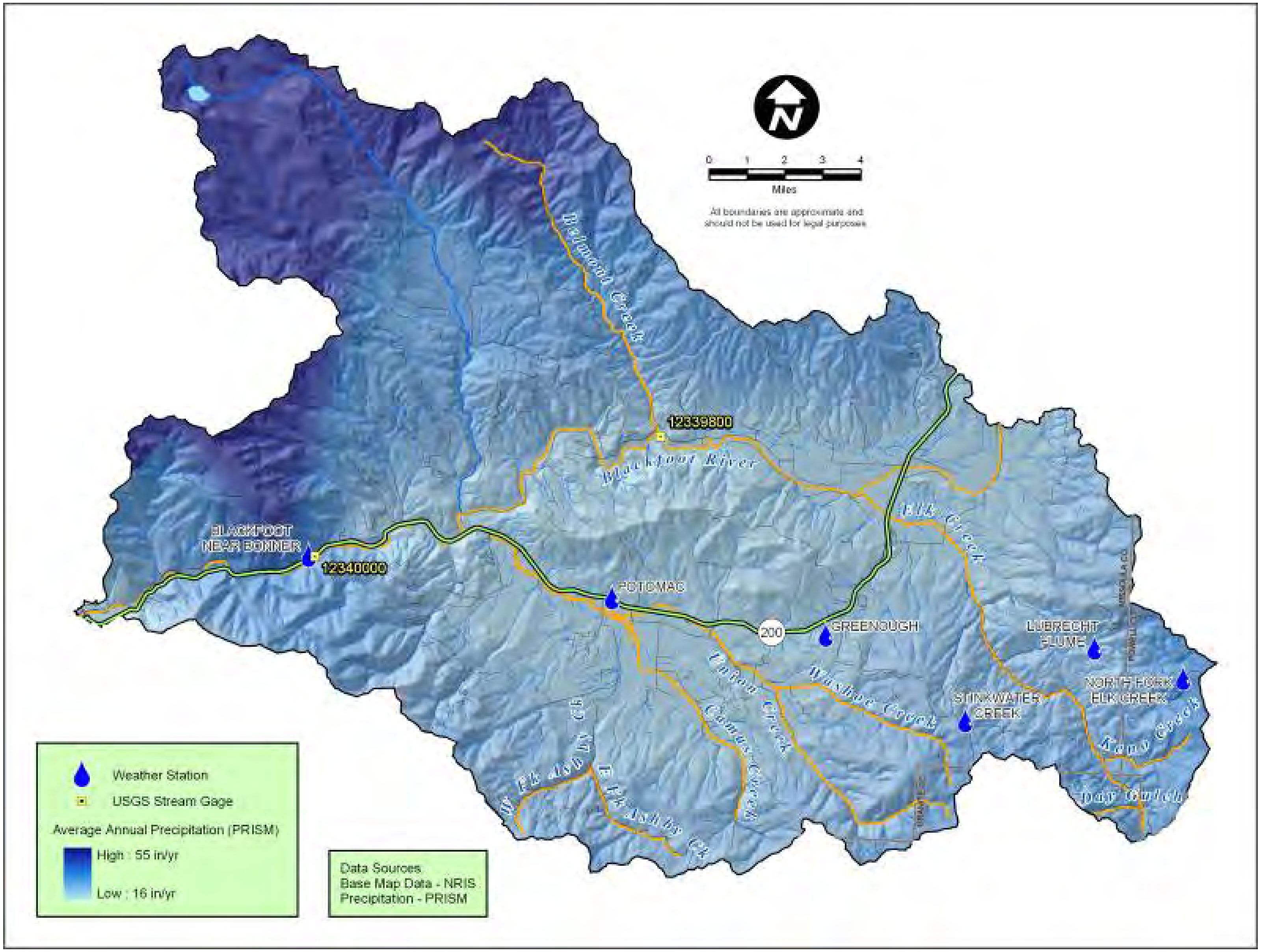


Figure A-7. Precipitation in the lower Blackfoot planning area (PRISM data).

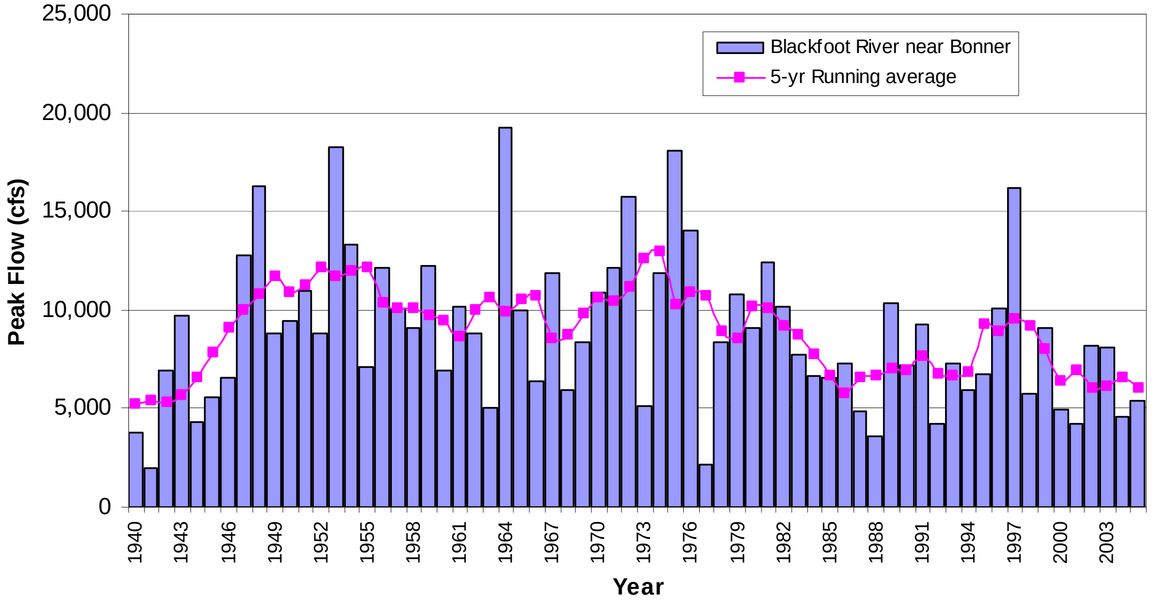


Figure A-8. Annual Peak Discharge, Blackfoot River near Bonner (12340000)

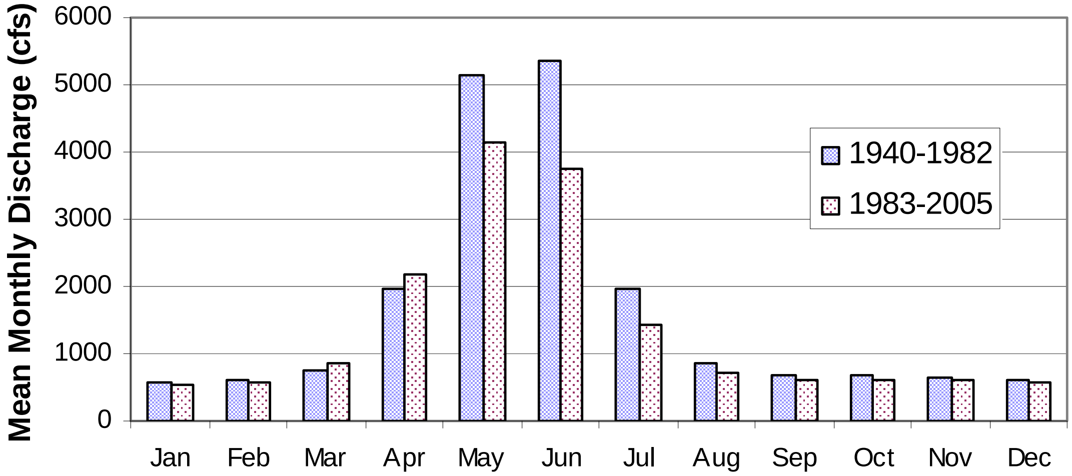


Figure A-9. Mean monthly discharge, Blackfoot river near Bonner (1234000), 1939-1982 and 1983-2005.

Figure A-10. Major vegetation cover types in the lower Blackfoot planning area (USGS GAP).

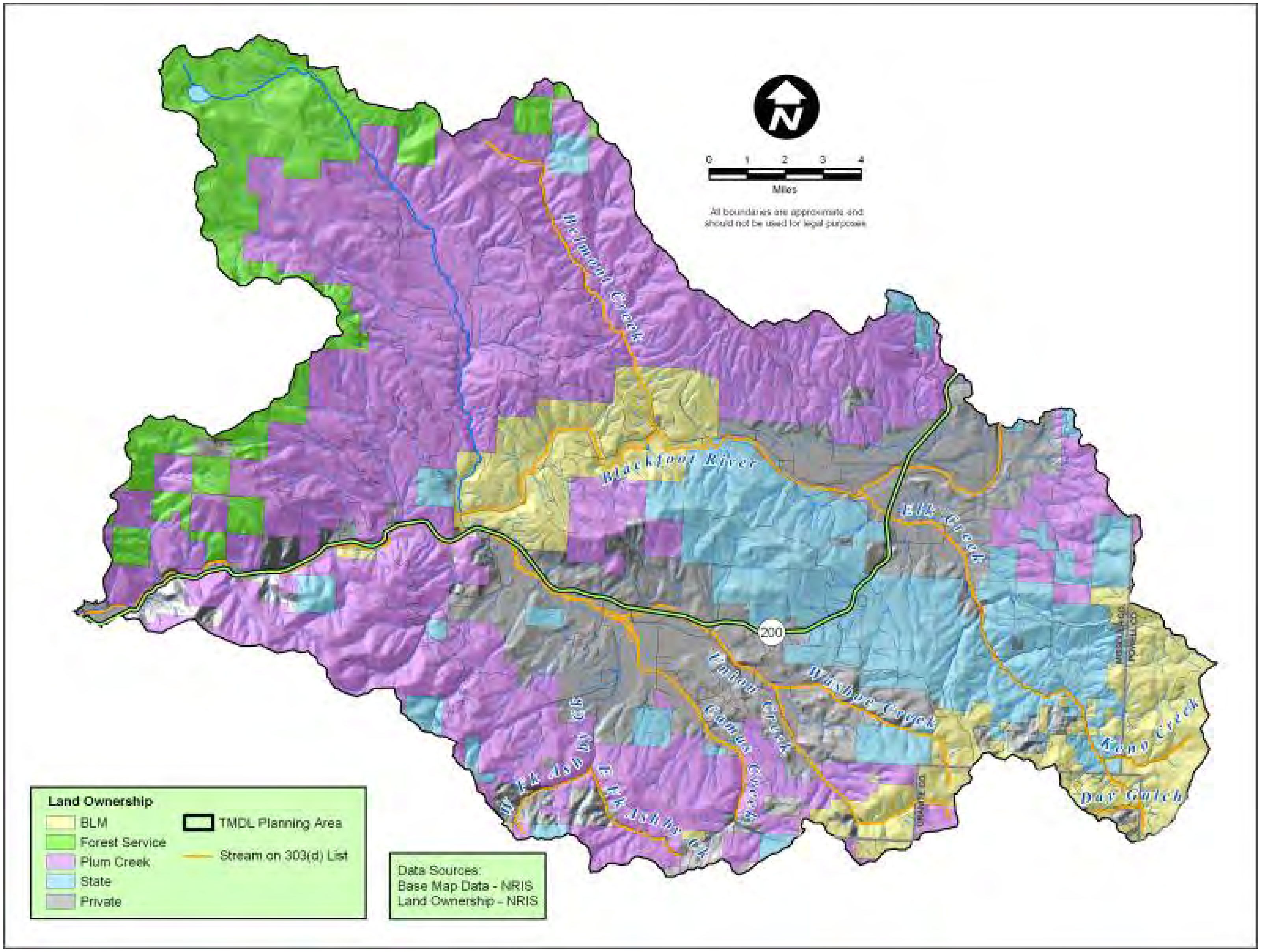


Figure A-11. Land ownership in the lower Blackfoot planning area.

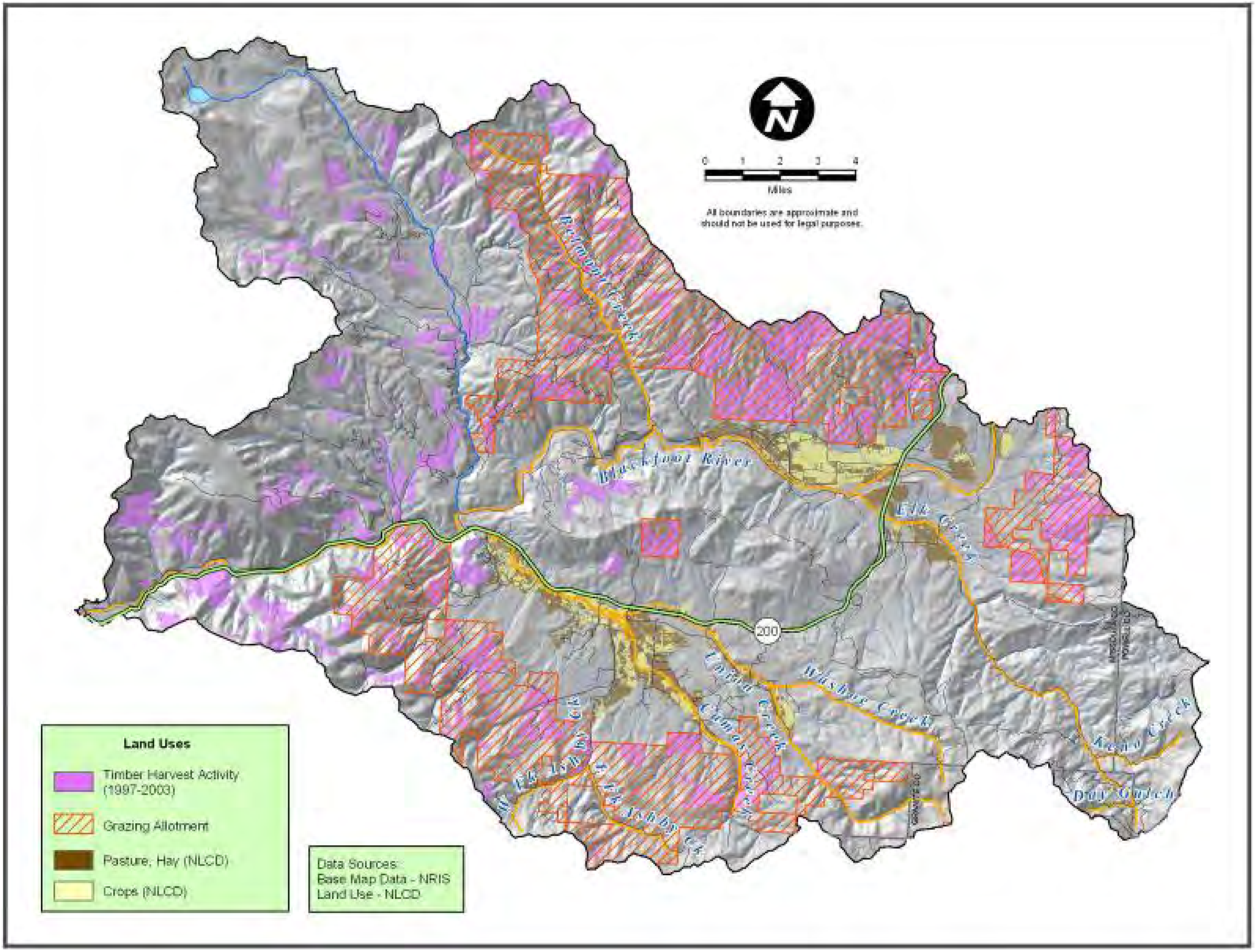


Figure A-12. Land uses in the lower Blackfoot planning area.

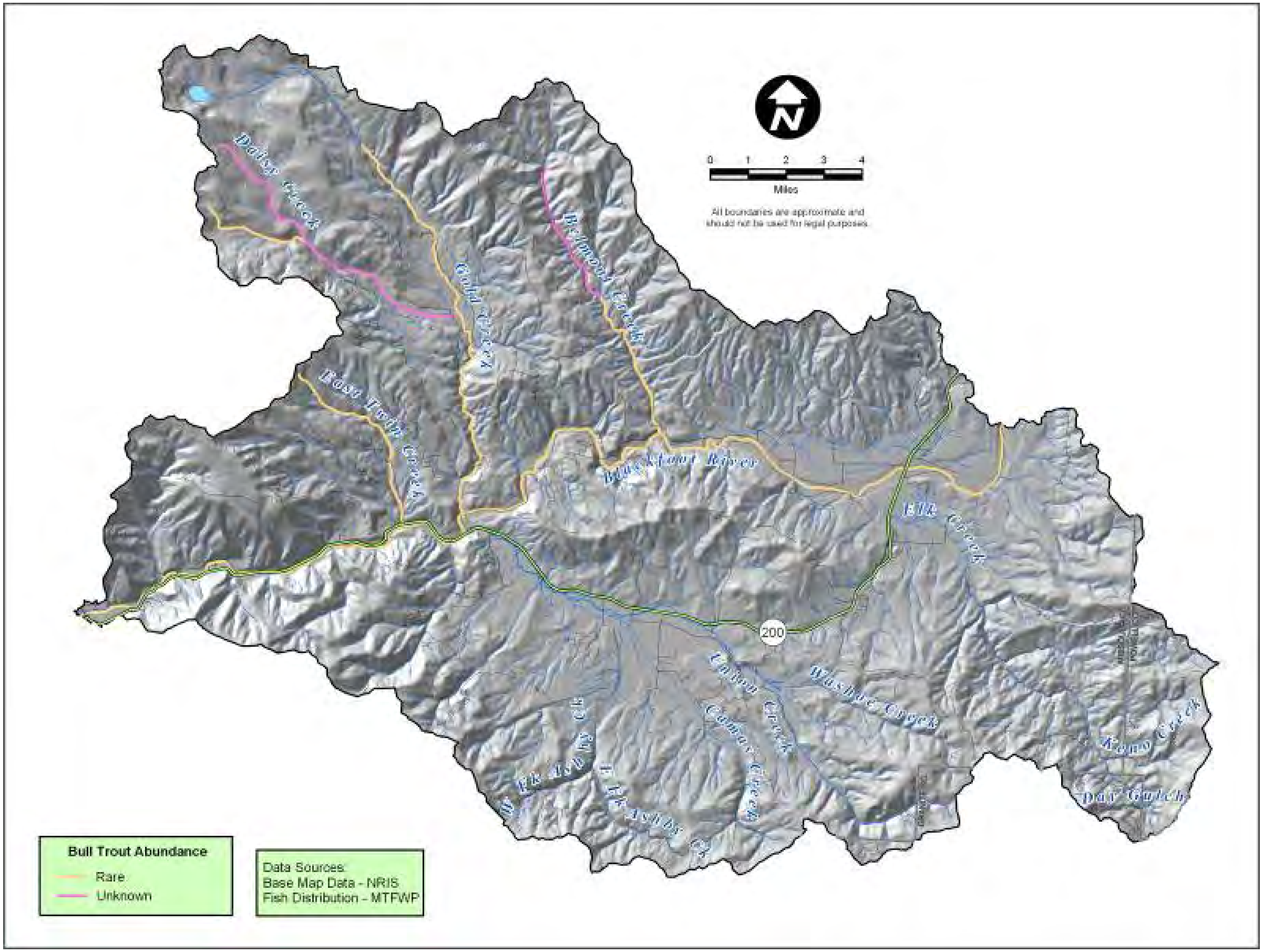


Figure A-13. Distribution of bull trout in the lower Blackfoot watershed.

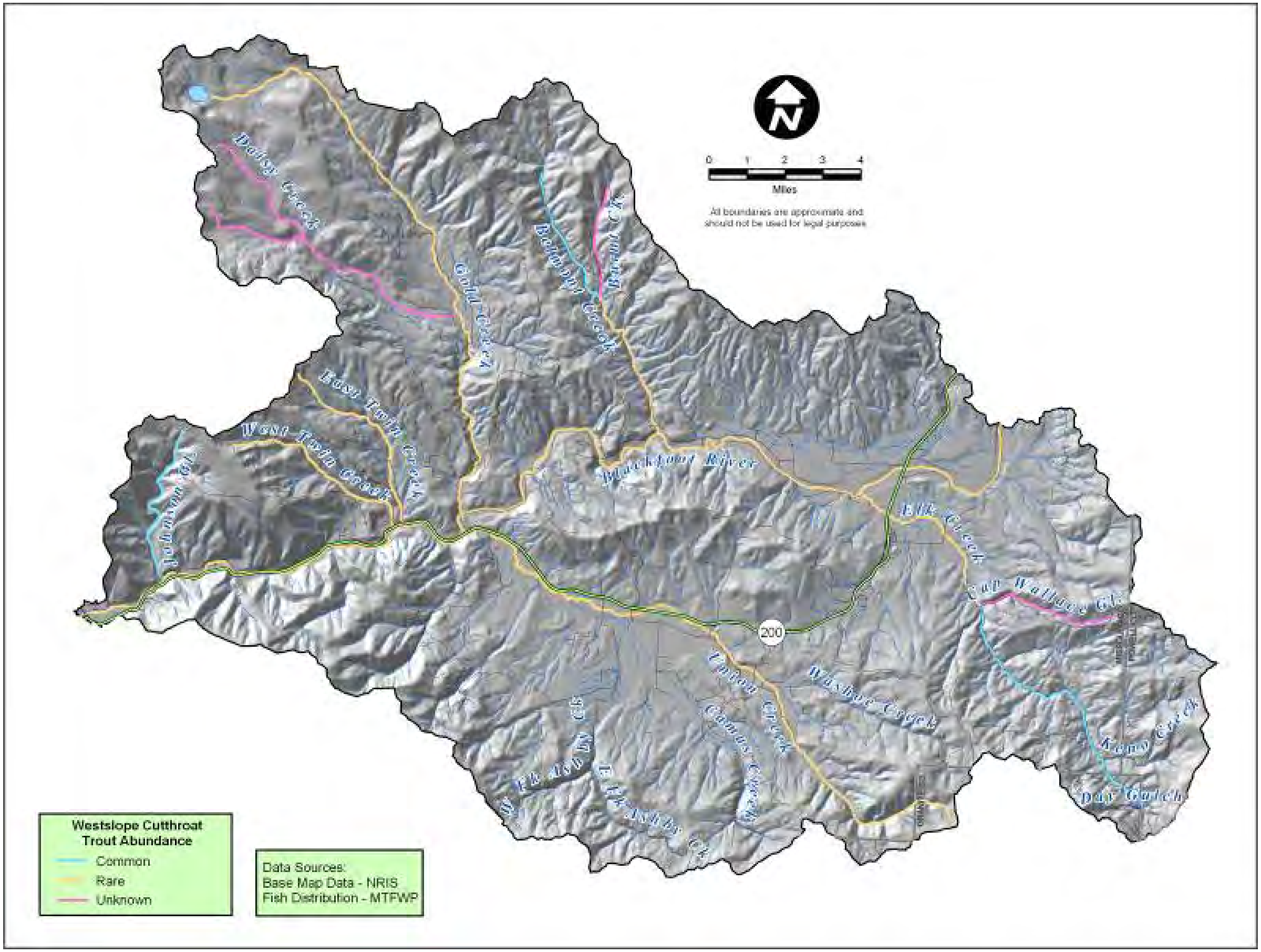


Figure A-14. Distribution of westslope cutthroat trout in the lower Blackfoot watershed.

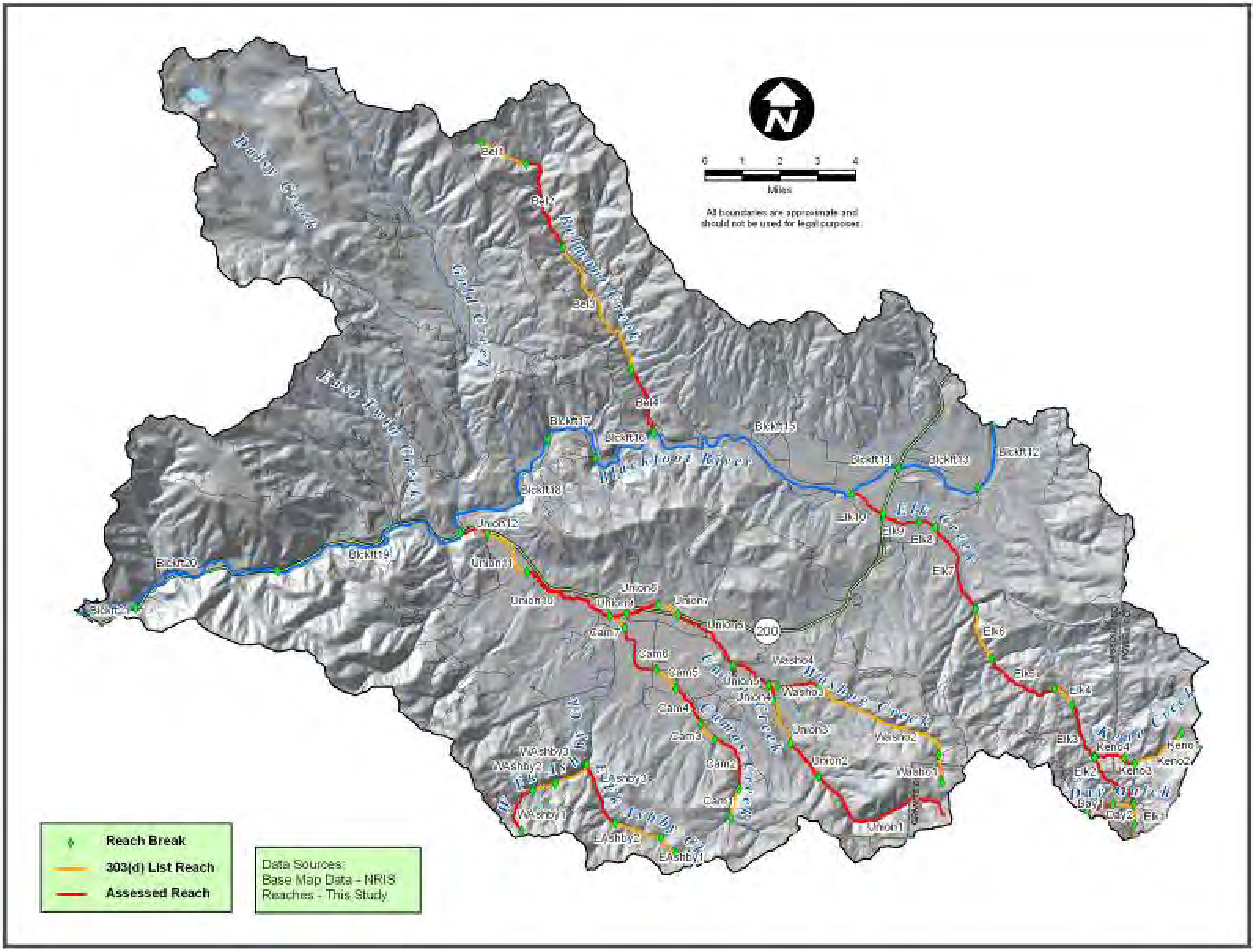


Figure A-15. Reaches in the lower Blackfoot planning areas.

APPENDIX B
AERIAL ASSESSMENT AND RECONNAISSANCE RESULTS

Table B-1. Aerial and Reconnaissance Assessment Results by Reach.

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Listing 2006	DEQ Sources	Reach Name	Reach Length (ft)	Base Parameter Assessment	Channel Type	Visible Sources of Impairment	Woody Vegetation Density	Dominant Stream-Side Veg	Apparent Land Use (Aerial)	Bounding Geology	Comments
Day Gulch	Flow Alteration, Other Habitat Alterations, Siltation,	Did Not Meet SCD	Did Not Meet SCD	Not Assessed		Day1	3,274		B	Hillslope logging/ mining	Moderate	Mixed conifer deciduous	Logging/ mining	YGr	Headwaters: north of Dandy Mine
						Day2	4,028	Yes	B	Valley bottom clearing/ logging/mining	Sparse	Mixed conifer		PDs	Extensive valley bottom disturbance/clearing/ upstream mining
Keno Creek	Flow Alteration, Other Habitat Alterations, Siltation, Thermal Modifications	Did Not Meet SCD	Did Not Meet SCD	Not Assessed		Keno1	2,357		A	Upland Logging	Dense	Conifer	Logging	PDs	Steep Headwaters
						Keno2	6,653		B	Riparian Degradation/ Logging	Moderate	Mixed conifer deciduous	Logging	PDs	To Rd Xing: Road Closely follows to south: logged/ mod steep/ potential riparian logging
						Keno3	2,057	Yes	Eb	Riparian Degradation/ Logging/ Channelization		Mixed conifer deciduous		Kgd	Reach appears channelized on toe of left (south) valley wall
						Keno4	4,685	Yes	Eb	Riparian Degradation/ Road Enc	Moderate/Dense	Mixed conifer deciduous	Logging	Kgd	Road closely follows to north/ relatively dense valley bottom veg with logged hillslopes
Elk Creek	Flow Alteration, Siltation	Metals (Cadmium), Siltation, Nutrients (Nitrate), Other Habitat Alterations	Metals (Cadmium), Nutrients (Nitrate), Siltation, Other Habitat Alterations	Cadmium Nitrate Nitrogen Physical Substrate Habitat Alterations Sedimentation/ Siltation	Placer Mining Forest Roads (Road Construction and Use) Streambank Modifications/ destablization	Elk1	3,389		A		Dense	Mixed conifer	Upland Logging	Paleozoic Seds	Confined headwaters above Day Gulch
						Elk2	9,915	Yes	Eb	Riparian degradation	Sparse/Moderate	Woody	Riparian clearing	Kgd	Highly disrupted valley bottom/ road encroachment
						Elk3	8,972	Yes	Eb	Riparian degradation	Sparse/Moderate	Woody	Valley Bottom Mining	Kgd	Highly disrupted valley bottom/ potential high sed loads from McManus Gulch at top of reach
						Elk4	4,354		C	Placer Mining, Road Encroachment	Sparse/Moderate	Woody	Valley bottom mining	Kgd	Heavily placered valley bottom at Yreka. Dredge ponds/ spoils abundant.
						Elk5	12,618	Yes	B	Channelization/ Road Encroachment	Moderate	Woody		Kgd	Confined reach with multiple road crossings/ encroachment
						Elk6	8,642		E	Road Encroachment/ mining on E trib/sed production	Moderate/Dense	Woody	Trib mining	Ygr/Ym/ Paleo Seds	Confined willow bottom with close road encroachment/ valley bottom disturbance (sed delivery?) from mined small trib center Sec16
	Flow Alteration, Siltation	Siltation, Thermal Modifications, Other Habitat Alterations	Siltation, Thermal Modifications, Other Habitat Alterations	Alteration in stream-side or littoral vegetative covers Sedimentation/ Siltation Temperature	Grazing in Riparian or Shoreline Zones Streambank Modifications/ destablization	Elk7	15,887	Yes	E	Dewatering/ Riparian degradataion	Sparse/Moderate	Mixed deciduous	Irrig Hay/Pasture	Qa	Open valley bottom with numerous ditch diversions/ channel trace hard to follow/ Some cottonwoods
						Elk8	4,496	Yes	E	Riparain degradation	Sparse	Herbaceous	Irrigated hay/pasture	Qa	Restored reach below road/ bar deposits on upstream end may reflect too low of slope/ or road work effects
						Elk9	7,241	Yes	E	Riparian degradation/ dewatering	Sparse	Herbaceous	Irrigated hay/pasture		Lower end of irrigated valley
						Elk10	6,224	Yes	E	Riparian degradation	Sparse/Moderate	Woody	Center pivots to north	Qa	Increasingly confined in d/s direction/ Ts hills to southwest/ rapids at confluence reflect flood deposits from Elk Cr.

Table B-1. Aerial and Reconnaissance Assessment Results by Reach.

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Listing 2006	DEQ Sources	Reach Name	Reach Length (ft)	Base Parameter Assessment	Channel Type	Visible Sources of Impairment	Woody Vegetation Density	Dominant Stream-Side Veg	Apparent Land Use (Aerial)	Bounding Geology	Comments
Belmont Creek	Other Habitat Alterations, Siltation	Siltation	Siltation	Sedimentation/ siltation	Forest Roads (Road Construction and Use) Grazing in Riparian or Shoreline Zones	Bel1	10,606		A	Intensive logging	Sparse/Moderate	Mixed conifer deciduous	Logging	Yh	Intensively logged headwaters/ skidlines extend to valley bottom/ valley bottom harvested.
						Bel2	23,540	Yes	B	Logging	Moderate	Mixed conifer deciduous	Logging	Ym	Long canyon section/ logging road encroachment/ some beaver ponding/ skidlines extensive
						Bel3	16,348		B	Logging	Moderate	Mixed conifer deciduous	Logging	Ysn	Mixed willow/conifer narrow valley bottom. Numerous logging rd xings
						Bel4	7,962	Yes	C	Riparian degradation	Sparse/Moderate	Mixed deciduous	Irrigated hay	Ysn/ Ts	Two relatively wide valleys separated by narrow constriction/ lower end approaching Blackfoot increasingly vegetated
Washoe Creek	Flow Alteration, Other Habitat Alterations, Siltation,	Did Not Meet SCD	Did Not Meet SCD	Chlorophyll-a NO2+NO3-N TP TKN Sedimentation/ Siltation	Silviculture Harvesting Source Unknown Open Pit Mining	Washoe1	4,579		B	Road Encroachment/ Mining	Moderate/Dense	Mixed conifer deciduous	Logging/ Mining	Ygr	Above main mining activity/ mostly headwater logging
						Washoe2	22,957		B	Road Encroachment/ Logging/ Mining	Moderate/Dense	Mixed deciduous	Logging/ Mining	Ym	Long straight valley (structural?)
						Washoe3	6,949		E	Upland Logging	Moderate	Woody		Ts	Valley widens onto Ts geology. Riparian degraded
						Washoe4	1,633	Yes	C	Dewatering/ Riparian degradation	Sparse	Woody	Adjacent hayfields	Qa	At fenceline/ riparian density plummets/ diversions mapped just upstream of reach break.
E. Ashby Creek	Siltation	Did Not Meet SCD	Did Not Meet SCD	Alteration in stream-side or littoral vegetative covers TP NO2+NO3-N Sedimentation/ siltation	Forest Roads (Road Construction and Use) Grazing in Riparian or Shoreline Zones Silviculture Activities Source Unknown	EAshb1	3,778		A				Logging	Paleozoic Seds	Channel closely confined by road to northeast/ may be channelized
						EAshb2	8,331		C	Road Encroachment/ Logging	Sparse/Moderate	Mixed conifer deciduous	Upland Logging	Paleozoic Seds	Series of open parks separated by short mod confined reaches
						EAshb3	10,814	Yes	Eb	Road Encroachment/ Mining	Moderate/Dense	Mixed conifer	Logging/ Mining	Paleozoic Seds/ Ygr	Left valley wall on Tgd/Ygr contact about 1/2 way down reach. Mouth open/ possibly C/E. Road closely follows channel
W. Ashby Creek	Other Habitat Alterations, Siltation	Did Not Meet SCD	Did Not Meet SCD	Alteration in stream-side or littoral vegetative covers TP Sedimentation/ siltation	Forest Roads (Road Construction and Use) Silviculture Activities Source Unknown	WAshb1	5,946		A	Upland logging	Moderate	Mixed conifer	Logging	Tgd	Pervasive logging
						WAshb2	3,540		B	Upland Logging/ Road encroachment	Moderate	Mixed conifer	Logging	YPi	Reach break as channel leaves Tgd
						WAshb3	7,903	Yes	Eb	Upland Logging/ Road encroachment	Moderate/Dense	Mixed conifer deciduous	Logging	Ygr	Road follows valley bottom margin
Camas Creek	Flow Alteration, Siltation, Thermal Modifications	Did Not Meet SCD	Did Not Meet SCD	Flow Alteration TP Sedimentation/ Siltation	Grazing in Riparian or Shoreline Zones Irrigated Crop Production Upstream Source	Cam1	5,074		A	Upland Logging	Moderate	Mixed conifer deciduous	Upland Logging		Headwaters to road xing/ major power line crossing/ road encroachment evident
						Cam2	10,577	Yes	E	Riparian Degradation/ Hillslope Logging	Sparse/Moderate	Woody		Qa	Upper end alluvial valley
						Cam3	4,167		C	Riparian degradation	Sparse	Woody	Irrig (?) hay?	Qa	Highly impacted riparian through fields

Table B-1. Aerial and Reconnaissance Assessment Results by Reach.

Water body Name	DEQ Listing 1996	DEQ Listing 2000	DEQ Listing 2002	DEQ Listing 2006	DEQ Sources	Reach Name	Reach Length (ft)	Base Parameter Assessment	Channel Type	Visible Sources of Impairment	Woody Vegetation Density	Dominant Stream-Side Veg	Apparent Land Use (Aerial)	Bounding Geology	Comments
						Cam4	9,224	Yes	E	Riparian degradation	Sparse	Mixed deciduous	Irrigated hay/pastur	Qa	Highly impacted valley bottom reach. Very narrow riparian thread. Dewatering/ riparian degradation evident
						Cam5	4,971		E	Riparian degradation/ dewatering	Sparse	Woody	Irrigated hay/pastur	Qa	Highly impacted irrigated valley bottom
						Cam6	10,357	Yes	E	Riparian deg/ dewatering	Sparse		Irrigated hay/pastur	Qa	Channel trace difficult to identify through dewatered reach. Reach ends at FWP temp site near Potomac
						Cam7	4,023		E	Dewatering/ Riparian degradation	Sparse	Woody	Irrigated hay/pastur	Qa	Highly impacted valley bottom section through flood irrigated area/ center pivit irrigation.
Union Creek	Flow Alteration, Other Habitat Alterations, Siltation, Thermal Modifications	Metals (Arsenic, Copper), Other Habitat Alterations, Suspended Solids, Nutrients (Phosphorus), Thermal Modifications	Metals (Arsenic, Copper), Nutrients (Phosphorus), Thermal Modifications, Other Habitat Alterations, Suspended Solids,	Arsenic Copper TP Physical substrate habitat alterations Solids (Suspended/ Bedload) Temperature, water	Impacts from Abandoned Mine Lands (Inactive) Animal Feeding Operations (NPS) Source Unknown Rangeland Grazing Streambank Modifications/ destablization Flow Alterations from Water Diversions	Union1	27,069	Yes	E	Hillslope logging/ road encroachment/ mining	Moderate/Dense	Mixed conifer deciduous	Mining/ logging	Ym	Confined headwaters area/ logged with several mines (Copper Cliff) on valley walls/ many rd xings
						Union2	7,513		E	Riparian degradation/ dewatering	Sparse/Moderate	Woody	Irrig crops/pasture	Qa	Qa valley bottom heavily irrigated/ narrow willow fringe on channel closely bounded by fields.
						Union3	7,461		E	Riparian degradation/ dewatering	Moderate	Mixed conifer deciduous	Irrig pasture/hay	Qa	Short section of higher canopy MD
						Union4	2,576	Yes	Eb	Riparian degradation/ dewatering	Sparse	Woody	Irrig pasture/hay	Qa	Highly impacted stretch above Washoe conf
						Union5	7,776	Yes	E	Riparian degradation/ dewatering	Sparse/Moderate	Woody	Irrig hay/pasture	Qa Ts Ybo	Constriction at d/s end is Prot seds knobs surrounded by Ts. Local subdivision/horse pasture
						Union6	14,080		E	Riparian degradation dewatering	Sparse/Moderate			Qa Ybo	Upper end open hayfields/ more confined and vegetated ds Potomac Spur Rd
						Union7	4,200		C	Riparian degradation/ channelization/ dewatering	Sparse	Woody	Irrig hay/pasture	Qa	Highly impacted dewatered channelized section below Hwy 200
						Union8	6,487	Yes	E	Riparian degradation dewatering	Sparse/Moderate	Woody	Irrig hay/pasture	Qa	Crosses hwy 200/ narrow riparian fringe on moderately sinuous channel
						Union9	4,605		F	Riparian degradation/ channelization/ dewatering	Sparse	N/A	Irrig hay	Qa	Severely degraded section below Potomac: ditched/ dewatered
						Union10	25,840		E	Riparian degradation/ dewatering	Sparse	Woody	Irrig. hay	Qa	Sinuous thread through ag impacted valley bottom. Numerous ditches/ obvious return flow from flood irrigated fields.
						Union11	15,821	Yes	E	Riparian degradation/ incision	Sparse	N/A	Irrig Hay	Qa	Incised reach with no riparian vegetation/ banks appear steep/ unstable.
						Union12	4,401	Yes	B	Road encroachment	Moderate	Mixed conifer deciduous	Transportation Corridor	Ym	Confined reach to Blackfoot River. Closely follows Hwy 200.

APPENDIX C
SEDIMENT/HABITAT TARGET DEVELOPMENT

The following section contains a summary data analysis for base parameter data collected in support of TMDL development in the Lower Blackfoot Planning Area. The analysis includes a basic reach classification and assignment of each assessed stream segment to a reach type population, and a presentation of summary statistics for each reach type. The summary statistics describe the quantitative data associated with each site that have been used to develop TMDL targets for sediment and habitat related impairments.

The development of sediment/habitat target values for the Lower Blackfoot TMDL Planning Area requires the identification of parameters that are closely linked to a cold water fishery or aquatic life beneficial use support. In some cases, the parameters also relate to the contact recreation beneficial use. That is, some streams have been listed as non-supporting or partially supporting of primary contact recreation due in part to problems with substrate or flow conditions, both of which can be assessed using parameters described below. The parameters for which target values have been developed to help determine the sediment/habitat impairment status include the following:

- Percent surface fines in riffles measured by pebble count,
- Percent subsurface fines measured by McNeil Core,
- Pool frequency,
- Residual pool depth,
- Width to depth ratio,
- Percent surface fines in pool tailouts,
- Woody bankline vegetation extent,
- Macroinvertebrate metrics,
- Pool extent,
- Entrenchment Ratio,
- Woody debris aggregate extent, and
- Woody debris aggregate frequency.

These parameters address a broad range of direct habitat measures, channel condition measures, and direct measures of aquatic life.

Ideally, reference values for each of the parameters listed above are measured from reference water bodies where all sediment and habitat conditions are functioning at their potential, given historic land uses and the application of all reasonable land, soil, and water conservation practices. However, there was very little internal reference data identified in the lower Blackfoot planning area. In this data summary, target values are derived from a statistical analysis of the entire dataset for the planning area, as well as from regional data from outside the area.

The base parameter assessment sites are grouped into populations based on Rosgen Level I channel type (Rosgen, 1994). For each channel type, fundamental statistics have been developed for each parameter. These statistics include the maximum, minimum, median, and quartile values for that specific parameter. The results are then compared to the target values developed for and applied to the Lower Blackfoot Planning Area. A Lower Blackfoot Planning Area target is then presented for each parameter. The departure level of each assessed reach relative to that target is displayed via bar chart.

Reach Classification

The reach classification is based on field observations and measurements of slope, cross section, and substrate. The potential channel type under minimally impaired conditions may be different than the existing channel type, reflecting some degradation of channel cross section. Where such sites were identified, the assigned population for departure analysis reflects the desired channel type condition. The assignment of a channel segment to population reflects a basic level of classification (Rosgen Level 1; Rosgen, 1994); that is, substrate was not included in the population assignment. As such, the population assignment is based on combined data including measured width to depth ratio, surveyed channel slope, surveyed entrenchment ratio, and field observations regarding site potential (**Table C-1**). E channel types include an Eb sub-type, to account for channels with low width to depth ratios and relatively steep slopes.

Table C-1. Summary of reach statistics by channel type.

Reach	Avg Width to Depth Ratio	Existing Slope (%)	Avg Entrench-ment Ratio	Average D50 (mm)	Existing Type	Potential Type	Population
Day2	5.1	7.7	2.5	9	B4a	B	B
Keno3	6.5	3.4	4.1	2.0	E4b	E4b	Eb
Keno4	4.7	4.2	2.0	6.0	E4b	E4b	Eb
Elk2	7.2	3.5	2.5	17.0	E4b	E4b	Eb
Elk3	5.8	1.6	14.7	18.5	E4b	E4b	Eb
Elk3	10.1	1.6	4.1	19.5	E4b	E4b	Eb
Elk5	12.8	2.1	1.7	37.5	B4	B4	B
Elk7	12.5	0.7	1.6	24.5	B4c	E	E
Elk7	14.1	0.6	1.2	15.0	B4c	E	E
Elk8	12.1	No data	1.5	12.0	B4c	E	E
Elk9	11.3	0.2	1.3	5.0	E5	E	E
Elk10	9.9	0.4	4.9	3.5	B4c	E	E
Elk10	6.4	0.1	1.5	15.0	B4c	E	E
Bel2	11.5	4.2	1.3	17.5	B4	B4	B
Bel4	14.5	1.9	3.6	33.5	C4	C4	C
Washoe4	9.5	2.1	7.7	37.0	E3	E3	E
EAshb3	6.4	3.1	5.2	12.5	E3b	E3b	Eb
WAshb3	8.0	2.5	2.4	21.0	E3b	E3b	Eb
Cam2	17.4	1.7	2.8	15.0	C2	E4	E
Cam4	10.3	1.5	2.5	4.5	C4	E4	E
Cam6	10.1	0.6	1.5	27.0	E4	E5	E
Union1	19.1	No data	1.6	18.0	B	B	B

Table C-1. Summary of reach statistics by channel type.

Reach	**Avg Width to Depth Ratio**	**Existing Slope (%)**	**Avg Entrench-ment Ratio**	**Average D50 (mm)**	**Existing Type**	**Potential Type**	**Population**
Union4	5.6	3.1	4.1	21.5	E4b	E4b	Eb
Union5	11.9	1.6	1.6	9.5	B4c	E4b	E
Union8	9.8	0.6	1.4	16.5	F4/G4c	E4	E
Union8	6.7	1.2	6.4	25.0	F4 /G4c	E4	E
Union11	11.6	0.5	1.8	18.5	F5	E5	E
Union12	14.4	2.4	1.4	111.0	B3	B3	B

Width to Depth Ratio

Width to depth ratio, measured as the ratio of bankfull width to mean bankfull depth at riffle cross sections, is an important measure of overall channel form. The parameter is commonly used as a primary stream classification criteria (Rosgen, 1994) and means of site stratification. Width to depth ratios also can provide some indication of channel function, as alluvial streams that undergo significant changes in hydrology, sediment load, or bank stability will respond morphologically and thereby display altered channel cross sections. Reference data sets for width to depth ratio include the Beaverhead/Deerlodge National Forest dataset (Bengeyfield, BDNF), and internal reference reach data from the Middle Blackfoot/Nevada Creek Planning areas.

Target values for width to depth ratio consist of an optimal range for a given channel type. Although the range expresses a typical minimum value for a given channel type, departures are identified in terms of an exceedence of the maximum value of the range (excessively high width to depth ratios). In some cases, the measured width to depth ratio is lower than the expressed minimum of the range. These cases of low width:depth ratios typically reflect natural erosion resistance of bank materials. As a result, measured width to depth ratios below the minimum value do not indicate impairment with respect to aquatic life or the cold water fishery.

A total of three cross sections were surveyed at each assessment site, and the average of those three values used to describes the assessment reach cross section. A statistical analysis of those values based on channel type indicates that several of the E and B assessment reaches have relatively high width to depth ratios (**Table C-2**, **Figure C-1**).

Table C-2. Lower Blackfoot Planning Area width to depth ratios.

Width to Depth Ratio(by Channel Type)				
	B	**C**	**E**	**Eb**
Q1	11.5	14.5	9.9	5.7
Min	5.1	14.5	6.4	4.7
Median	12.8	14.5	10.8	6.4
Max	19.1	14.5	17.4	10.1
Q3	14.4	14.5	12.0	7.4
N	5	1	14	8

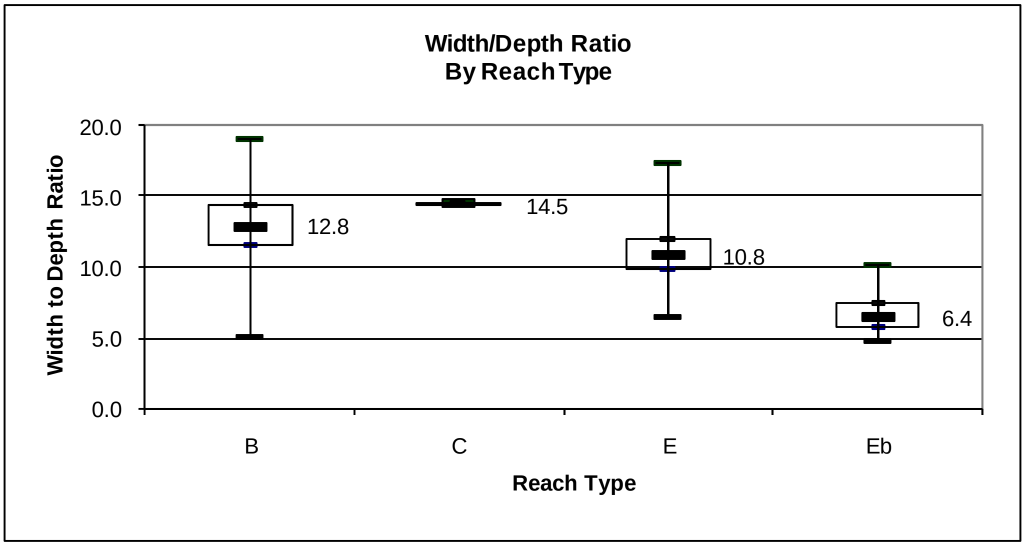


Figure C-1. Width to depth ratio summarized by channel type, Lower Blackfoot Planning Area; median values are labeled.

A series of width to depth ratio targets for the Lower Blackfoot Planning Area is compiled in **Table C-3**. For B and E channel types, the target values are the same as those defining the channel type and are consistent with those of the Nevada Creek and Middle Blackfoot Planning Areas. The target for C channel types is based on Middle Blackfoot Planning Area data, due to the single data point available for the Lower Blackfoot Planning Area.

A comparison of those target values to measured width to depth ratios indicates that upper Union Creek (Un1) has a width to depth ratio that exceeds the B channel target, and that several reaches on Camas Creek and Elk Creek exceed the proposed target for E channel types (**Figure C-2**).

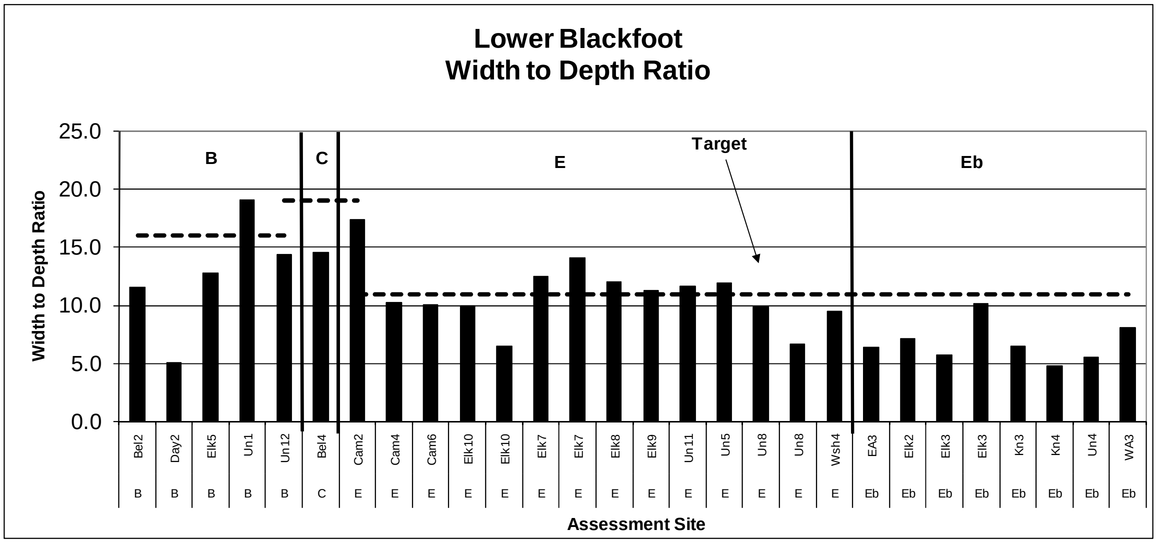


Figure C-2. Width to depth ratio values for assessment reaches and target values.

Table C-3. Lower Blackfoot targets for width to depth ratio.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**			
		Channel Type	**25th Percentile (Q1)**	**Min**	**Median**	**Max**	**75th Percentile (Q3)**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Lower Blackfoot Targets**	**Basis**
Width to Depth Ratio	Type II	B	11.5	5.1	12.8	19.1	14.4	5	12 to 16	Minimum: B type classification	12 to 16	Minimum: B type classification	12 to 16	Minimum: B type classification
										Maximum: Beaverhead/ Deerlodge National Forest (BDNF) Q3; Nevada Creek Q3		Maximum: BDNF Q3; Nevada Creek Q3		Maximum: BDNF Q3
		C	14.5	14.5	14.5	14.5	14.5	1	12 to 19	Minimum: C type classification	12 to 20	Minimum: C type classification	12 to 19	Minimum: C type classification
										Maximum: Middle Blackfoot median		Maximum: Nevada Creek median		Maximum: Middle Blackfoot median
		E	9.9	6.4	10.8	17.4	12.0	14	6 to 11	Minimum: E type classification, Middle Blackfoot Q1	6 to 11	Minimum: E type classification, Nevada Creek Q1	6 to 11	Minimum: E type classification
		E b	5.7	4.7	6.4	10.1	7.4	8		Maximum: E type classification, Middle Blackfoot Q3		Maximum: E type classification, Nevada Creek Q3		Maximum: E type classification, Middle Blackfoot and Nevada Creek Q3

Entrenchment Ratio

Entrenchment ratio targets are applied to channels for which entrenchment is identified as a negative alteration of the natural channel form. An entrenched condition on open valley stream types reflects a loss in floodplain access. This may occur from channel incision below the active floodplain, or potentially from channel widening and consequent reduction in mean channel depth. Entrenched channels classified as potential E or Eb channel types have an entrenchment target of >2.2, which defines the classification boundary between entrenched and unentrenched streams in the Rosgen classification scheme (Rosgen, 1994).

A summary of measured entrenchment ratios for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-4** and **Figure C-3**. Target values are listed in **Table C-5**. When site values are compared with those proposed target values, numerous E type assessment reaches show a high degree of entrenchment (entrenchment value less than the target; **Figure C-4**). This entrenchment of E channel types reflects downcutting and/or channel widening that has reduced floodplain access within the assessment reach.

Table C-4. Lower Blackfoot Planning Area entrenchment ratios.

Entrenchment Ratio				
Statistic	**B**	**C**	**E**	**Eb**
Q1	1.4	3.6	1.5	2.5
Min	1.3	3.6	1.2	2.0
Median	1.6	3.6	1.6	4.0
Max	2.5	3.6	7.7	5.2
Q3	1.7	3.6	2.7	4.1
N	5	1	14	8

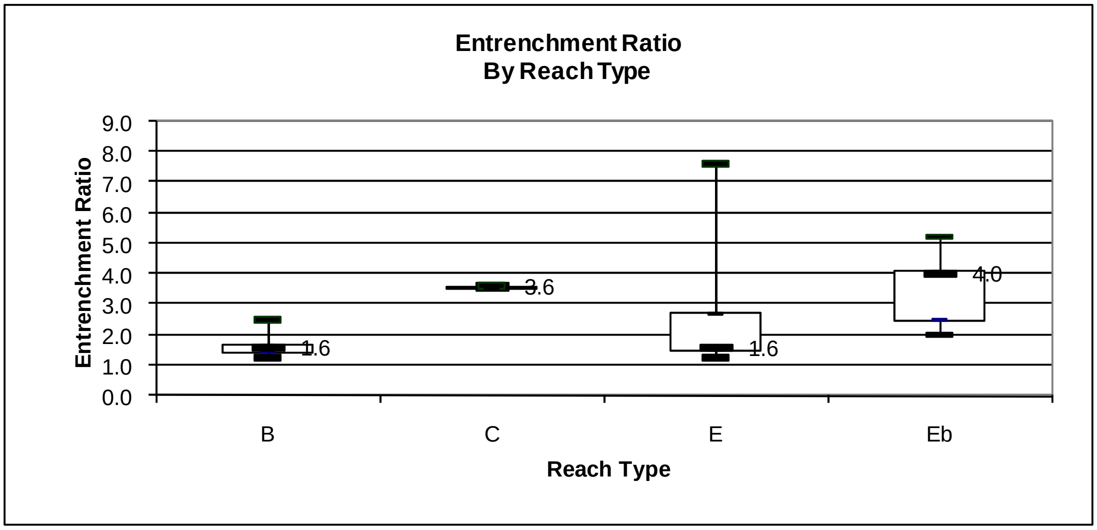


Figure C-3. Entrenchment ratio summarized by channel type, Lower Blackfoot Planning Area

Table C-5. Lower Blackfoot targets for entrenchment ratio.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Targets**	
Entrenchment Ratio	Supp Indicator	Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
		B	1.4	1.3	1.6	2.5	1.7	5	N/A		N/A		N/A	
		C	3.6	3.6	3.6	3.6	3.6	1	N/A	>2.2	N/A	>2.2	>2.2	Minimum: C type classification
		E	1.5	1.2	1.6	7.7	2.7	14	N/A	>2.2	N/A	>2.2	>2.2	Minimum: E type classification
		Eb	2.5	2.0	4.0	5.2	4.1	8	N/A	>2.2	N/A	>2.2		

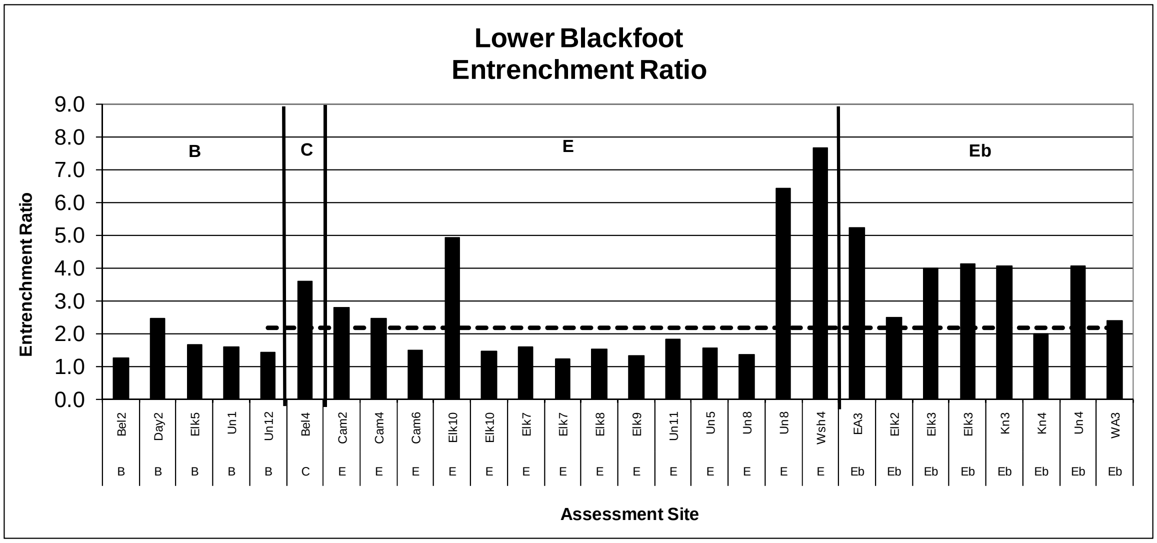


Figure C-4. Entrenchment ratio values for assessment reaches and target values.

Pool Frequency

Pool frequency is an important measure of stream habitat conditions. Pools provide critical habitat for cold-water fish and are linked to the storage, deposition, and sorting of sediment within a channel.

A summary of measured pool frequencies for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-6** and **Figure C-5**. Target values are listed in **Table C-7**. For B and E channel types, the pool frequency values measured in the Lower Blackfoot Planning Area are significantly higher than the targets developed for the Middle Blackfoot and Nevada Creek Planning Areas. Because of these high pool frequencies, the median value measured in the Lower Blackfoot Planning area was selected as an appropriate target. Because there is only one C channel type assessment reach in the Lower Blackfoot Planning Area, the Middle Blackfoot target has been applied for C channel types. When site values are compared with those target values, the assessment reaches show a high variability in pool frequency values for B, E, and Eb channel types (**Figure C-6**).

Table C-6. Lower Blackfoot Planning Area pool frequency statistics.

Pool Frequency				
Statistic	**B**	**C**	**E**	**Eb**
Q1	21.1	63.4	33.0	42.2
Min	10.6	63.4	21.1	26.4
Median	47.5	63.4	50.2	50.2
Max	84.5	63.4	105.6	95.0
Q3	84.5	63.4	70.0	68.6
N	5	1	14	8

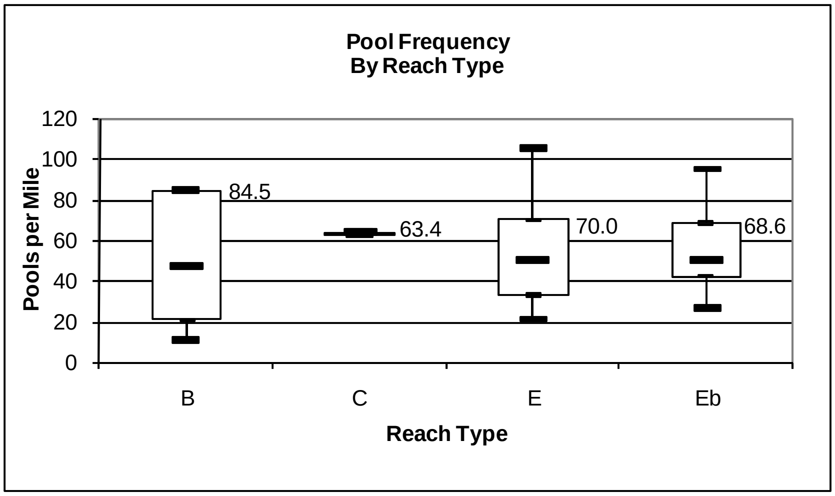


Figure C-5. Pool frequency summarized by channel type, Lower Blackfoot Planning Area

Table C-7. Lower Blackfoot targets for pool frequency.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Targets**	
		Channel Type	**Q1**	**Min**	**Median**	**Max**	**Q3**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Target**	**Basis**
Pool Frequency (pools per mile)	Target	B	21	11	48	84	84	5	≥ 20	Nevada Creek Q3; Reference stream median	≥ 20	Nevada Creek Q3; Reference stream median	≥ 48	Lower Blackfoot Median
		C	63	63	63	63	63	1	≥ 55	Middle Blackfoot Q3	≥ 46	Nevada Creek Q3	≥ 55	Middle Blackfoot Q3
		E	33	21	50	106	70	14	≥ 40	Nevada Creek Q3; Middle Blackfoot reference Q3	≥ 40	Nevada Creek Q3	≥ 50	Lower Blackfoot Median
		Eb	42	26	50	95	69	8						

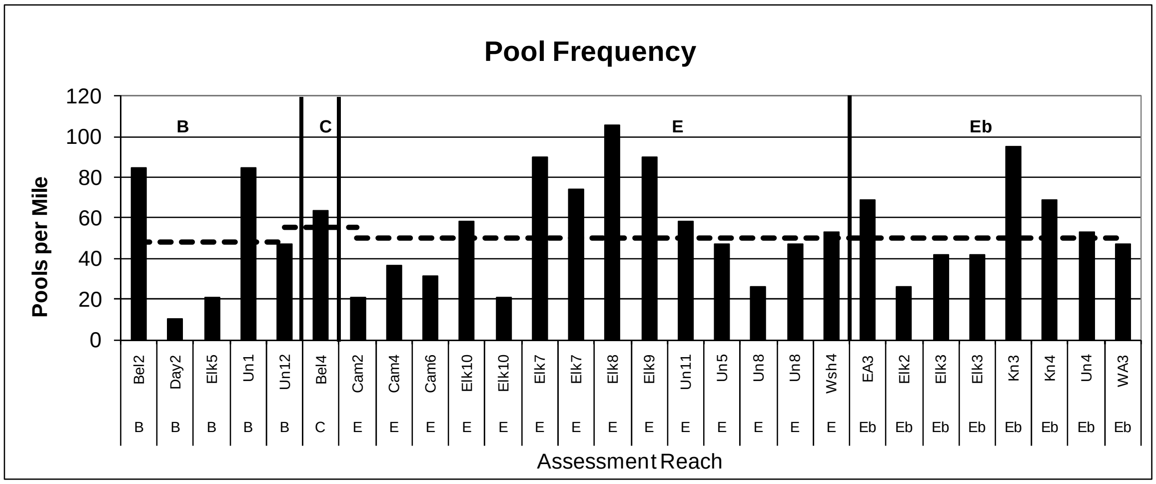


Figure C-6. Pool frequency values for assessment reaches and target values.

Residual Pool Depth

Residual pool depth is a general descriptor of overall pool quality. Pools provide important winter habitat for juvenile fish, as well as refuge from thermal stressors, cover from predators, food, and rearing areas. Pools also provide a general indicator of overall stream complexity.

A summary of residual pool depth statistics for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-8** and **Figure C-7**. Target values are listed in **Table C-9**. The 75th percentile value was selected as a target for B, E, and Eb channel types, and due to a low number of data points, the Middle Blackfoot target was utilized for C channels. A comparison of site values to proposed target values indicate that all reach types have sites in which the target values are not met (**Figure C-8**).

Table C-8. Lower Blackfoot Planning Area residual pool depth statistics.

Residual Pool Depth				
Statistic	**B**	**C**	**E**	**Eb**
Q1	0.58	1.12	0.66	0.59
Min	0.15	1.12	0.41	0.41
Median	0.80	1.12	0.74	0.64
Max	1.15	1.12	1.51	1.22
Q3	1.08	1.12	0.97	0.77
N	5	1	14	8

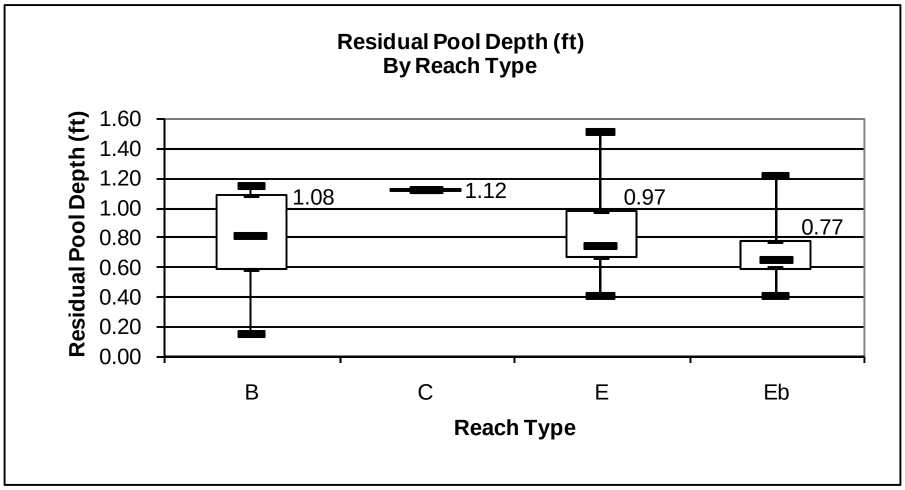


Figure C-7. Residual pool depth summarized by channel type, Lower Blackfoot Planning Area.

Table C-9. Lower Blackfoot targets for residual pool depth.

Parameter	Target Level	Lower Blackfoot Statistics							Middle Blackfoot Targets		Nevada Creek Targets		Lower Blackfoot Targets	
Residual Pool Depth	Type I	Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
		B	0.58	0.15	0.8	1.15	1.08	5	≥ 0.6	Nevada Creek Q3	≥ 0.6	Nevada Creek Q3	≥ 1.1	Lower Blackfoot Q3
		C	1.12	1.12	1.12	1.12	1.12	1	≥ 2.0	Nevada Creek Q3; Middle Blackfoot Q3	≥ 2.0	Nevada Creek Q3; Middle Blackfoot Q3	≥ 2.0	Nevada Creek Q3; Middle Blackfoot Q3
		E	0.66	0.41	0.74	1.505	0.97	14	≥ 1.5	Middle Blackfoot reference Q3	≥ 1.5	Nevada Creek Q3	≥ 1.0	Lower Blackfoot Q3
		Eb	0.59	0.41	0.64	1.215	0.77	8					≥ 0.8	Lower Blackfoot Q3

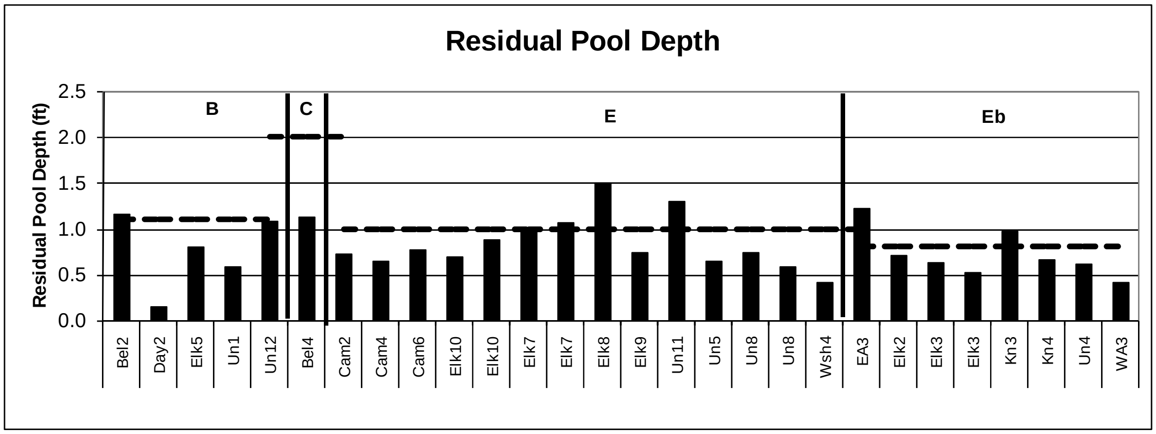


Figure C-8. Residual pool depth values for assessment reaches and target values.

Pool Habitat Extent

The pool extent parameter refers to the percent of total channel length that is comprised of mapped pools units. This measure is linear, and does not reflect pool width or overall volume. However, it is a general indicator of overall channel complexity and extent of pool habitat area.

A summary of pool habitat extent statistics for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-10** and **Figure C-9**. The summary statistics show that Eb channels tend to have a lower extent of pools than E channels; this reflects the high slopes characteristic of the Eb channel type. Proposed target values for pool habitat extent are listed in **Table C-11**. The 75th percentile for assessed sites was used to define the target for B, E, and Eb channel types; the target for C channels is based on Middle Blackfoot Planning Area data due to a low number of C channel assessment sites in the Lower Blackfoot. A comparison of site values to proposed target values indicate that these pool habitat extent targets are not met in most reaches (**Figure C-10**).

Table C-10. Lower Blackfoot Planning Area pool habitat extent statistics.

Pool Extent				
Statistic	**B**	**C**	**E**	**Eb**
Q1	4%	41%	10%	6%
Min	2%	41%	3%	5%
Median	13%	41%	19%	7%
Max	25%	41%	48%	27%
Q3	22%	41%	35%	10%
N	5	1	14	8

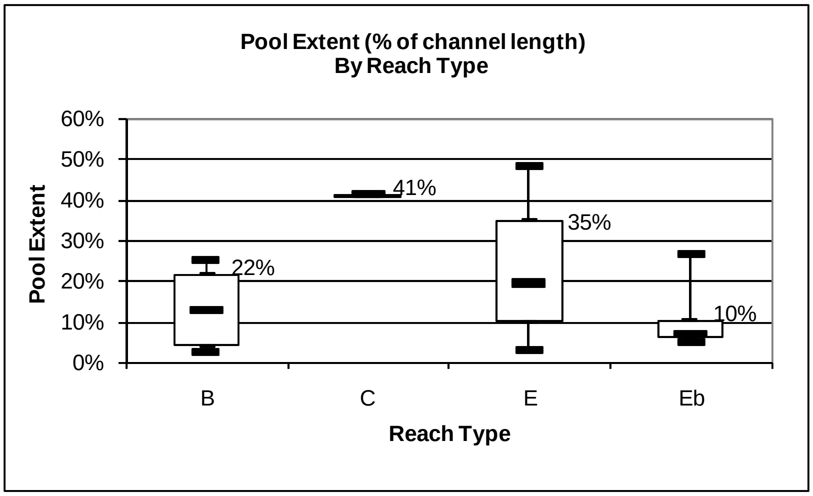


Figure C-9. Pool habitat extent summarized by channel type, Lower Blackfoot Planning Area

Table C-11. Lower Blackfoot targets for pool habitat extent.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Target**	
Pool Habitat Extent	Supp. Indicator	**Channel Type**	**Q1**	**Min**	**Median**	**Max**	**Q3**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Target**	**Basis**
		B	4%	2%	13%	25%	22%	5	≥ 10	Nevada Creek reference Q3	≥ 10	Nevada Creek reference Q3	≥22	Lower Blackfoot Q3
		C	41%	41%	41%	41%	41%	1	≥ 35	Nevada Creek Q3; Middle Blackfoot Q3	≥ 35	Nevada Creek Q3; Middle Blackfoot Q3	≥ 35	Nevada Creek Q3; Middle Blackfoot Q3
		E	10%	3%	19%	48%	35%	14	≥ 19	Middle Blackfoot reference Q3	≥29	Nevada Creek Q3	≥ 35	Lower Blackfoot Q3
		Eb	6%	5%	7%	27%	10%	8					≥10	Lower Blackfoot Q3

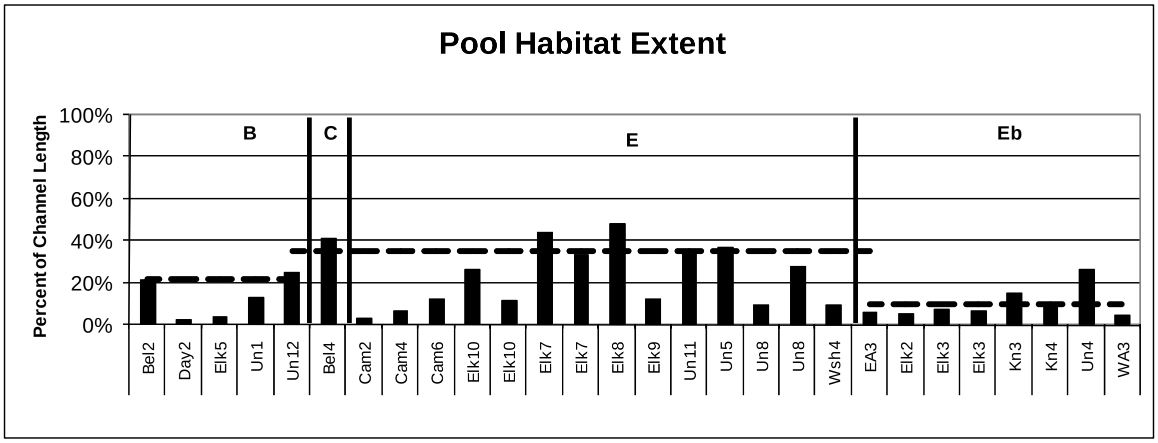


Figure C-10. Pool habitat extent values for assessment reaches and target values.

Woody Debris Aggregate Extent

The percent of total channel length occupied by woody debris aggregates is a general indicator of channel complexity.

A summary of woody debris aggregate extent statistics for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-12** and **Figure C-11**. The assessed B channel on Belmont Creek (Bel2) is in an area of logging activity. As such, B channel types were also evaluated with that site removed from the dataset, since field crews indicated that the conditions were directly associated with proximal land use. Target values for woody debris aggregate extent are listed in **Table C-13**. For B channels, the 75th percentile value for the B channel types was adopted as the target value, with Belmont Creek removed from the dataset. Middle Blackfoot targets were adopted for C, E, and Eb channel types, as these values are slightly higher than the 75th percentile values measured in the Lower Blackfoot Planning Area. A comparison of site values to proposed target values indicate that these preliminary woody debris aggregate extent targets are not met in most reaches (**Figure C-12).**

Table C-12. Lower Blackfoot Planning Area woody debris aggregate extent statistics (expressed as percent of channel length).

Woody Debris Aggregate Extent					
Statistic	**B**	**B (no Bel4)**	**C**	**E**	**Eb**
25th Percentile	3%	2%	6%	2%	4%
Min	0%	0%	6%	0%	1%
Median	9%	6%	6%	4%	5%
Max	75%	21%	6%	19%	12%
75th Percentile	21%	12%	6%	7%	8%
N	5	4	1	14	8

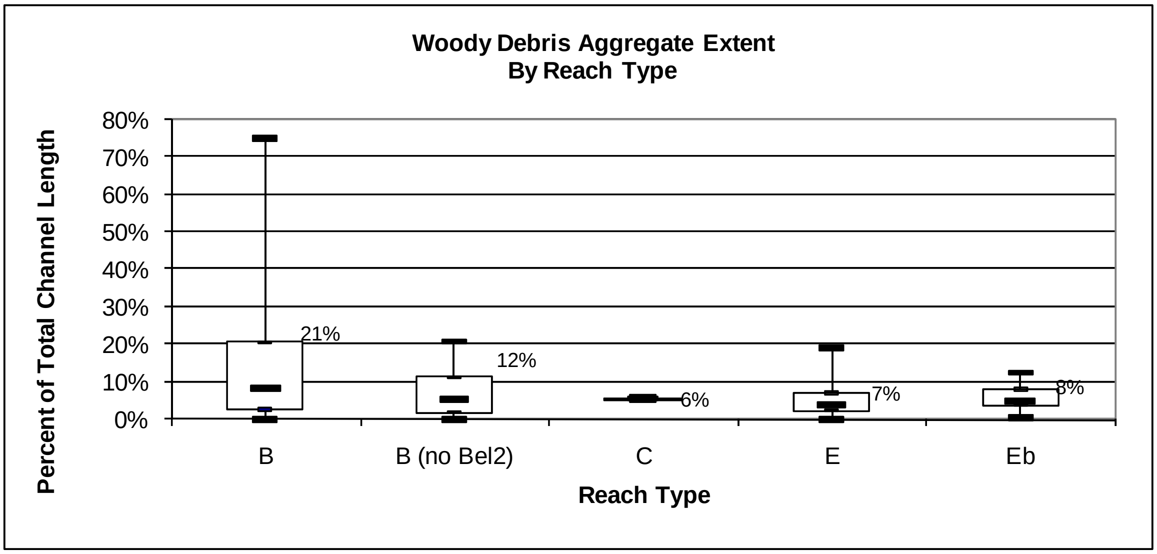


Figure C-11. Woody debris aggregate extent summarized by channel type, Lower Blackfoot Planning Area.

Table C-13. Lower Blackfoot targets for woody debris aggregate extent.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Target**	
		Channel Type	**Q1**	**Min**	**Median**	**Max**	**Q3**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Target**	**Basis**
Woody Debris Aggregate Extent	Supp. Indicator	B	3%	0%	9%	75%	21%	5	> 3 %	Nevada Creek Q3	> 3 %	Nevada Creek Q3	>12%	Lower Blackfoot Q3 (Bel4 excluded)
		B (no Bel4)	2%	0%	6%	21%	12%	4						
		C	6%	6%	6%	6%	6%	1	> 8%	Middle Blackfoot Q3	> 7%	Nevada Creek Q3	> 8%	Middle Blackfoot Q3
		E	2%	0%	4%	19%	7%	14	> 12%	Middle Blackfoot reference Q3	> 12%	Middle Blackfoot reference Q3	> 12%	Middle Blackfoot reference Q3
		Eb	4%	1%	5%	12%	8%	8						

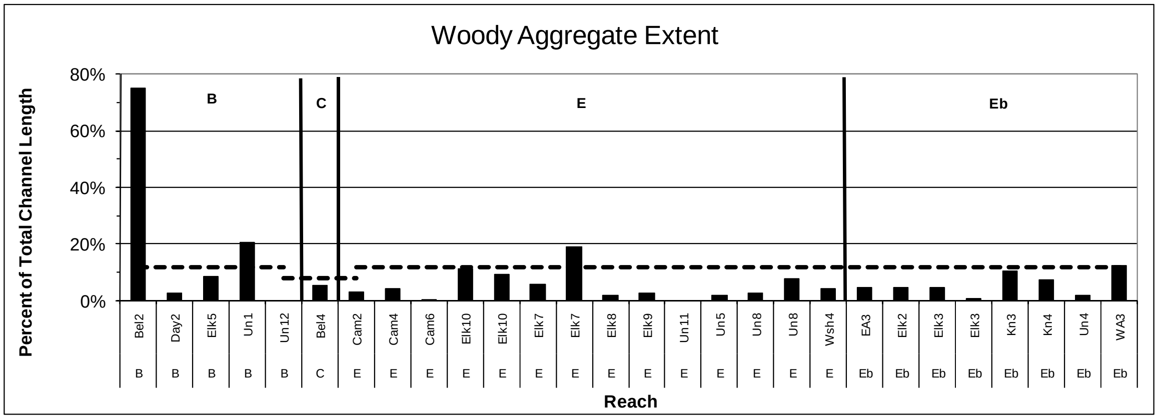


Figure C-12. Woody debris aggregate extent values for assessment reaches and proposed target values.

Woody Debris Aggregate Frequency

The density of woody debris aggregates is a general indicator of channel complexity. A summary of woody debris aggregate frequency (aggregates per mile) statistics for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-14** and **Figure C-13**. The assessed B channel on Belmont Creek (Bel2) is in an area of logging activity. As such, B channel types were also evaluated with that site removed from the dataset due to its high woody debris aggregate extent value that may be directly associated with proximal land use. Target values for woody debris aggregate frequency are listed in **Table C-15**. Targets were not developed for this parameter in the Middle Blackfoot and Nevada Creek TMDL Planning Areas. As a result, for all channel types, the 75th percentile value measured in assessed reaches defines the target. A comparison of site values to proposed target values indicate that these preliminary woody debris aggregate frequency targets are not met in most reaches (**Figure C-14**).

Table C-14. Lower Blackfoot Planning Area woody debris aggregate frequency statistics.

Woody Debris Aggregate Frequency (aggregates per mile)					
Statistic	**B**	**B (no Bel2)**	**C**	**E**	**Eb**
25th Percentile	79	59	74	20	24
Min	0	0	74	0	11
Median	95	87	74	40	50
Max	491	222	74	137	148
75th Percentile	222	127	74	55	73
N	5	4	1	14	8

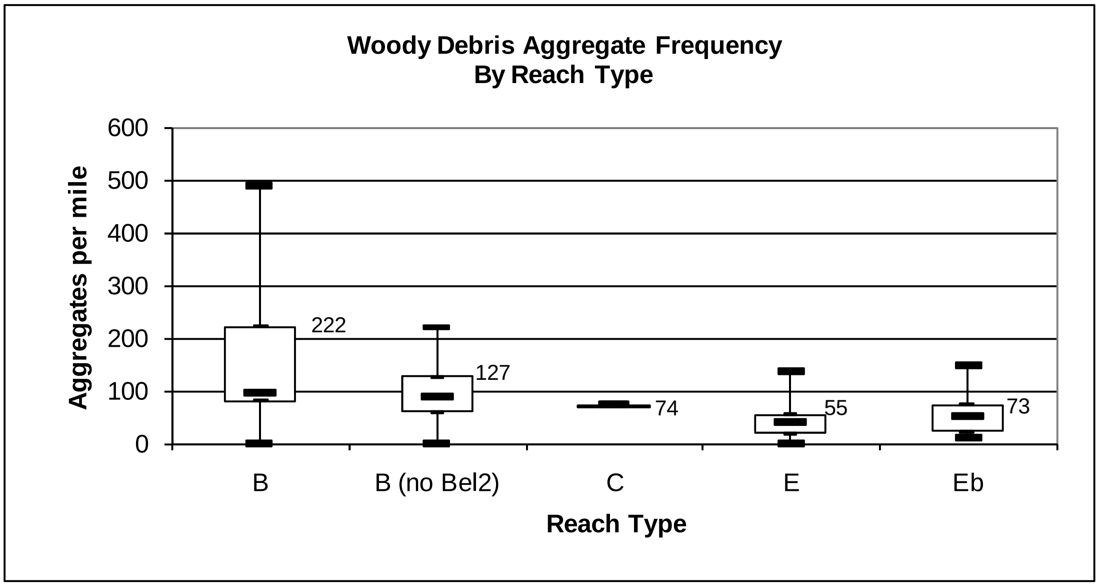


Figure C-13. Woody debris aggregate frequency summarized by channel type, Lower Blackfoot Planning Area

Table C-15. Lower Blackfoot targets for woody debris aggregate frequency (aggregates per mile).

Parameter	Target Level	Lower Blackfoot Statistics							Middle Blackfoot Targets		Nevada Creek Targets		Lower Blackfoot Target	
		Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
Woody Debris Aggregate Frequency	?	B	79	0	95	491	222	5	N/A	N/A	N/A	N/A	127	Lower Blackfoot Q3 (Bel4 excluded)
		B (no Bel4)	59	0	87	222	127	4						
		C	74	74	74	74	74	1	N/A	N/A	N/A	N/A	74	Lower Blackfoot Q3
		E	20	0	40	137	55	14	N/A	N/A	N/A	N/A	55	Lower Blackfoot Q3
		Eb	24	11	50	148	73	8	N/A	N/A	N/A	N/A	73	Lower Blackfoot Q3

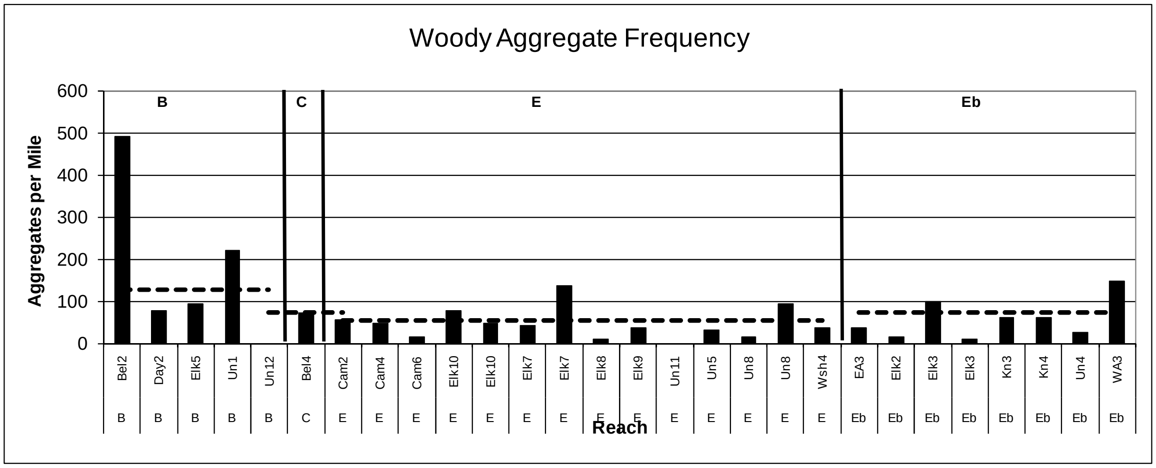


Figure C-14. Woody debris aggregate frequency values for assessment reaches and target values.

Woody Vegetation Extent

The extent of woody vegetation on either channel bank is an important indicator for stream condition related to habitat in terms of cover, shade, and woody debris recruitment. Woody vegetation also adds to bank stability, and can thereby reduce sediment loading to streams. A summary of woody vegetation extent statistics for assessed reaches in the Lower Blackfoot Planning Area is shown in **Table C-16** and **Figure C-15**. Target values for woody vegetation extent are listed in **Table C-17**. For B and C channel types, the Middle Blackfoot targets were adopted, and for E and Eb channel types, the Lower Blackfoot Planning Area 75th percentile value is the target condition. A comparison of site values to proposed target values indicate that the measured extent of woody vegetation is highly variable among E channel types (**Figure C-16**). The results indicate that the listed streams are commonly densely vegetated with woody vegetation.

Table C-16. Lower Blackfoot Planning Area woody vegetation extent statistics.

Woody Vegetation Extent (% of total channel length)				
Statistic	**B**	**C**	**E**	**Eb**
25th Percentile	100	99	16	71
Min	64	99	0	33
Median	100	99	51	99
Max	100	99	100	100
75th Percentile	100	99	67	100
N	5	1	14	8

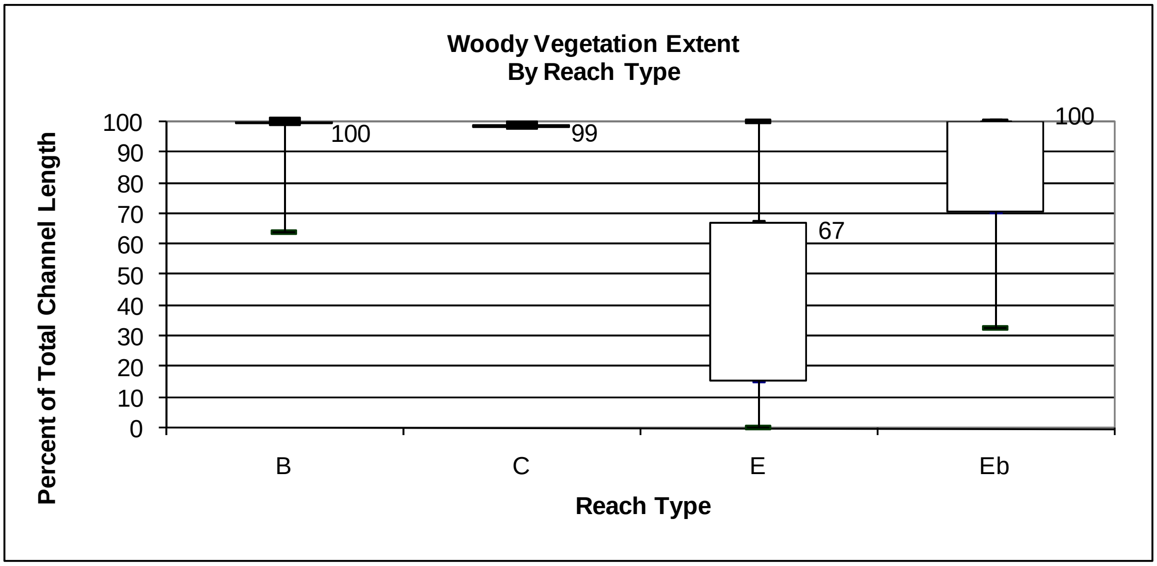


Figure C-15. Woody vegetation extent statistics summarized by channel type, Lower Blackfoot Planning Area

Table C-17. Lower Blackfoot targets for woody vegetation extent.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Target**	
Woody Vegetation Extent	Type II	**Channel Type**	**Q1**	**Min**	**Median**	**Max**	**Q3**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Target**	**Basis**
		B	100	64	100	100	100	5	> 88 %	Nevada Creek Q3	> 88 %	Nevada Creek Q3	>88%	Nevada Creek Q3
		C	99	99	99	99	99	1	> 84%	Middle Blackfoot Q3	> 61%	Nevada Creek Q3	> 84%	Middle Blackfoot Q3
		E	16	0	51	100	67	14	> 69%	Middle Blackfoot Q3	> 74%	Nevada Creek Q3	> 67%	Lower Blackfoot Q3
		Eb	71	33	99	100	100	8					100	Lower Blackfoot Q3

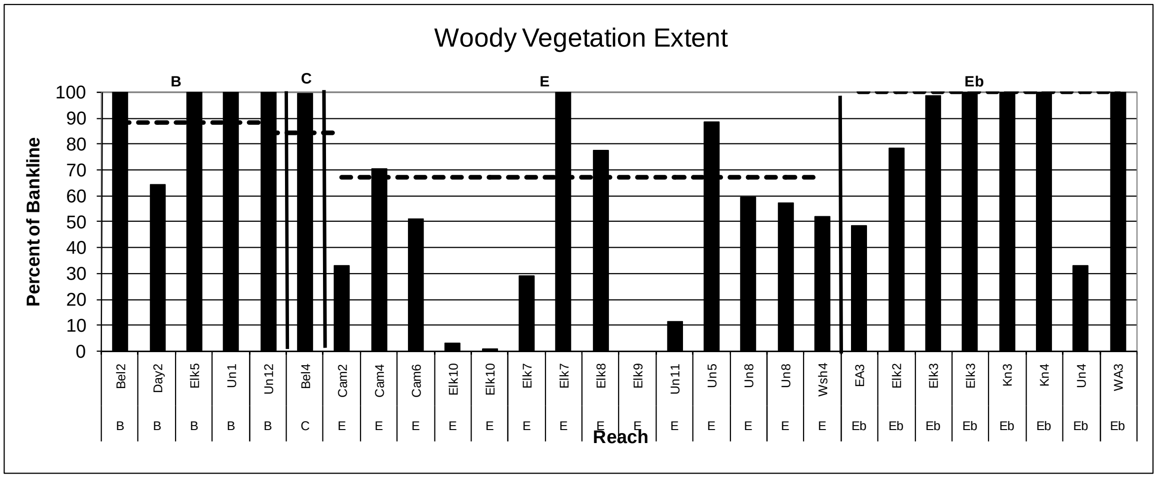


Figure C-16. Woody vegetation extent values for assessment reaches and target values.

Pebble Count <2mm

Target values for percent surface fines provide important criteria used to help define whether excess sediment loading has resulted in a siltation related cause of impairment. A summary of the percent fines fraction less than 2mm in riffles, as measured by pebble counts, is shown in **Table C-18** and **Figure C-17**. Target values for the less than 2mm size fraction in riffles are listed in **Table C-19**. These targets reflect 75th percentile values for all channel types. For B channel types, the Middle Blackfoot/Nevada Creek target is utilized.

Because granitic geology can commonly result in a high production rate of sand-sized sediment, those reaches that have granitic host rock, including upper Elk Creek, Keno Creek, and West Ashby Creek, were analyzed separately from other assessed reaches. These sites are grouped into B(gr) and E(gr) populations. On Elk Creek, only the upper reaches of the listed segment, Elk1 through Elk5 were defined as granitic in nature. A plot of a percent fines trend along Elk Creek shows that fine sediment concentrations decrease in the downstream direction from Elk1 to Elk5, and then increases in the lowermost channel segments (**Figure C-18**). In the lowermost reaches, there is insufficient evidence to indicate that these high fines measurements are directly attributable to headwaters geology. In these lower reaches, low channel gradients, sediment reworking, additional fine sediment inputs, and proximal land uses may be significant controlling factors in sediment concentrations. A comparison of site values to target values indicate that the concentrations of fine sediment <2mm is highly variable among most channel types (**Figure C-19**). For the <2 size fraction, the 75th percentile values are quite close for the Eb and Eb(gr) channel types (33 percent and 35 percent, respectively), indicating that a single target value will likely suffice for these channel types.

Table C-18. Lower Blackfoot Planning Area pebble count statistics for less than 2mm size fraction in riffles.

Statistic	B	B (gr)	C	E	Eb	Eb(gr)
25th Percentile	5.5	12.0	3.8	4.5	8.0	16.0
Min	1.0	11.0	2.0	0.0	2.0	7.0
Median	13.0	13.0	5.5	8.0	19.5	19.0
Max	36.0	15.0	9.0	55.0	43.0	63.0
75th Percentile	15.0	14.0	7.3	20.0	32.5	34.5
N	7	2	2	27	4	11

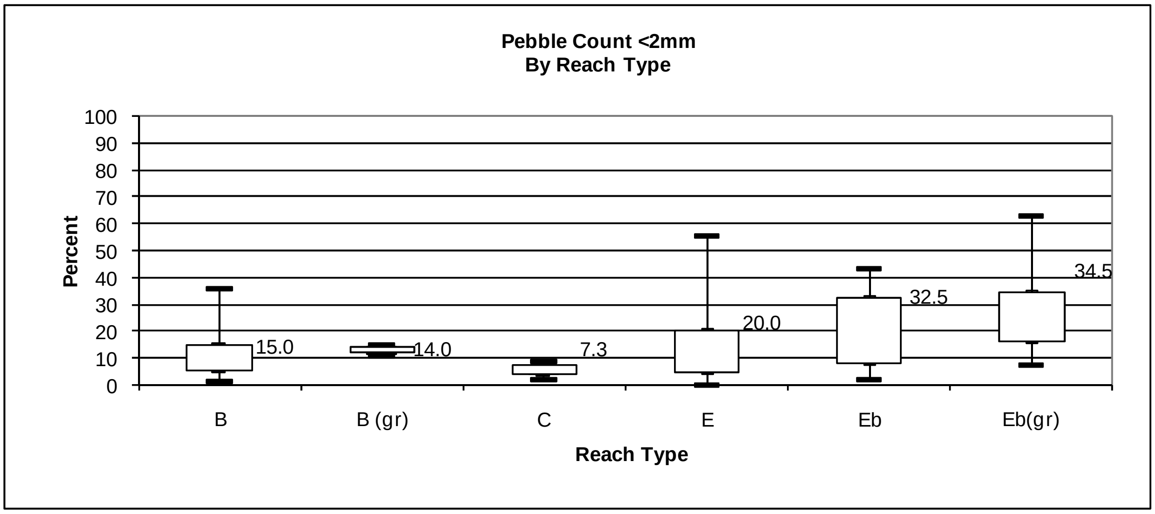


Figure C-17. Pebble count statistics for less than 2mm size fraction in riffles summarized by channel type, Lower Blackfoot Planning Area

Table C-19. Lower Blackfoot targets for pebble count statistics for less than 2mm size fraction in riffles.

Parameter	Target Level	Lower Blackfoot Statistics							Middle Blackfoot Targets		Nevada Creek Targets		Lower Blackfoot Targets	
		Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
Substrate: Percent <2mm in riffles measured by Pebble Count	Type I	B	6	1	13	36	15	7	≤ 10	Nevada Creek reference Q3	≤ 10	Nevada Creek Q3	≤ 10	Nevada Creek reference Q3
		B (gr)	12	11	13	15	14	2						
		C	4	2	6	9	7	2	≤ 11	Middle Blackfoot Q3	≤ 7	Nevada Creek Q3	≤ 7	Lower Blackfoot Q3, Nevada Creek Q3
		E	5	0	8	55	20	27	≤ 34	Middle Blackfoot reference Q3	≤ 20	Nevada Creek Q3	≤ 20	Lower Blackfoot Q3, Nevada Creek Q3
		Eb	8	2	20	43	33	4					≤ 33	Lower Blackfoot Q3
		Eb(gr)	16	7	19	63	35	11					≤ 35	Lower Blackfoot Q3

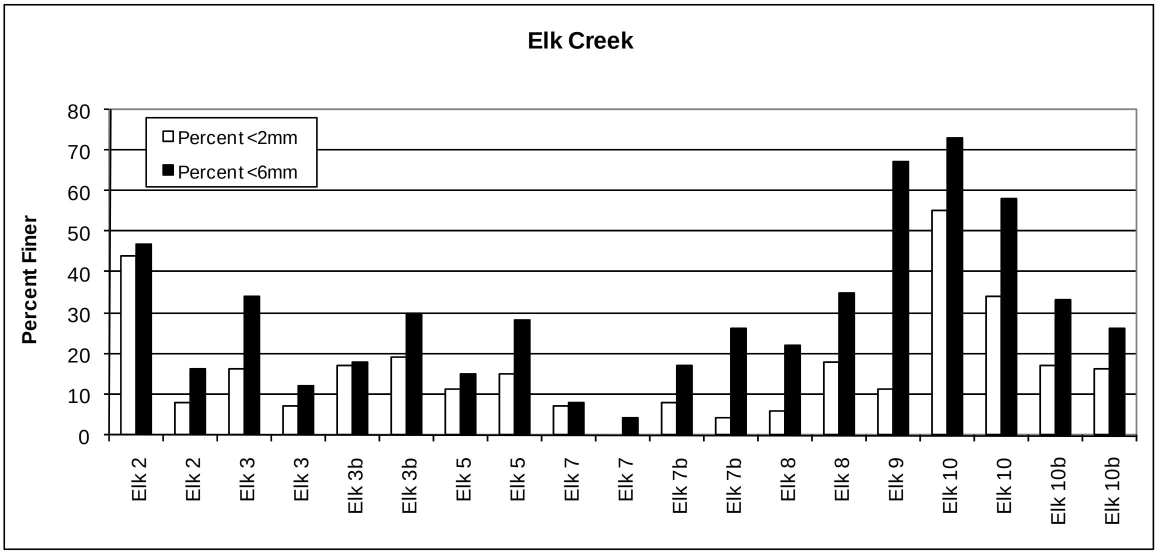


Figure C-18. Plot of pebble count data showing downstream trend (left to right) in less than 2mm and less than 6mm size fractions, Elk Creek.

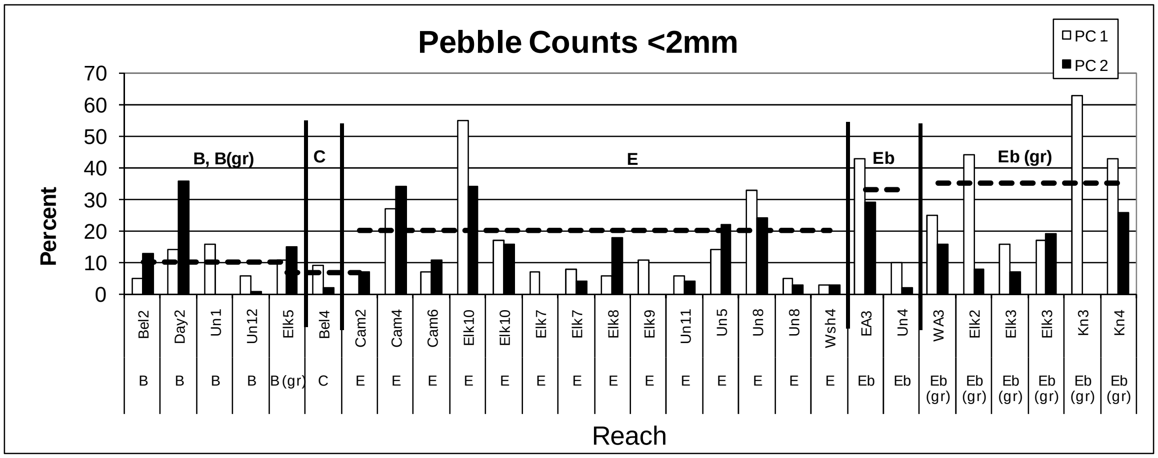


Figure C-19. Less than 2mm size fraction in riffles values for assessment reaches and target values.

Pebble Counts <6mm

Target values for percent surface fines provide important criteria used to help define whether excess sediment loading has resulted in a siltation related cause of impairment. A summary of the percent fines fraction less than 6mm in riffles, as measured by pebble counts, is shown in **Table C-20** and **Figure C-20** Target values for the less than 6mm size fraction in riffles are listed in **Table C-21**. These targets reflect 75th percentile values derived from the Lower Blackfoot Planning Area for E and Eb channel types. For B and C channel types, Beaverhead/Deerlodge National Forest (BDNF) data were utilized to define targets similar to the Middle Blackfoot/Nevada Creek Planning Areas.

Because granitic geology can commonly result in a high production rate of sand-sized sediment, those reaches that have granitic host rock, including upper Elk Creek, Keno Creek, and West

Ashby Creek were analyzed separately from other assessed reaches. These sites are grouped into B(gr) and E(gr) populations. A comparison of site values to proposed target values indicate that the concentrations of fine sediment <6mm is highly variable among most channel types (**Figure C-21**).

Table C-20. Lower Blackfoot Planning Area pebble count statistics for less than 6mm size fraction in riffles.

Statistic	**B**	**B (gr)**	**C**	**E**	**Eb**	**Eb(gr)**
25th Percentile	11.5	18.3	8.5	8.5	16.5	19.0
Min	1.0	15.0	6.0	3.0	9.0	12.0
Median	23.0	21.5	11.0	22.0	27.0	34.0
Max	49.0	28.0	16.0	74.0	43.0	85.0
75th Percentile	32.5	24.8	13.5	35.0	37.0	44.5
N	7	2	2	27	4	11

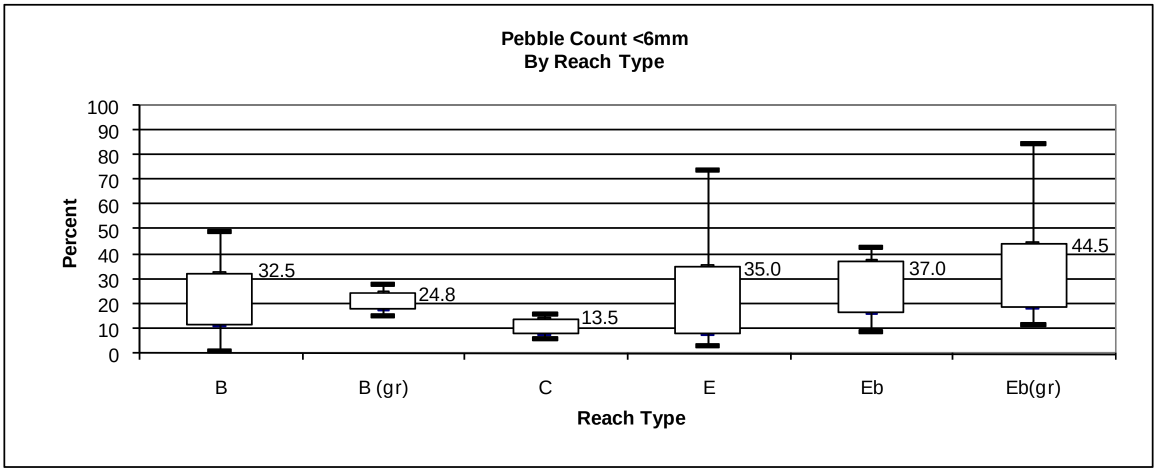


Figure C-20. Pebble count statistics for less than 6mm size fraction in riffles summarized by channel type, Lower Blackfoot Planning Area

Table C-21. Lower Blackfoot targets for pebble count statistics for less than 6mm size fraction in riffles.

Parameter	Target Level	Lower Blackfoot Statistics							Middle Blackfoot Targets		Nevada Creek Targets		Lower Blackfoot Targets	
		Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
Substrate: Percent <2mm in riffles measured by Pebble Count	Type I	B	12	1	23	49	33	7	≤ 20	Beaverhead/ Deerlodge National Forest (BDNF) Q3	≤ 20	BDNF Q3	≤ 20	BDNF Q3
		B (gr)	18	15	22	28	25	2						
		C	9	6	11	16	14	2	≤ 22	BDNF median (C4 streams)	≤ 22	BDNF median	≤ 22	BDNF median
		E	9	3	22	74	35	27	≤ 36	BDNF Q3 (E4 streams); Middle Blackfoot A ref Q3	≤ 36	BDNF Q3 (E4 streams); Middle Blackfoot ref Q3	≤ 36	Lower Blackfoot Q3 BDNF Q3
		Eb	17	9	27	43	37	4					≤ 37	Lower Blackfoot Q3 BDNF Q3
		Eb(gr)	19	12	34	85	45	11					≤ 45	Lower Blackfoot Q3

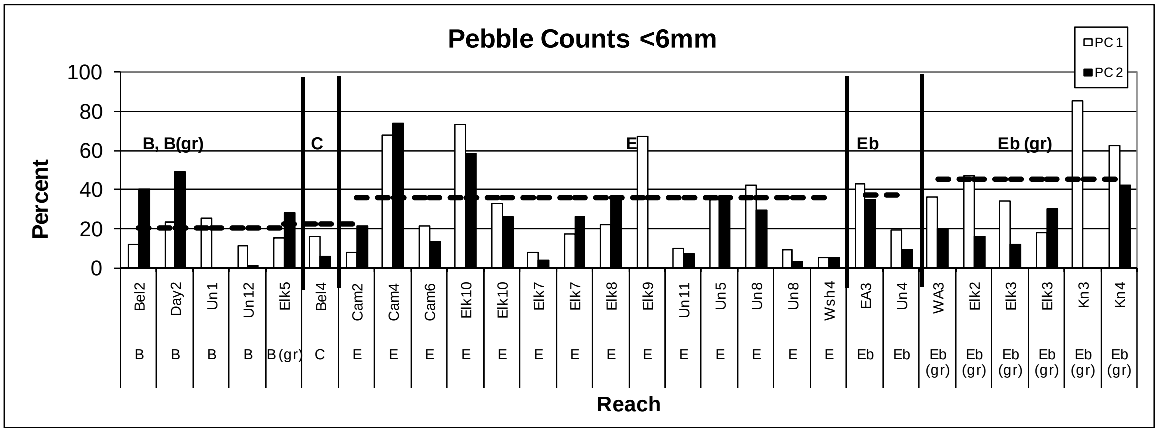


Figure C-21. Pebble count statistics for less than 6mm size fraction in riffles values for assessment reaches and proposed target values.

Surface Fines in Pool Tailouts

Target values developed for surface fines <6mm on the channel bed surface in pool tail environments provide criteria used to help define whether excess sediment loading has resulted in a siltation related cause of impairment. A summary of the percent fines fraction less than 6mm in pool tailouts, as measured by viewing bucket, is shown in **Table C-22** and **Figure C-22.** When the reaches that are located within granitic geology were assessed separately, there was no stratification between that dataset and the non-granitic data set. As such, these separate targets were not developed for granitic and non-granitic source rock for this parameter. Target values for the less than 6mm size fraction in tailouts are listed in **Table C-23**. These targets reflect 75th percentile values for various datasets. A comparison of site values to proposed target values indicate that the concentrations of fine sediment <6mm is highly variable among most channel types, although most assessment reaches meet preliminary targets (**Figure C-23**).

Table C-22. Lower Blackfoot Planning Area statistics for less than 6mm size fraction in pool tailouts.

Pool Tailout Fines				
Statistic	**B**	**C**	**E**	**Eb**
25th Percentile	12.5	37.5	18.0	27.8
Min	5.0	37.5	3.0	6.0
Median	20.0	37.5	23.3	40.5
Max	50.0	37.5	50.0	50.0
75th Percentile	31.3	37.5	45.5	42.0
N	4	1	14	7

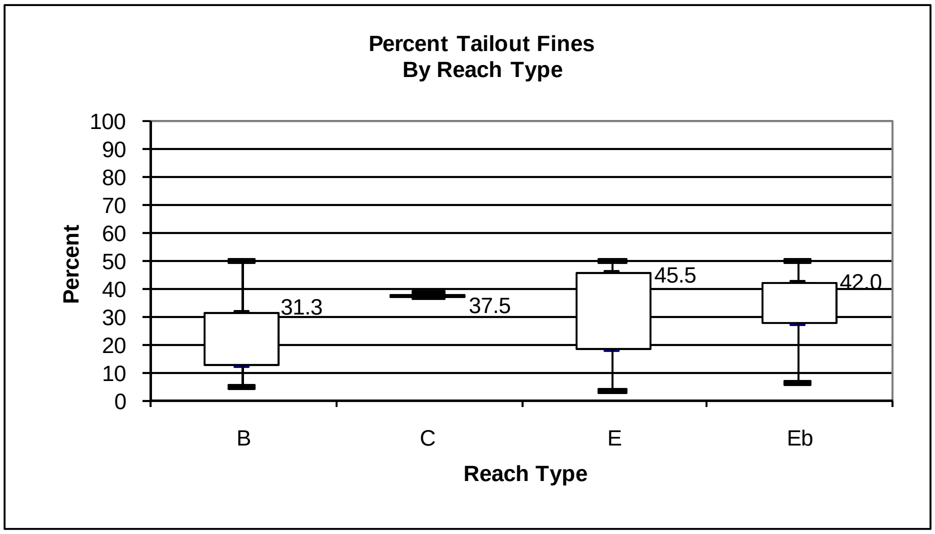


Figure C-22. Less than 6mm size fraction in pool tailouts summarized by channel type, Lower Blackfoot Planning Area

Table C-23. Lower Blackfoot targets for less than 6mm size fraction in pool tailouts.

Parameter	**Target Level**	**Lower Blackfoot Statistics**							**Middle Blackfoot Targets**		**Nevada Creek Targets**		**Lower Blackfoot Targets**	
Percent Surface Fines < 6 mm, Pool Tailouts, Median	Type II	**Channel Type**	**Q1**	**Min**	**Median**	**Max**	**Q3**	**N**	**Target**	**Basis**	**Target**	**Basis**	**Target**	**Basis**
		B	13	5	20	50	31	4	≤ 17	Nevada Creek Q3	≤ 17	Nevada Creek Q3	≤ 17	Nevada Creek Q3
		C	38	38	38	38	38	1	≤ 20	Middle Blackfoot Q3	≤ 23	Nevada Creek ref Q3	≤ 23	Nevada Creek ref Q3
		E	18	3	23	50	46	14	≤ 48	Middle Blackfoot ref Q3	≤ 82	Nevada Creek Q3	≤ 46	Lower Blackfoot Q3
		Eb	28	6	41	50	42	7					≤ 42	Lower Blackfoot Q3

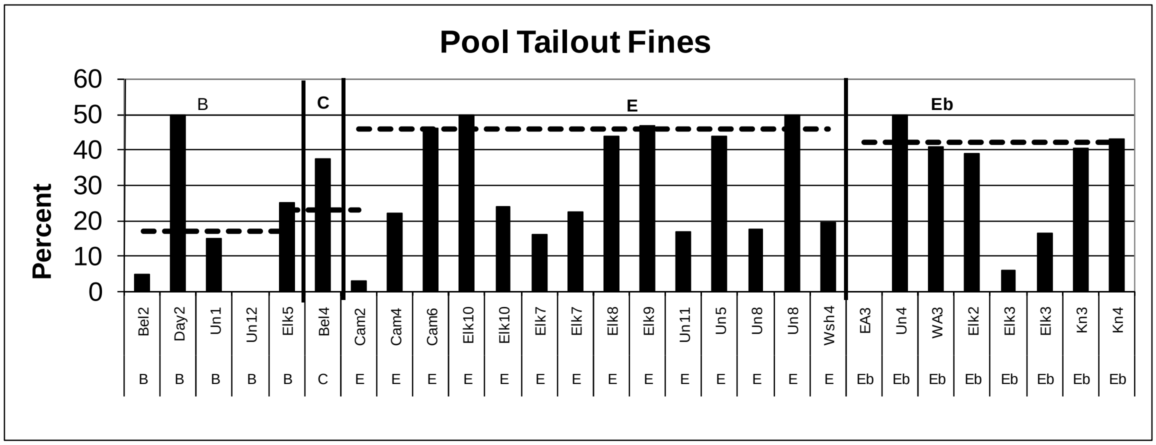


Figure C-23 Less than 6mm size fraction in pool tailouts values for assessment reaches and target values.

McNeil Cores

McNeil Core data provide a quantitative measurement of subsurface fines concentrations in pool tailouts. These measurements are important indicators of excess sediment loading and associated siltation impairment causes. A significant inverse relationship has been observed between the amount of material <6.35mm and bull trout fry emergence success (Weaver and Fraley, 1991). Weaver (1996) stated that streams are threatened as bull trout spawning/rearing streams when the <6.35mm value exceeds 35 percent in any given year. Based on Weaver and Fraley's data (1991), Tepper (2003) predicted an 8.4 percent decrease in egg fry emergence success with an increase in the <6.35mm substrate fraction from 25 percent to 31.7 percent.

A summary of the available McNeil core data is shown in **Table C-24**, **Figure C-24**, and **Figure C-25**. The listed stream segments for which data are available include Belmont Creek (Bel4) and Elk Creek (Elk7). Proposed target values for the McNeil Core data are listed in **Table C-25**. Targets were only developed for C channel types, as no data are available to help define appropriate E channel type targets for McNeil Cores. Targets were not developed for the <2mm size fraction because the available data from Elk Creek and Belmont Creek did not identify that size class (**Table C-24**). Targets were developed for the <84mm size fraction for C-type channels (**Table C-24**). The targets adopted are those developed for the Middle Blackfoot and Nevada Creek Planning Areas. A comparison of site values to proposed target values indicate that each of the six samples collected on Belmont Creek exceed the proposed target values for both the <6.35mm and <0.84mm size fractions (**Figure C-26** and **Figure C-27**).

Table C-24. Lower Blackfoot Planning Area McNeil Core data summary.

	Bel 4 (C channel type)			Elk 7 (E channel type)		
Statistic	**<0.84mm**	**<0.46mm**	**<6.35mm**	**<0.84mm**	**<0.46mm**	**<6.35mm**
25th Percentile	7.7	27.4	34.9	25.1	48.3	53.7
Min	6.3	25.4	31.0	24.5	46.2	51.1
Median	8.8	34.9	43.5	29.4	51.3	57.8
Max	13.2	49.3	57.5	33.6	61.0	70.3
75th Percentile	10.2	44.2	53.6	33.0	55.6	60.3
N	6	6	6	6	6	6

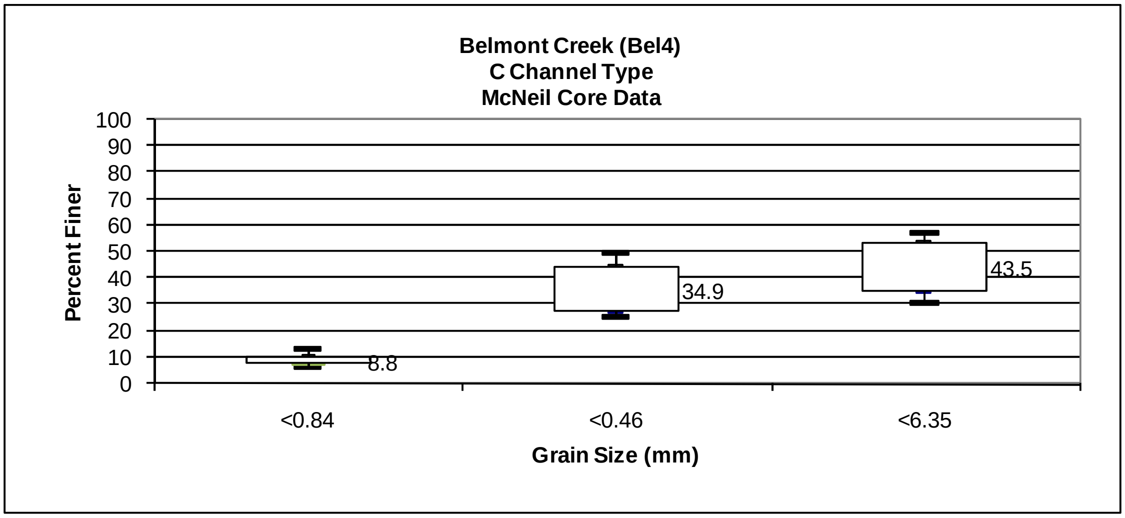


Figure C-24. McNeil Core data summarized by channel type, Lower Blackfoot Planning Area

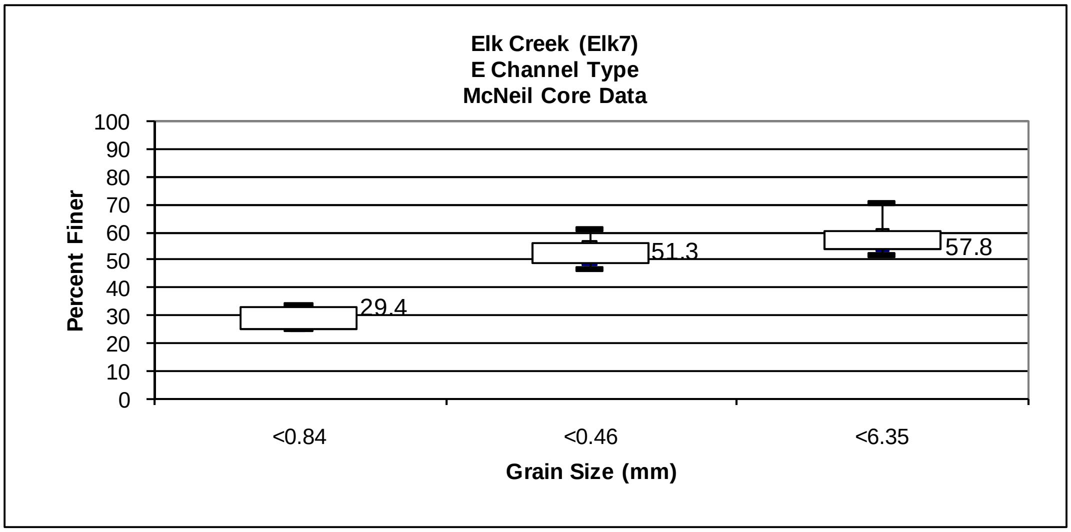


Figure 25. McNeil Core data summarized by channel type, Lower Blackfoot Planning Area

Table C-25. Lower Blackfoot targets for McNeil Core data <6.35mm size fraction.

Parameter	Target Level	Lower Blackfoot Statistics							Middle Blackfoot Targets		Nevada Creek Targets		Lower Blackfoot Targets	
		Channel Type	Q1	Min	Median	Max	Q3	N	Target	Basis	Target	Basis	Target	Basis
McNeil Cores Measured Percent < 6.35 mm	Type I	C	35	31	44	58	54	6	≤ 27	Q1 for all data collected 2003-2006	≤ 27	Q1 for all data collected 2003-2006	≤ 27	Q1 for all data collected 2003-2006
		E	54	51	58	70	60	6	N/A	N/A	N/A	N/A	N/A	N/A
McNeil Cores Measured Percent < 2 mm	Type II	C	N/A	N/A	N/A	N/A	N/A	N/A	≤ 15	Q1 for all data collected 2003-2006	≤ 15	Q1 for all data collected 2003-2006	N/A	No <2mm data summaries
		E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
McNeil Cores Measured Percent < 0.84 mm	Type II	C	7.7	6.3	8.8	13.2	10.2	6	≤ 6	Q1 for all data collected 2003-2006	≤ 6	Q1 for all data collected 2003-2006	≤ 6	Q1 for all data collected 2003-2006
		E	25.1	24.5	29.4	33.6	33.0	6	N/A	N/A	N/A	N/A	N/A	N/A

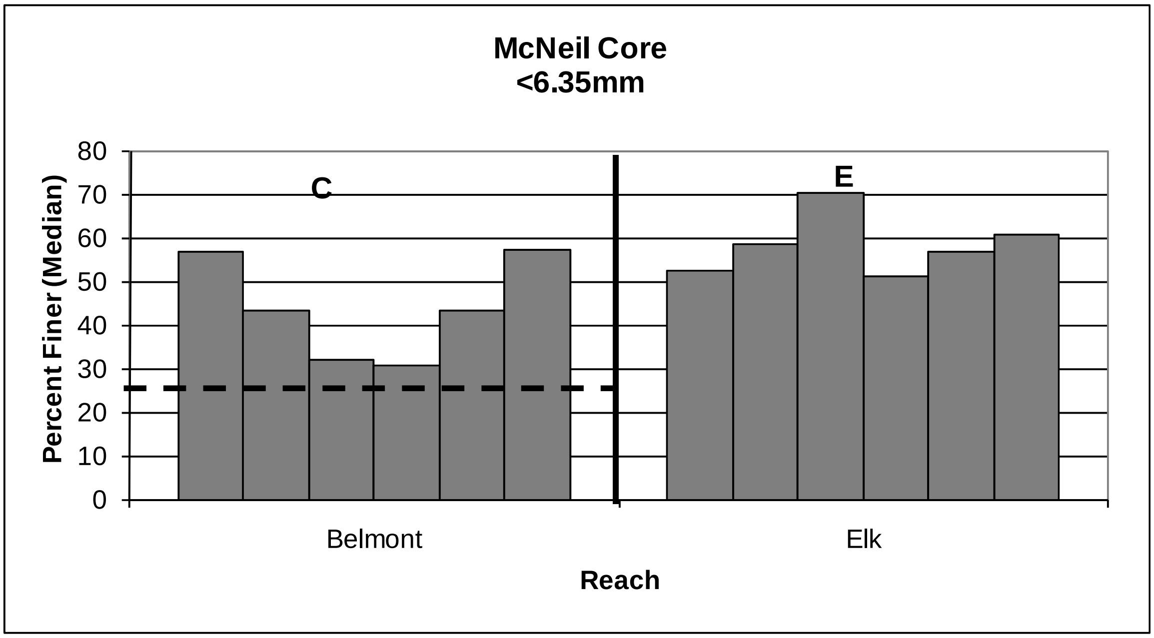


Figure C-26. McNeil Core data for assessment reaches and proposed target values.

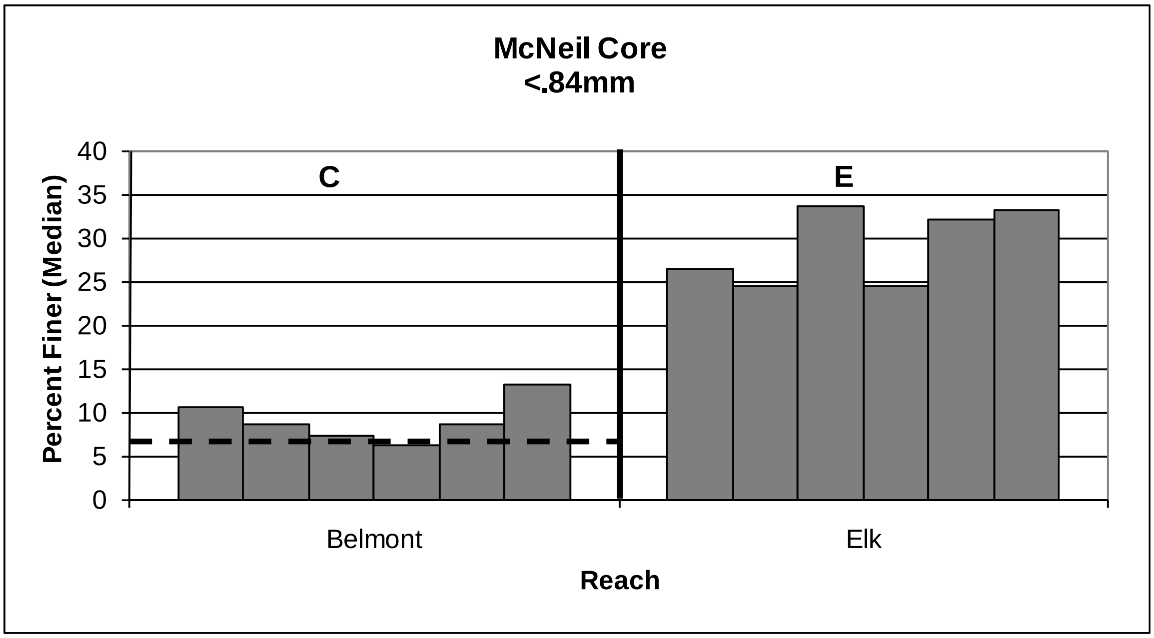


Figure C-27. McNeil Core data for assessment reaches and proposed target values.

References

Rosgen, D.L., 1994, A classification of natural rivers. Catena: 22, 169-199.

APPENDIX D
STREAMFLOW, SEDIMENT, AND NUTRIENT SIMULATION ON THE BLACKFOOT WATERSHED USING SWAT

By Michael Van Liew and Kyle Flynn

Model Description

The Soil Water Assessment Tool (SWAT) model was originally developed by the USDA ARS to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large ungaged basins (Arnold et al., 1998). SWAT incorporates features of several ARS models and is a direct outgrowth of the SWRRB model (Simulator for Water Resources in Rural Basins) (Williams et al, 1985). Specific models that contributed to the development of SWAT include CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems) (Knisel, 1980), GLEAMS (Groundwater Loading Effects on Agricultural Management Systems) (Leonard et al., 1987), and EPIC (Erosion-Productivity Impact Calculator) (Williams et al., 1984). The SCS runoff curve number is used to estimate surface runoff from daily precipitation (USDA SCS, 1986). The curve number is adjusted according to moisture conditions in the watershed (Arnold et al, 1993). SWAT can also be run on a sub-daily time step basis using the Green and Ampt (Green and Ampt, 1911) infiltration method. Other hydrologic processes simulated by the model include evapotranspiration; infiltration; percolation losses; channel transmission losses; channel routing; and surface, lateral, shallow aquifer, and deep aquifer flow (Arnold and Allen, 1996). The runoff curve number option (Neitsch et al, 2002) is adopted in this study. Evapotranspiration (ET) in SWAT is computed using the Priestly Taylor (Priestly and Taylor, 1972), Penman-Monteith (Allen et al., 1989) or Hargreaves (1975) method. For this study, the Hargreaves (1975) method was used to estimate potential ET, since extraterrestrial radiation and air temperature were the only two measured variables required for computing daily potential ET values with this method. Channel routing in SWAT is accomplished by either the variable storage or Muskingum routing methods. For this study, the variable storage method was used to route flows in SWAT.

SWAT is a distributed parameter model that partitions a watershed into a number of subbasins. Each subbasin delineated within the model is simulated as a homogeneous area in terms of climatic conditions, but with additional subdivisions within each subbasin to represent various soils and land use types. Each of these subdivisions is referred to as a hydrologic response unit (HRU) and is assumed to be spatially uniform in terms of soils, land use, topographic, and climatic data.

AVSWAT 2003 was the version of the model used in this study, which incorporates an ArcView GIS interface for expediting model input and output (Di Luzio et al., 2002). The ArcView GIS raster based system consists of a modular structure that contains a tool for optimizing the definition and segmentation of a watershed and network based on topography. It also consists of a tool for defining the HRUs over the watershed and an integrated user-friendly interface. The GIS interface not only allows users to segment a watershed, but to import and format the supporting data necessary for the specific application and calibration of the model.

AVSWAT 2003 also includes a multi-objective, automated calibration procedure that was developed by Van Griensven and Bauwens (2003). The calibration procedure is based on a shuffled complex evolution algorithm (SCE-UA; Duan et al., 1992) and a single objective function. In a first step, the SCE-UA selects an initial population of parameters by random sampling throughout the feasible parameter space for "p" parameters to be optimized, based on given parameter ranges. The population is partitioned into several communities, each consisting of "2p+1" points. Each community is made to evolve based on a statistical "reproduction process" that uses the simplex method, an algorithm that evaluates the objective function in a systematic way with regard to the progress of the search in previous iterations (Nelder and Mead, 1965). At periodic stages in the evolution, the entire population is shuffled and points are reassigned to communities to ensure information sharing. As the search progresses, the entire population tends to converge toward the neighborhood of global optimization, provided the initial population size is sufficiently large (Duan et al., 1992). The SCE-UA has been widely used in watershed model calibration and other areas of hydrology such as soil erosion, subsurface hydrology, remote sensing, and land surface modeling and has generally been found to be robust, effective, and efficient (Duan, 2003).

In the optimization scheme developed for SWAT 2003, parameters in the model that affect hydrology or water quality can be changed in either a lumped (over the entire watershed) or distributed (for selected subbasins or hydrologic response units (HRUs)) way. In addition, the parameters can be modified by replacement, by addition of an absolute change or by a multiplication of a relative change. In addition to weight assignments for output variables that can be made in multi-objective calibrations (e.g., 50 percent streamflow, 30 percent sediment, 20 percent nutrients), the user can specify a particular objective function that is minimized. The objective function is an indicator of the deviation between a measured and a simulated series (Van Griensven and Bauwens, 2003). An approach often selected as an objective function is the sum of squares of residuals method:

$$SSQ = (1/n) \sum_{i=1,n}^{n} (Qi,obs - Qi, sim)2 \qquad (1)$$

where

SSQ = the sum of squares of the residuals
n = the number of pairs of measured and simulated variables
$Q_{i, obs}$ = observed variable at a daily time scale
$Q_{i,sim}$ = simulated variable at a daily time scale

Equation (1) represents the classical mean square error method that aims at matching a simulated time series to a measured series.

Erosion and sediment yield are estimated for each HRU in SWAT using the Modified Universal Soil Loss Equation (MUSLE) (Williams, 1975), an enhancement of the USLE (Borah et al., 2006). Sediment is routed through the stream channel considering deposition and degradation processes and using a simplified equation based on stream power. SWAT comprehensively models transfers and internal cycling of the major forms of nitrogen and phosphorus. The model monitors two pools of inorganic and three pools of organic forms of nitrogen. SWAT also monitors three pools of inorganic and three pools of organic forms of phosphorus. SWAT incorporates instream nutrient dynamics using kinetic routines from the instream water quality model referred to as QUAL2E (Brown and Barnwell, 1987). Other in-stream variables that are simulated include temperature, dissolved oxygen, bacteria, and pesticides.

Model documentation is well formulated in SWAT, with considerable detail that is provided regarding model structure, algorithms, data input, and viewing of test results. SWAT documentation can be accessed through the theoretical documentation and user's manuals (Neitsch et al., 2002).

Watershed Delineation within AVSWAT 2003

Elevation, land use, and soil characteristics were obtained from GIS data layers for the Blackfoot Watershed. The elevation layer was developed from a 30 m DEM obtained from the Shuttle Radar Topography Mission (Rabus et al., 2003), and the soils layer was obtained from available STATSGO data. The land use layer was obtained from the 1992 USGS National Land Cover Database and was modified by including data from Landsat satellite imagery and historic county water resource surveys to better describe the presence of irrigated pasture on the watershed.

For this investigation, 65 subbasins were delineated in the Blackfoot to account for climatic variations based on the spatial distribution of precipitation and temperature gages within the watershed and to account for hydrologic differences among impaired subwatersheds within the watershed. The subbasin delineation of the Blackfoot River watershed is shown in **Figure D-1**. Five reservoir files were also created to consider the effects of storage and release of water from the larger dams within the watershed. The number of HRUs in the delineation of the respective watersheds was constrained by a threshold based on a land use and soil type covering an area of at least 10 percent and 10 percent, respectively, within any given subbasin. At this threshold level, a total of 633 HRUs were delineated within the Blackfoot. The original delineation of the watershed considered five land cover types that included forest, irrigated pasture with cattle grazing, range-grass, range-brush, and wetlands. This delineation was later modified to include four additional land cover/management types that consisted of urban development, residential development, forest harvest, and forest roads. Cattle grazing within the watershed was also expanded to include seasonal variations among the pasture, range, and forest cover types within a given subbasin.

Default values of the runoff curve number in SWAT were assigned to the various land cover types that were originally delineated in the Blackfoot project. Curve numbers were estimated for the urban development, residential development, forest harvest, and forest roads based on information available from published data by SCS (1986) and our understanding of existing field conditions on the watershed.

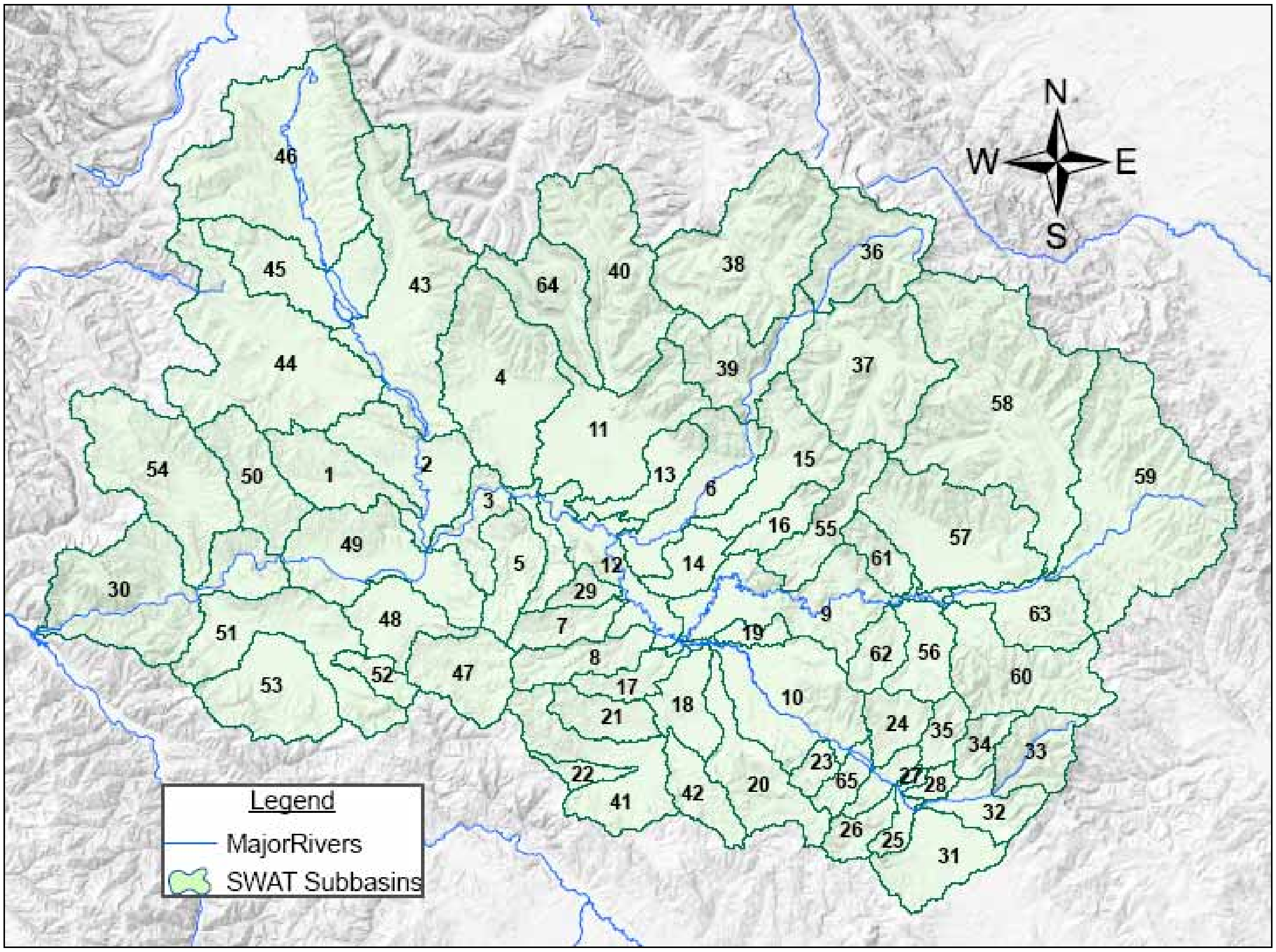


Figure D-1. SWAT Model Delineation of 65 Subbasins in the Blackfoot River Watershed

Table D-1 presents a listing of the respective land cover types, percent of watershed areas, representative curve number values, and USLE C factors for each land cover type delineated in the Blackfoot project. USLE C factor values shown in **Table D-1** represent values that yield average annual erosion rates that are similar to those reported in the literature for various land cover conditions present in Montana.

Table D-1. A Listing of the Representative Land Cover Types, Percent of Watershed Areas, Representative Curve Numbers, and USLE C Factors Delineated In the Blackfoot Project

Land Use/Management	Percent of Watershed Area	Representative Curve Number	USLE C Factor
Pasture	3.5	49	0.018
Range brush	6.6	41	0.04
Range grass	15.5	49	0.045
Wetlands	0.2	46	0.0085
Forest	71	35	0.004
Forest harvest	0.7	39	0.01
Forest roads	0.2	80	0.85
Urban	0.3	72	0.1
Residential	2	49	0.045

Urban and Residential Septic Systems

HRUs within SWAT were modified to estimate the impact of on-site septic systems within the Blackfoot Watershed. Urban and residential septic systems were represented on 16 of the 65 subbasins based on estimates of population density within the watershed. Nitrogen and phosphorus were applied at equivalent rates of 60 and 10 mg per liter, respectively. Septic discharge was assumed to be 165 liters per person per day times an average household occupancy of 2.5 persons. The resultant N and P application rates were therefore 2.48 and 0.41 kg per ha per day, respectively. These nutrients were input into SWAT as fertilizer beneath the land surface on a daily basis throughout the year.

Forest Roads

HRUs within SWAT were also modified to estimate the impact of unpaved forest roads within the watershed. These roads were represented on 8 of the 65 subbasins, and were assumed to have a slope steepness of 7 percent and a slope length of 5 m.

Miscellaneous Land Cover Types

Fertilizer 28-47-7 was assumed to be applied each year on April 15th at a rate of 282 Kg/ha on the pasture land cover type. If a given subbasin within the delineated project contained pasture as one of the cover types, it was assumed that livestock would be rotated among pasture, range grass, and forest cover types within that subbasin according the schedule presented in **Table D-2**. Livestock density on pasture, range grass, and forest lands was assumed to be 1.2, 0.35, and 0.067 animals per ha, respectively.

Table D-2. Yearly Simulated Rates of Total Nitrogen and Total Phosphorus from Fertilizer or Livestock Sources

Source	Land Cover	Time of Application	Annual Total N (Kg/ha)	Annual Total P (Kg/ha)
Fertilizer	Pasture	April 15th	79	56
Livestock	Pasture	Daily: Nov 1st to April 14th	17.2	4.7
Livestock	Range grass	Daily: April 15th to June 14th	1.6	0.45
Livestock	Forest	Daily: June 15th to Oct. 31st	0.78	0.22
Fertilizer*	Residential	Daily	905	150
Fertilizer*	Urban	Daily	905	150

*applied fertilizer used to mimic on site septic systems

Hydrologic Calibration and Validation

Based on available climatic and streamflow data within the watershed, model parameters in SWAT were calibrated for a period of record from 2002 to 2004 at four streamgaging locations. To account for spatial variability in topographic, soil, and land use factors among subwatersheds within the Blackfoot, parameters governing streamflow response in SWAT were calibrated in a distributed fashion using the automated calibration procedure, where observed and simulated outputs were compared at the same outlet points on the watershed. Therefore, with the completion of the optimization run, a set of calibrated parameters was computed for the Blackfoot River above Nevada Creek, Nevada Creek below the reservoir, the North Fork of the

Blackfoot River, and the Blackfoot River near Bonner. With a decision that was made sometime following the streamflow autocalibration, two additional gaging stations were added as calibration points within the watershed. These two additional calibration points included the Nevada Creek above the reservoir and Clearwater Creek subwatersheds within the Blackfoot. Since streamflow data were not available for Clearwater Creek during the 2002 to 2004 period, the average annual ratio of streamflow for Clearwater Creek to Blackfoot River at Bonner based on the 1975 to 1992 available period of record for these two gages was used to estimate parameter values for the Clearwater subwatershed. Manual adjustments were then implemented at the six locations to fine tune the autocalibration. Available streamflow data at Nevada Creek above the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner from 1998 to 2001 were used for model validation. A description of parameters calibrated in the model is as follows.

Description of Calibration Parameters

For this investigation, fourteen parameters that govern hydrologic processes in SWAT were selected for calibration on the Blackfoot Watershed. Although the runoff curve number (CN2) could have also been calibrated, default values input during project delineation were assumed to be valid for model simulations. This assumption in turn facilitated the selection of appropriate curve number values for proposed changes in land management and cover associated with various simulation scenarios. The 14 hydrologic model parameters were grouped into three categories (**Table D-3**), which were considered to predominantly govern surface, subsurface, and basin response.

Following calibration of the hydrologic response of the model, 15 parameters governing sediment and nutrient response on the Bitterroot Watershed were calibrated. These 15 parameters are presented in **Table D-3**. The following is a brief description of parameters governing hydrologic, sediment and nutrient response in SWAT.

Parameters Governing Surface Response

Calibration parameters governing the surface water response in SWAT include the soil evaporation compensation factor and the available soil water capacity. The soil evaporation compensation factor (ESCO) adjusts the depth distribution for evaporation from the soil to account for the effect of capillary action, crusting, and cracks. The available soil water capacity (SOL_AWC) is the volume of water that is available to plants if the soil was at field capacity. It is estimated by determining the amount of water released between in situ field capacity and the permanent wilting point.

Parameters Governing Subsurface Response

Six calibration parameters govern the subsurface water response in SWAT. One of these parameters is referred to as the ground water "revap" coefficient (GW_REVAP), which controls the amount of water that will move from the shallow aquifer to the root zone as a result of soil moisture depletion and the amount of direct ground water uptake from deep-rooted trees and shrubs. Another parameter that governs the subsurface response is the threshold depth of water in the shallow aquifer for "revap" to occur (REVAPMN). Movement of water from the shallow aquifer to the root zone or to plants is allowed only if the depth of water in the shallow aquifer is equal to or greater than the minimum "revap." A third parameter is the threshold depth of water in the shallow aquifer required for return flow to occur to the stream (GWQMN). Two other parameters that govern watershed response include the baseflow alpha factor and ground water delay. The baseflow alpha factor (ALPHA_BF), or recession constant, characterizes the ground water recession curve. This factor approaches one for flat recessions and approaches zero for steep recessions. The ground water delay (GW_DELAY) is the time required for water leaving the bottom of the root zone to reach the shallow aquifer. A sixth factor is the deep aquifer percolation fraction which governs the fraction of percolation from the root zone to the deep aquifer (RCHRG_DP).

Parameters Governing Basin Response

Seven parameters that govern basin response in SWAT were calibrated in this study. Two of these parameters included channel hydraulic conductivity (CH_K2) that governs the movement of water from the streambed to the subsurface and the surface runoff lag time (SURLAG) that accounts for the storage of runoff in the model for a given subbasin. Five other basin parameters govern snowfall and snowmelt in SWAT. One parameter is the snowfall temperature (SFTMP) which is the mean air temperature at which precipitation is equally likely to be rain as snow or freezing rain. A second parameter is the snowmelt base temperature (SMTMP) that defines the snow pack temperature above which snowmelt will occur. SMFMX and SMFMN are melt factors for snow on June 21 and December 21, respectively, in the Northern Hemisphere that allow the rate of snowmelt to vary through the year as a function of snow pack density. A fifth parameter is the snow pack temperature lag factor (TIMP) that controls the impact of the current day's air temperature on the snow pack temperature.

Parameters Governing Sediment Response

Four parameters in SWAT must be calibrated to simulate processes of erosion and sedimentation in the model. One of these parameters is the channel erodibility factor (CH_EROD) which is conceptually similar to the soil erodibility factor in the universal soil loss equation. A second parameter is the channel cover factor (CH_COV) which is defined as the ratio of degradation from a specified vegetative cover to the corresponding degradation from a channel with no vegetative cover. The third and fourth sediment parameters that must be calibrated in SWAT are the coefficient and exponent parameters that are used to calculate the maximum amount of sediment that can be reentrained during channel sediment routing. These two parameters are referred to respectively as SPCON and SPEXP.

Parameters Governing Nutrient Response

Several parameters govern the movement and transformation of various constituents of nitrogen and phosphorus in SWAT. Five parameters govern nitrogen fate and transport on the landscape. One of these parameters in SWAT is referred to as the nitrogen uptake distribution parameter (N_UPDIS) which controls the amount of nitrogen removed from the different soil layers by the plant. A second parameter is the rate factor for humus mineralization of active organic nitrogen

(CMN). A third parameter is referred to as the nitrogen percolation coefficient (NPERCO). This parameter controls the amount of mineral N removed from the surface layer in runoff relative to the amount removed via percolation. The fourth and fifth parameters are SOL_NO3 and SOL_ORGN which represent the initial nitrate and organic N concentrations in the respective soil layers.

Six parameters control phosphorus rate and transport on the landscape. One of these parameters governing phosphorus response in the model is referred to as the phosphorus percolation coefficient (PPERCO). Like NPERCO for nitrogen, PPERCO controls the ratio of the amount of soluble P removed from the surface layer in runoff relative to the amount of soluble P removed via percolation. A second parameter is the phosphorus soil partitioning coefficient (PHOSKD), which represents the ratio of phosphorus attached to sediment to phosphorus dissolved in soil water. A third parameter describes the phosphorus uptake distribution (P_UPDIS) which governs the plant uptake of phosphorus from the different soil horizons in the same way that N_UPDIS controls nitrogen uptake. Yet a fourth parameter is the phosphorus sorption coefficient (PSP). This parameter represents the fraction of mineral phosphorus remaining in the labile pool after initial rapid sorption to the soil. The fifth and sixth parameters are SOL_LABP and SOL_ORGP which represent the initial soluble P and organic P concentrations in the respective soil layers.

Table D-3. A Listing of Parameters, Their Description, and Units That Were Calibrated In SWAT

Parameter	Description	Units
Parameters governing surface water response		
ESCO	soil evaporation compensation factor	none
SOL_AWC	available soil water capacity	mm/mm
Parameters governing subsurface water response		
ESCO	soil evaporation compensation factor	none
SOL_AWC	available soil water capacity	mm/mm
Parameters governing subsurface water response		
GW_REVAP	ground water "revap" coefficient	none
REVAPMN	threshold depth of water in the shallow aquifer for "revap to occur"	mm
GWQMN	threshold depth of water in the shallow aquifer required for return flow to occur	mm
GW_DELAY	ground water delay	days
ALPHA_BF	baseflow alpha factor, or recession constant	days
RCHRG_DP	deep aquifer percolation fraction	fraction
Parameters governing basin response		
SFTMP	snowfall temperature	degrees C
SMTMP	snowmelt temperature	degrees C
SMFMX	melt factor for snow on June 21	mm/deg C day
SMFMN	melt factor for snow on December 21	mm/deg C day
TIMP	snow pack temperature lag factor	none
SURLAG	surface runoff lag time	days
Parameters governing sediment response		
CH_EROD	channel erodibility factor	none
CH_COV	channel cover factor	cm/hour-Pa
SPCON	coefficient for sediment reentrainment function	none
SPEXP	exponent for sediment reentrainment function	none
Parameters governing nutrient response		
N_UPDIS	nitrogen uptake distribution factor	none
CMN	humus mineralization of active organic nitrogen factor	none
NPERCO	nitrogen percolation coefficient	10 m**3/Mg
SOL_NO3	initial nitrate concentration in soil layer	mg/kg
SOL_ORGN	initial organic nitrogen concentration in soil layer	mg/kg
PPERCO	phosphorus percolation coefficient	10 m**3/Mg
PHOSKD	phosphorus soil partitioning coefficient	none
P_UPDIS	phosphorus uptake distribution factor	none
PSP	phosphorus sorption coefficient	none
SOL_LABP	initial soluble phosphorus concentration in soil layer	mg/kg
SOL_ORGP	initial organic phosphorus concentration in soil layer	mg/kg

Evaluation Criteria

Four evaluation criteria were used to assess monthly and daily streamflow simulated by SWAT. The first evaluation criterion used was the percent bias (PBIAS), which is a measure of the average tendency of the simulated flows to be larger or smaller than their observed values. The optimal PBIAS value is 0.0; a positive value indicates a model bias toward underestimation, whereas a negative value indicates a bias toward overestimation (Gupta et al., 1999). PBIAS may be expressed as

$$\text{PBIAS} = \sum_{k=1,n} (Qk\ obs - Qk\ sim)\ (100) \,/ \sum_{k=1,n} (Qk\ obs) \qquad (2)$$

where

PBIAS = deviation of streamflow discharge, expressed as a percent
$Q_{k\ obs}$ = observed streamflow in $m^3\ s^{-1}$ (cms)
$Q_{k\ sim}$ = simulated streamflow (cms)

Donigian et al. (1983) considered HSPF model performance “very good” if the absolute percent error is <10 percent, “good” if the error is between 10 percent and <15 percent, and “fair” if the error is between 15 percent and <25 percent for calibration and validation. Measurement errors associated with streamflow as recommended by Harmel et al. (2006) follow the same standard. This standard was therefore adopted for the PBIAS evaluation criterion used in this study, with PBIAS values >25 percent considered as unsatisfactory.

The second evaluation criterion was the model coefficient of efficiency (NSE; Nash and Sutcliffe, 1970), which Sevat and Dezetter (1991) found to be the best objective function for reflecting the overall fit of a hydrograph. NSE expresses the fraction of the measured streamflow variance that is reproduced by the model.

$$\text{NSE} = 1 - \left[\sum_{k=1,n}^{n} (Qk\ obs - Qk\ sim)2 \,/ \sum_{k=1,n}^{n} (Qk\ obs - Qmean)2\right] \qquad (3)$$

where

NSE = Nash Sutcliffe coefficient of efficiency
Q_{mean} = mean observed streamflow during the evaluation period (cms)

NSE values were computed for both monthly and daily streamflow. Simulation results were considered to be good for values of NSE >0.75, while for values of NSE between 0.75 and 0.36, the simulation results are considered to be satisfactory. (Motovilov et al., 1999). For this study NSE values <0.36 were considered to be unsatisfactory.

The third evaluation criterion compared simulated daily and monthly hydrographs to observed values. At the daily time scale, particular attention was given to the timing and magnitude of peak flows and the shape of the recession curves. The fourth criterion compared average monthly measured versus simulated streamflow for the calibration period.

Results of Streamflow Calibration

Average annual values of precipitation as well as measured and simulated streamflow for five of the watershed measurement points are presented in **Table D-4**. Especially noteworthy in the table is the differences in average annual precipitation and discharge for the Nevada Creek subwatershed as compared to either the Blackfoot River above Nevada Creek or the North Fork of the Blackfoot River subwatersheds. For the calibration period for example, the Nevada Creek below the reservoir subwatershed average annual precipitation of 445 mm is about half of the 848 mm measured for the Blackfoot River above Nevada Creek subwatershed. For this time series the measured average annual discharge for Nevada Creek below the reservoir was 64 mm, or about 20 percent of the measured value of 316 mm for the Blackfoot River above Nevada Creek.

Table D-4. Drainage Area, Average Annual Precipitation, and Measured Versus Simulated Average Annual Discharge for the Blackfoot Streamgaging Locations

Measurement Point and Simulation Type	**Drainage Area (Km^2)**	**Average Annual Precipitation (mm)**	**Measured Average Annual Discharge (mm)**	**Simulated Average Annual Discharge (mm)**
Blackfoot abv Nevada-c*	1294	848	316	318
Nevada Cr abv res-c	310	471	70	67
Nevada Cr abv res v*	310	486	80	66
Nevada Cr bel res-c	885	445	64	66
North Fk Blackfoot-c	824	941	409	406
North Fk Blackfoot-v	824	919	377	333
Blackfoot nr Bonner-c	5958	819	203	204
Blackfoot nr Bonner-v	5958	809	194	192

c* = calibration v* = validation

Percent bias and the Nash Sutcliffe (1970) coefficient of efficiency values are presented in **Table D-5** for the calibration and validation periods on the Blackfoot Watershed. A comparison of measured versus simulated daily hydrographs shows good agreement for the Blackfoot River above Nevada Creek, the North Fork of the Blackfoot River, and the Blackfoot River at Bonner subwatersheds (**Figures D.2-D.4**). Based on the calibration period from 2002 to 2004, daily NSE values were 0.68, 0.81, and 0.77 for these three subwatersheds, respectively. A comparison of measured versus simulated daily hydrographs was considered poor for the calibration period for Nevada Creek above the reservoir (NSE = 0.08) and Nevada Creek below the reservoir (-0.26) (**Figures D-5 and D-6**), and adequate for the validation period for Nevada Creek above the reservoir (0.46). The difficulties encountered in calibrating the Nevada Creek subwatershed were attributed in part to an inadequate precipitation signal based on the available climatological stations on or near the watershed and the fair to poor measured streamflow records collected by the USGS which are due to the numerous irrigation diversions in the subwatershed.

Table D-5. Percent Bias and Nash Sutcliffe Coefficient of Efficiency Statistics for Streamflow during the Calibration (2002-2004) and Validation (1998-2001) Periods on the Blackfoot Watershed

Measurement Point	Time Series	Percent Bias	Monthly NSE	Daily NSE
BFT abv Nevada	Calibration	-5.9%	0.78	0.68
Nevada Cr. abv res	Calibration	6.9%	0.27	0.08
Nevada Cr. abv res	Validation	19.30%	0.6	0.46
Nevada Cr. bel res	Calibration	-2.70%	-0.17	-0.26
North Fk BFT	Calibration	-1.60%	0.91	0.81
North Fk BFT	Validation	13.90%	0.9	0.82
BFT nr Bonner	Calibration	-10.00%	0.81	0.77
BFT nr Bonner	Validation	-0.70%	0.84	0.81

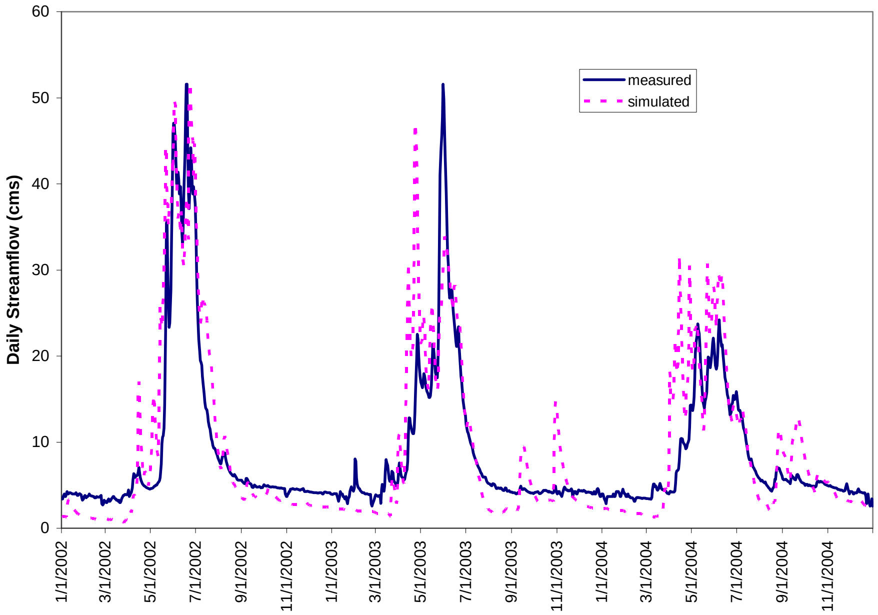


Figure D-2. Comparison of Measured Versus Simulated Daily Discharge for the Blackfoot River above Nevada Creek during The 2002 To 2004 Calibration Period

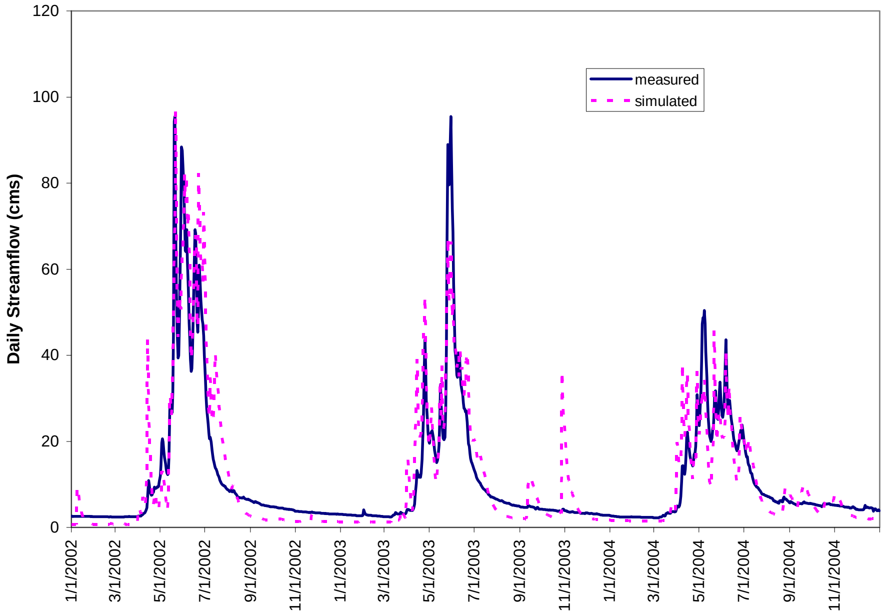


Figure D-3. Comparison of Measured Versus Simulated Daily Discharge for the North Fork of the Blackfoot River during The 2002 To 2004 Calibration Period

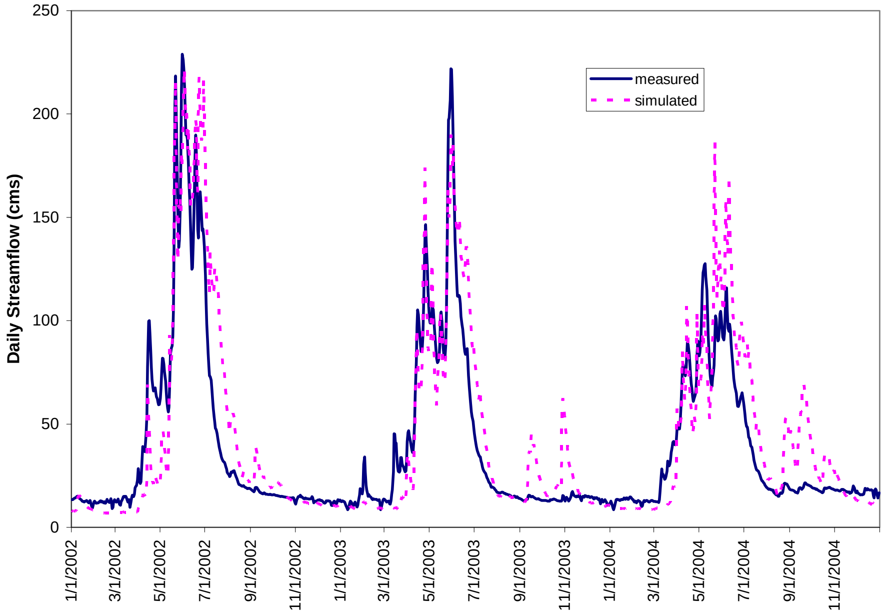


Figure D-4. Comparison of Measured Versus Simulated Daily Discharge for the Blackfoot River at Bonner during The 2002 To 2004 Calibration Period

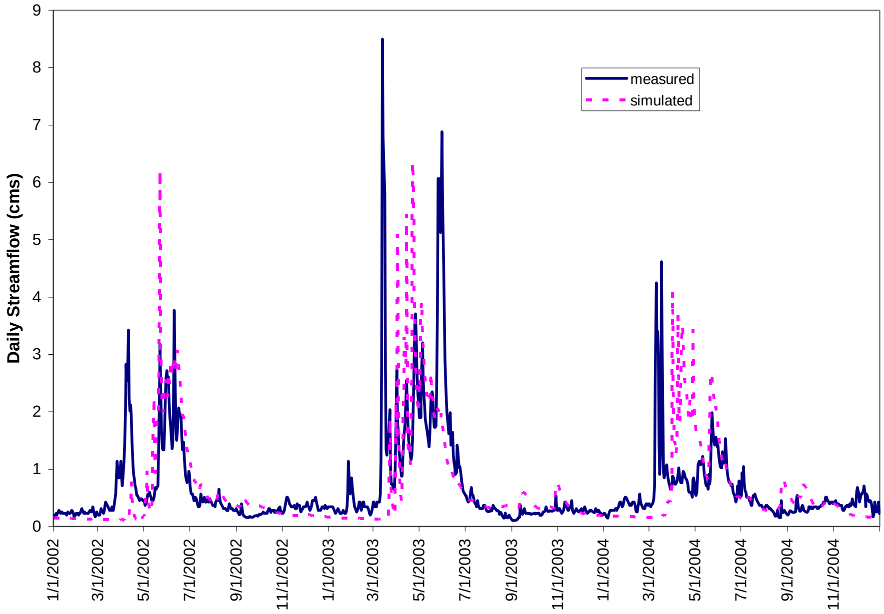


Figure D-5. Comparison of Measured Versus Simulated Daily Discharge for Nevada Creek above the Reservoir during The 2002 To 2004 Calibration Period

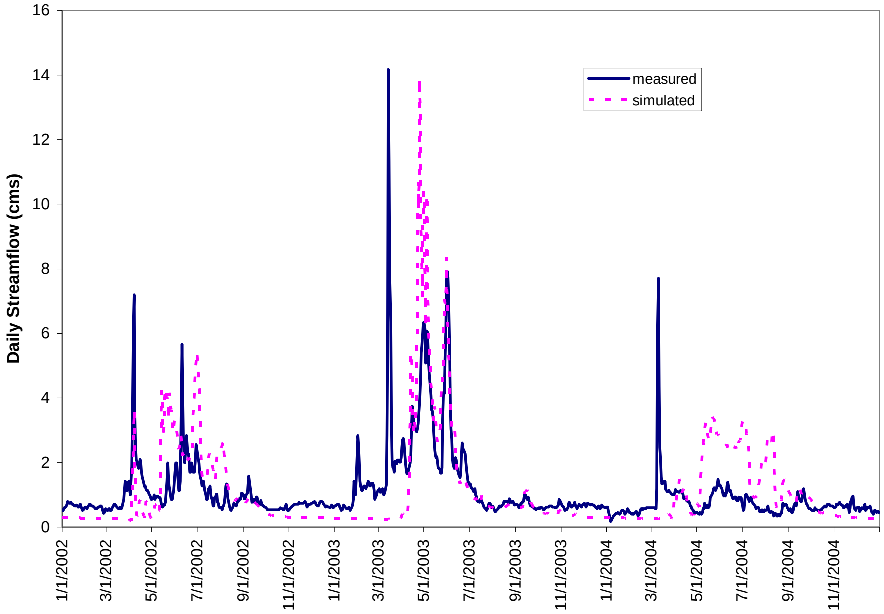


Figure D-6. Comparison of Measured Versus Simulated Daily Discharge for Nevada Creek below the Reservoir during The 2002 To 2004 Calibration Period

With the exception of the Nevada Creek subwatershed (**Figure D-7**), very good agreement was obtained in the comparison of measured versus simulated monthly hydrographs as illustrated in **Figures D-8 and D-9** for the North Fork of the Blackfoot River and the Blackfoot River at Bonner, respectively. Examination of the average monthly measured versus simulated hydrographs shows that SWAT tended to somewhat underestimate flows during the winter and late fall months (**Figures D-10 through D-12**). A suitable explanation could not be found to account for SWAT's tendency to substantially underestimate flows during the month of March for Nevada Creek above the reservoir.

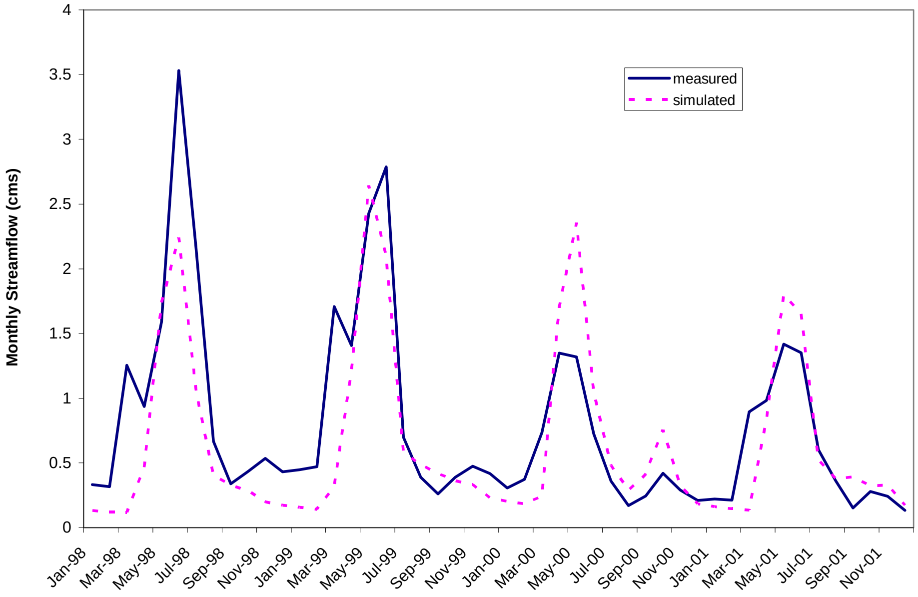


Figure D-7. Comparison of Measured Versus Simulated Monthly Discharge for Nevada Creek above the Reservoir during the 1998 To 2001 Validation Period

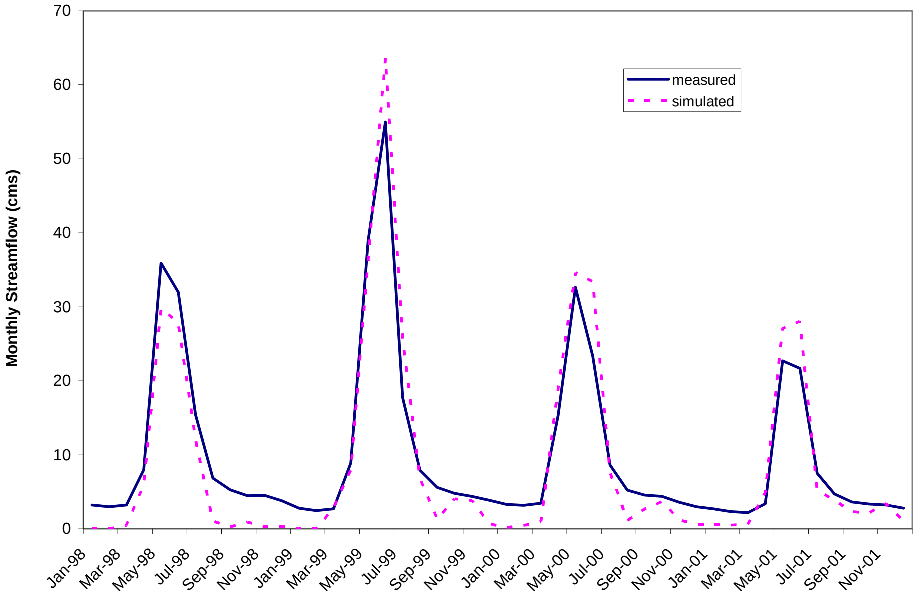


Figure D-8. Comparison of Measured Versus Simulated Monthly Discharge for the North Fork of the Blackfoot River during the 1998 To 2001 Validation Period

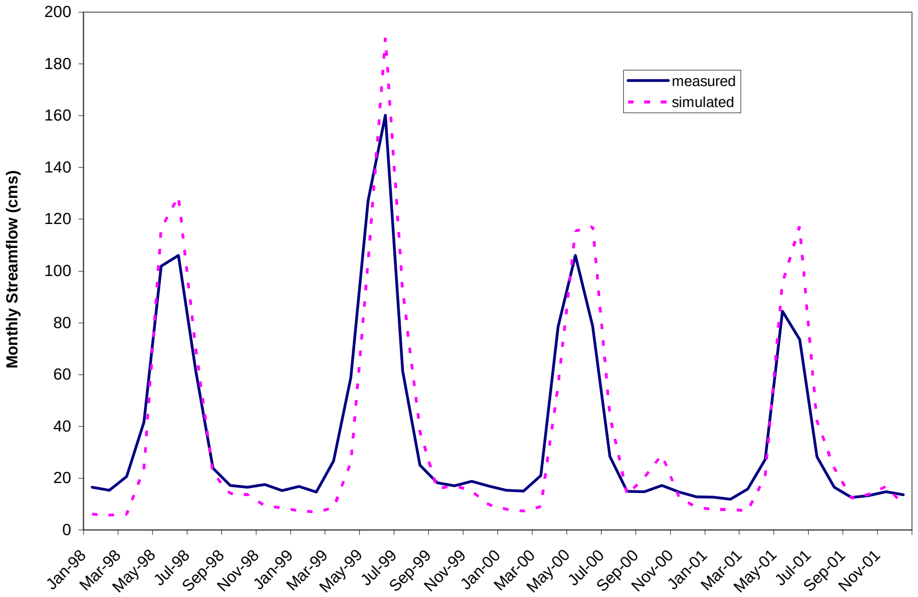


Figure D-9. Comparison of Measured Versus Simulated Monthly Discharge for the Blackfoot River at Bonner during the 1998 To 2001 Validation Period

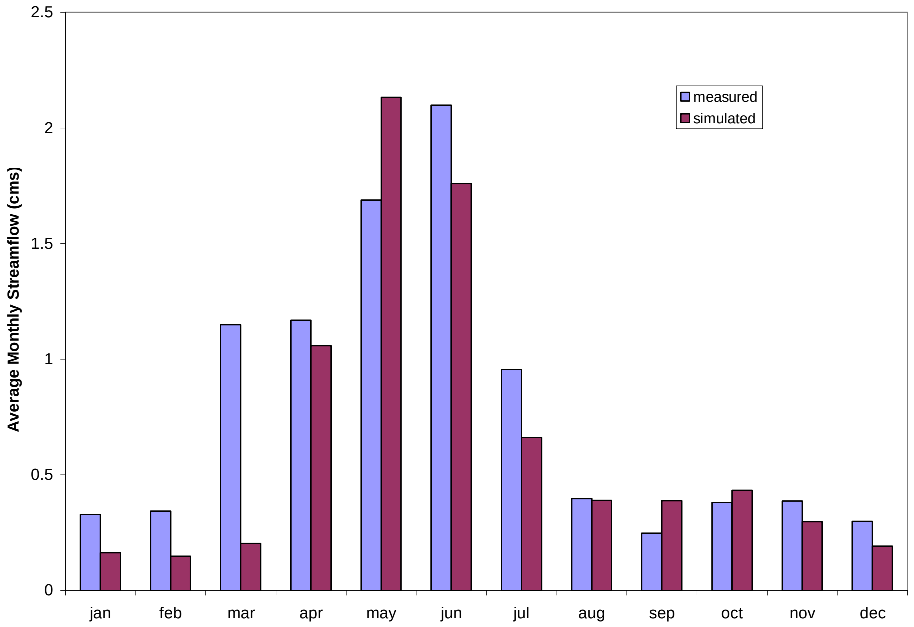


Figure D-10. Comparison of Measured Versus Simulated Average Monthly Discharge for Nevada Creek above the Reservoir during the 1998 To 2001 Validation Period

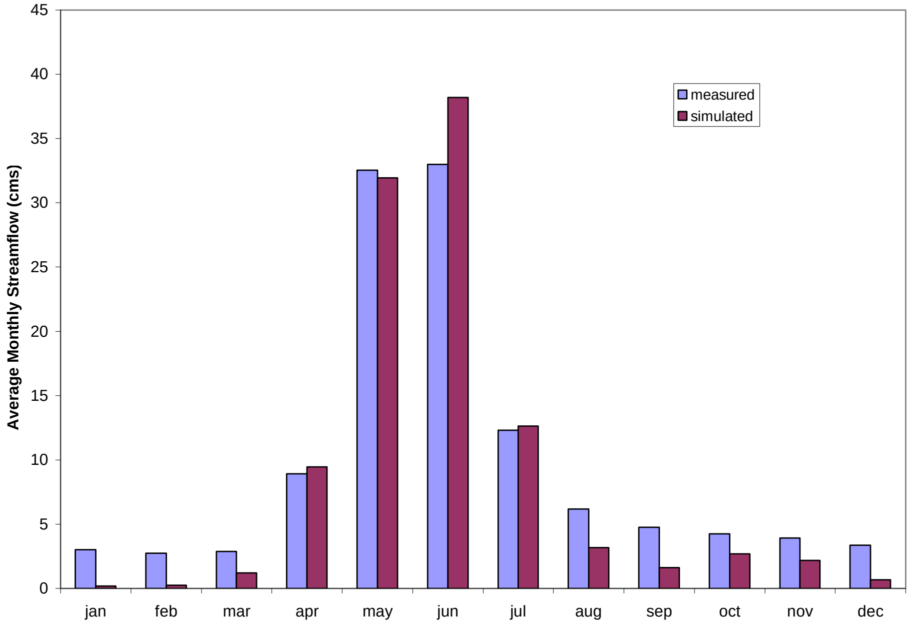


Figure D-11. Comparison of Measured Versus Simulated Average Monthly Discharge for the North Fork of the Blackfoot River during the 1998 To 2001 Validation Period

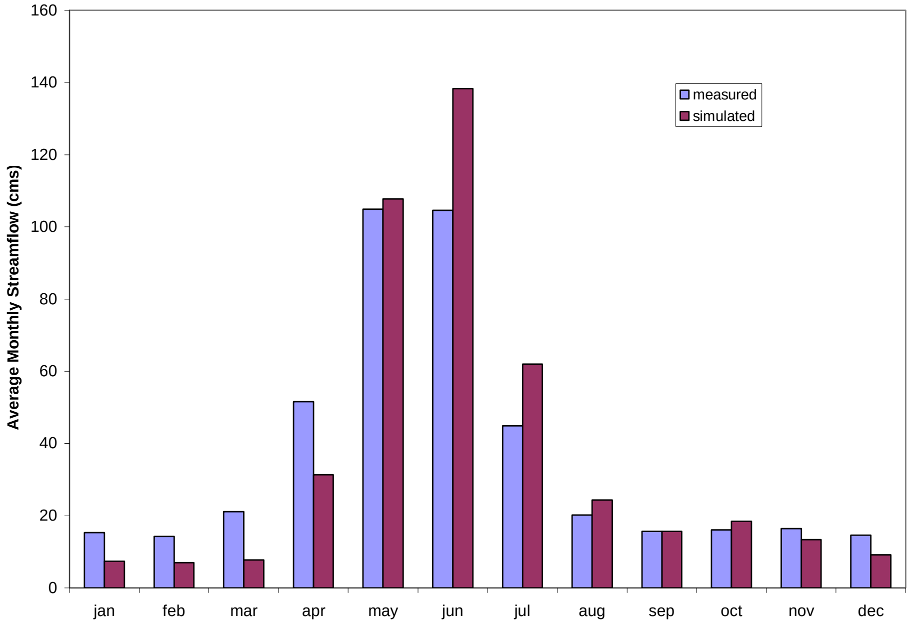


Figure D-12. Comparison of Measured Versus Simulated Average Monthly Discharge for the Blackfoot River at Bonner during the 1998 To 2001 Validation Period

Cursory testing with SWAT revealed that improvements in streamflow on the Blackfoot Watershed could be achieved in at least two ways. First of all, a single set of parameters was used to describe snow accumulation and melt processes across the basin. The utilization of regional sets of calibration parameters to account for these processes in the model would better represent spatial and temporal variations that take place across the watershed. Second, the hydrologic calibration did not include a consumptive use term to account for various losses associated with irrigation of pasture lands on the watershed. Recalibration of the model by adjusting the deep aquifer recharge parameter and including monthly consumptive use losses during the summer and early fall months would result in better matches between measured and simulated streamflow for the winter and summer months.

Calibration of Water Quality Parameters

Very limited data were available to calibrate sediment, total nitrogen, and total phosphorus for the Blackfoot Watershed. For these three water quality constituents, only 5 to 16 measured instantaneous values were used for calibration at any given streamgaging location. Sites selected for model calibration included the Blackfoot River above Nevada Creek, Nevada Creek above the reservoir, Nevada Creek below the reservoir, the North Fork of the Blackfoot River, and the Blackfoot River near Bonner locations. Model calibrations were performed by comparing graphical results of measured versus simulated constituent concentrations. A comparison of average measured versus simulated daily sediment, total nitrogen, and total phosphorus concentration for the calibration period at the five measurements points in the watershed is presented in **Table D-6**.

Table D-6. Comparison of Average Measured Versus Simulated Daily Sediment, Total Nitrogen, and Total Phosphors Concentration for the Calibration Period (2002-2004) At the Five Measurements Points on the Blackfoot Watershed

USGS Gage Location	Constituent	Number of Measured Points	Avg. Measured Concentration (mg/L)	Number of Simulated Points	Avg. Conc. On day of Measurement (mg/L)	Number of Simulated Points	Avg. Simulated Conc. For Calibration Period
Bk abv Nevada	Sediment	14	28.6	14	41.3	1096	17.6
Bk abv Nevada	Total N	6	0.1	6	0.152	1096	0.104
Bk abv Nevada	Total P	14	0.0253	14	0.0136	1096	0.009
Nevada abv Res	Sediment	10	11.6	10	12.6	1096	6.2
Nevada abv Res	Total N	6	0.463	6	0.13	1096	0.467
Nevada abv Res	Total P	10	0.0783	10	0.129	1096	0.512
Nevada bel Res	Sediment	16	45.3	16	7.3	1096	3.4
Nevada bel Res	Total N	6	1.05	6	0.573	1096	0.302
Nevada bel Res	Total P	13	0.21	13	0.688	1096	0.227
North Fk Bk	Sediment	5	3.2	5	55	1096	28.5
North Fk Bk	Total N	5	0.13	5	0.148	1096	0.202

Table D-6. Comparison of Average Measured Versus Simulated Daily Sediment, Total Nitrogen, and Total Phosphors Concentration for the Calibration Period (2002-2004) At the Five Measurements Points on the Blackfoot Watershed

USGS Gage Location	Constituent	Number of Measured Points	Avg. Measured Concentration (mg/L)	Number of Simulated Points	Avg. Conc. On day of Measurement (mg/L)	Number of Simulated Points	Avg. Simulated Conc. For Calibration Period
North Fk Bk	Total P	5	0.0052	5	0.0128	1096	0.0086
Bk near Bonner	Sediment	16	25.5	16	35.7	1096	15.7
Bk near Bonner	Total N	6	0.117	6	0.182	1096	0.132
Bk near Bonner	Total P	13	0.0323	13	0.0265	1096	0.0171

The calibration of sediment loading with SWAT proved to be a very daunting task for the Blackfoot Watershed. Adjusting the four parameters that govern sediment transport and bank erosion within the model did not provide consistent results when compared to measured data for the five calibration points. **Figures D-13 through D-17** illustrate the comparison of measured versus simulated sediment concentration for the five measurements points on the watershed. Results show reasonably good agreement for Nevada Creek above the reservoir, the Blackfoot River above Nevada Creek, and the Blackfoot River at Bonner, but poor agreement for the other two measurement points. Because the sediment calibration consisted of a parameter set with very high values of CH_EROD and CH_COV for the Nevada Creek subwatersheds and very low values for the other three Blackfoot gages, the contribution of sediment from bank erosion sources to total sediment sources was unrealistically low throughout the Blackfoot River reaches. Two improvements could be made in the project to better reflect processes of erosion and sedimentation. First of all, a delineation of the GIS data for the watershed with the option to specify the slope steepness of the various land cover types within a given subbasin would represent a significant improvement in erosion prediction with MULSE across the landscape. Second, the use of regional sets of the SPCON and SPEXP parameters in SWAT instead of a single set for the entire basin would provide the flexibility that is needed to consider spatial variability in sediment transport processes that exist on the watershed.

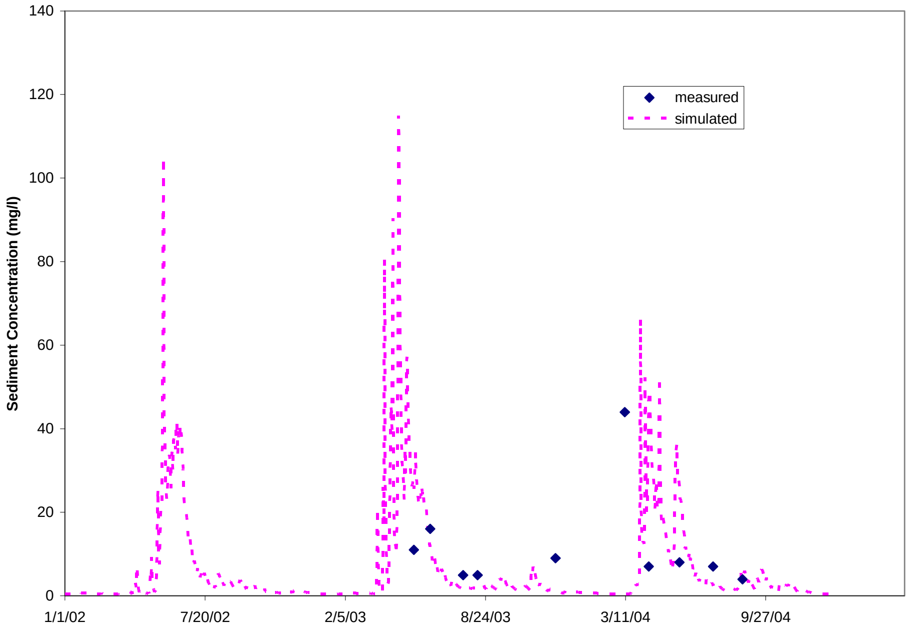


Figure D-13. Comparison of Measured Versus Simulated Sediment Concentration for Nevada Creek above the Reservoir during the 2002 To 2004 Calibration Period

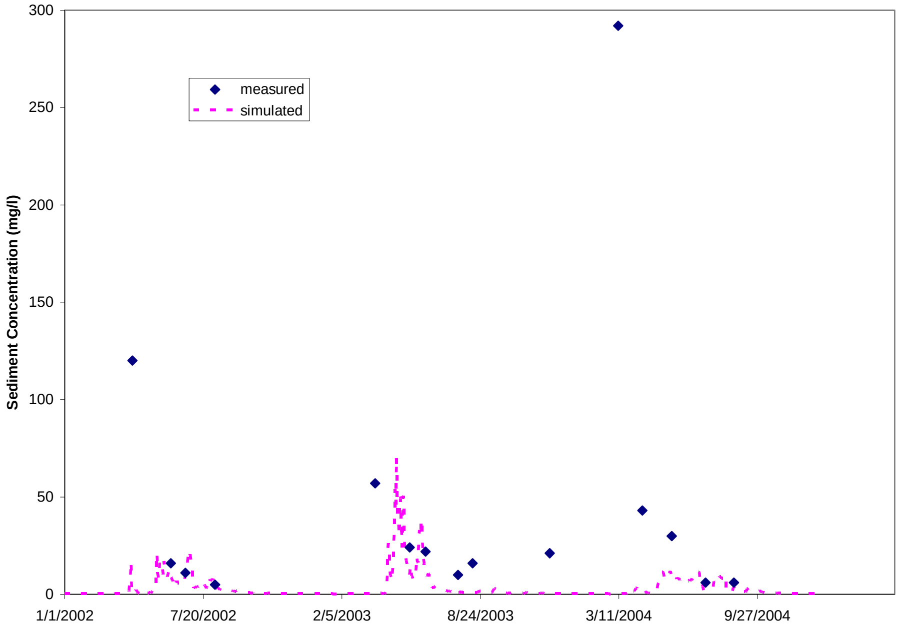


Figure D-14. Comparison of Measured Versus Simulated Sediment Concentration for Nevada Creek below the Reservoir during the 2002 To 2004 Calibration Period

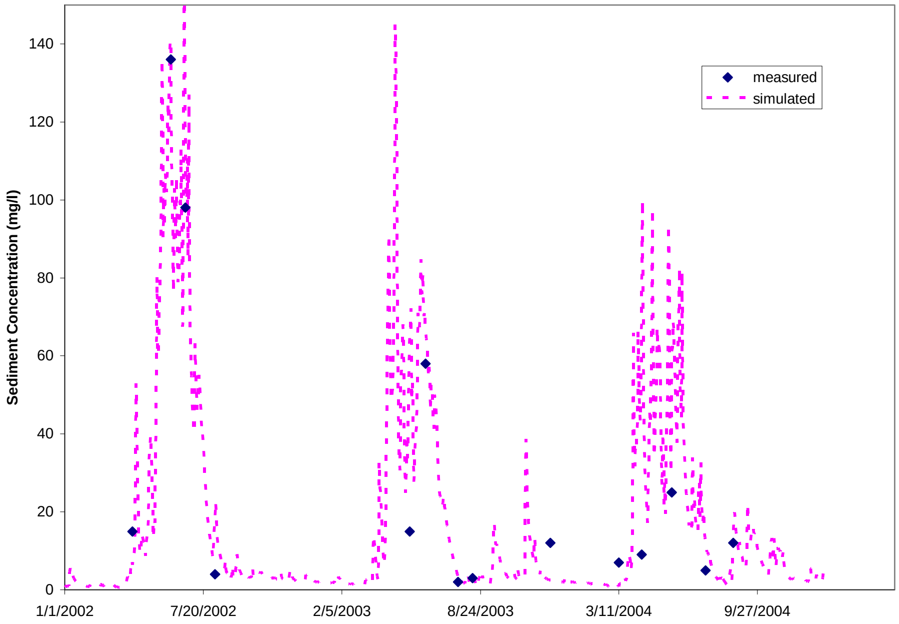


Figure D-15. Comparison of Measured Versus Simulated Sediment Concentration for the Blackfoot River above Nevada Creek during the 2002 To 2004 Calibration Period

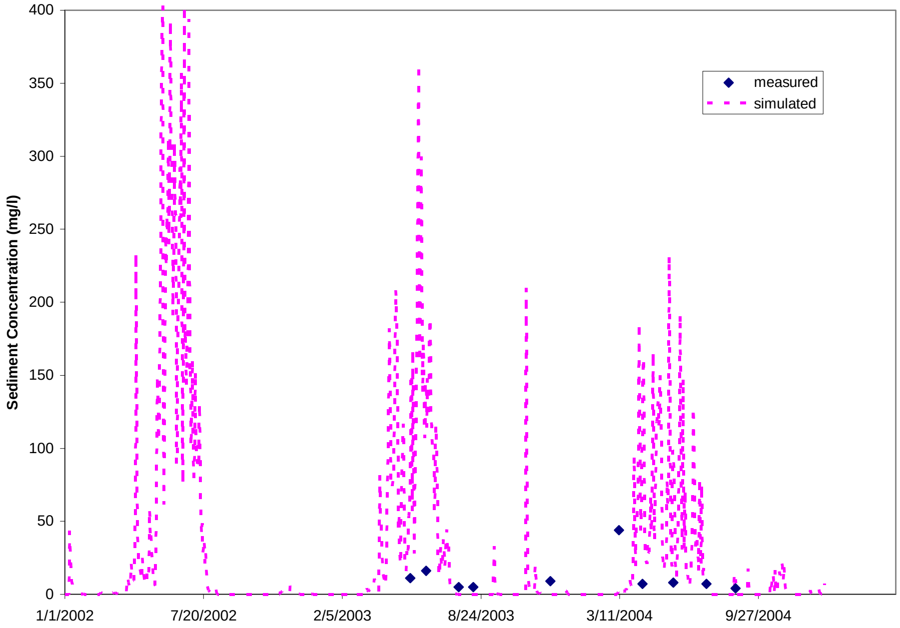


Figure D-16. Comparison of Measured Versus Simulated Sediment Concentration for the North Fork of the Blackfoot River during the 2002 To 2004 Calibration Period

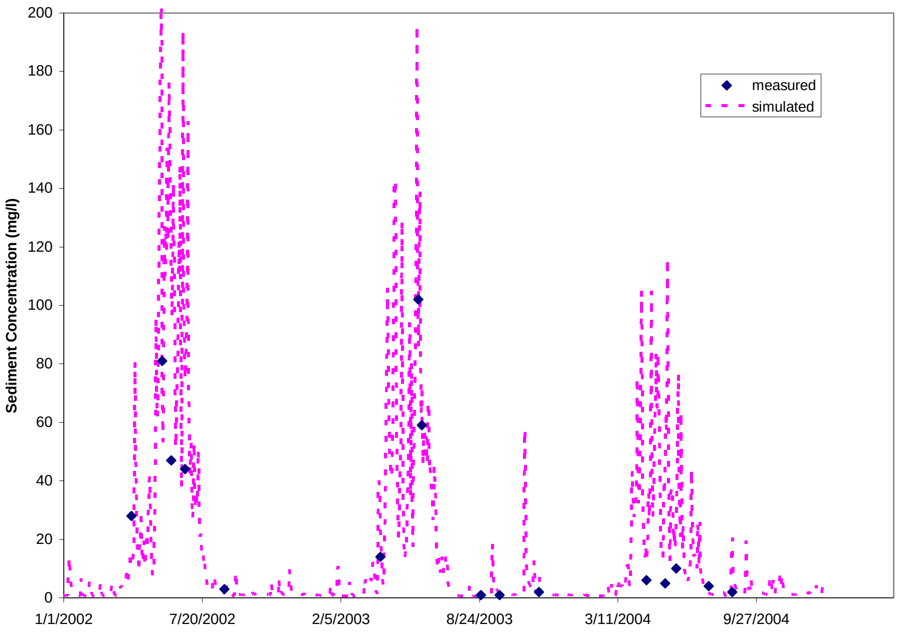


Figure D-17. Comparison of Measured Versus Simulated Sediment Concentration for the Blackfoot River at Bonner during the 2002 To 2004 Calibration Period

Simulation of Baseline Water Quality Conditions

Following calibration of the streamflow and water quality parameters in SWAT, a baseline period was selected for performing model simulations to represent current water quantity and quality conditions on the watershed. Simulations performed for this period not only provided estimates of sediment concentrations, and loadings for each of the 65 subbasins within the watershed, but also estimates of the source allocation by land cover/management type. Using available climatic and streamflow data, a 9-year period of record from 1996 to 2004 (preceded by a 5-year warm up period) was selected as the baseline condition for the Blackfoot. For this period, the annual mean, daily low flow and daily high flow are 44.1, 7.08, and 448 cms, respectively for the Blackfoot River near Bonner gage. These values compare to 44.5, 5.67, and 510 cms, respectively, for the long term record at the gage.

Daily and average annual values of water yield and sediment were simulated for selected stream reaches within the Blackfoot Watershed. Because output from the autocal or reach files in SWAT is not specific to particular land cover and management conditions, it was necessary to use output from the HRU file to estimate the land cover source allocation of sediment. This was accomplished in the following manner.

HRU files were retrieved from the 9-year baseline condition after SWAT was rerun without simulating the effect of channel bank and bed erosion. The assumption was made that the relative proportions of sediment that were simulated from the landscape for each land cover type would be the same as those in the stream reaches. Results of this analysis are illustrated in **Figures D-18** that gives respective land cover percentages of modeled sediment for the Lower Blackfoot planning area.

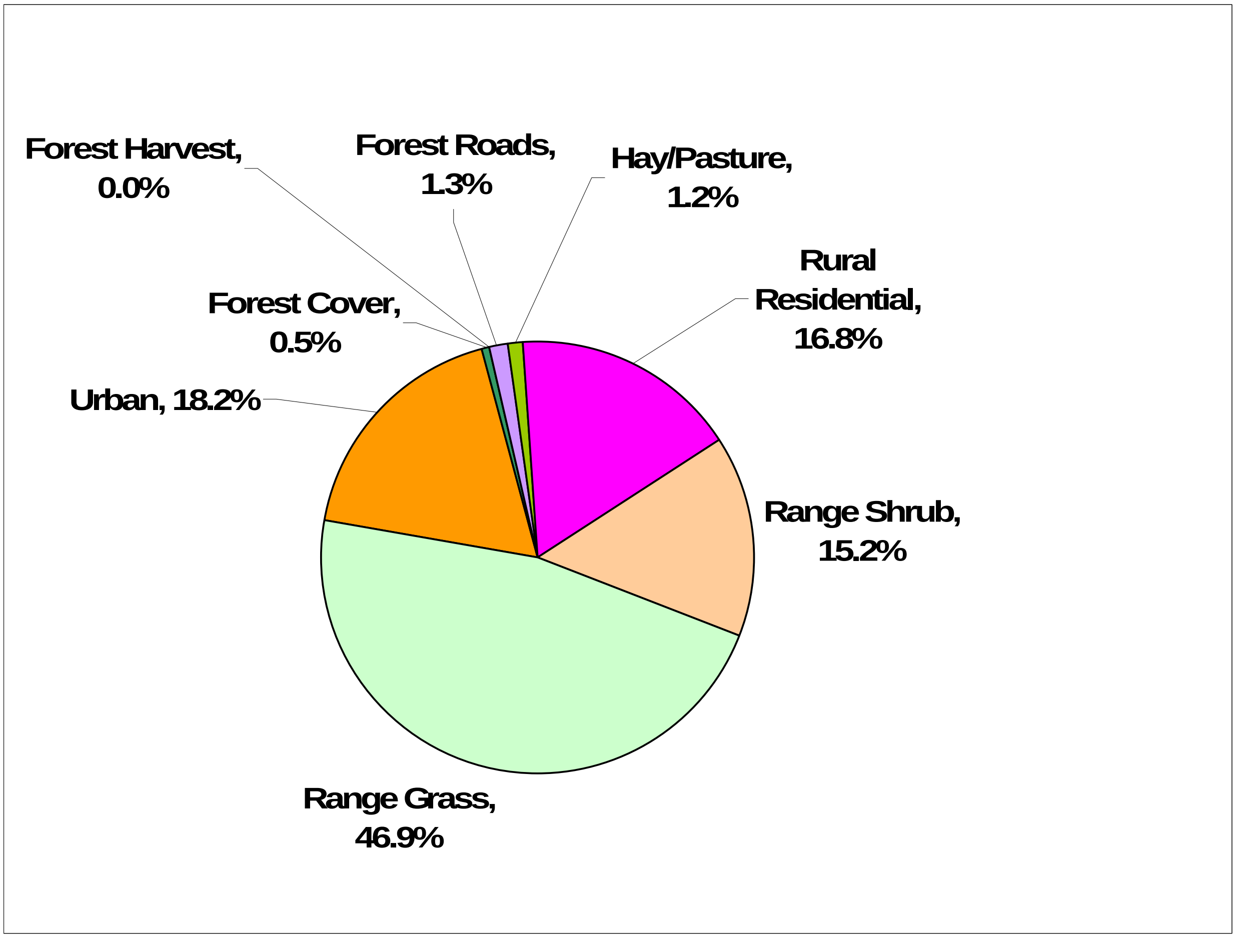


Figure D-18. Modeled Land Cover Sources of Sediment for the Lower Blackfoot Planning Area

The chart shows the relatively minor sediment contributions from forest cover and timber harvest compared to those for rangeland HRUs. This difference is mainly a function of the more closed ground cover in forested HRUs. The contribution from the rural residential cover type is likely exaggerated because the extent of these HRUs was based on the extent of conspicuously small lot sizes compared to surrounding agricultural uses. While the lot size indicates that the area has been subdivided, much of the current management is agricultural.

REFERENCES

Allen, R.G., M.E. Jensen, J.L. Wright, and R.D. Burman. (1989). “Operational estimates of evaportranspiration.” Agronomy J. 81(4),650-662.

Arnold, J.G., P.M. Allen, and G. Bernhardt. (1993). “A comprehensive surface-groundwater flow model.” J. Hydrology 142,47-69.

Arnold, J.G. and P.M. Allen. (1996). “Estimating hydrologic budgets for three Illinois watersheds.” J. Hydrology 176,57-77.

Arnold, J.G., R. Srinivasan, R.S. Muttiah, and J.R. Williams. (1998). “Large area hydrologic modeling and assessment, part I: model development.” J. American Water Resources Assoc. 34(1),73-89.

Borah, D.K. and M. Bera. (2003). “Watershed-scale hydrologic and nonpoint-source pollution models: review of mathematical bases.” Trans. ASAE 46(6),1553-1566.

Brown, L.C. and T.O. Barnwell. 1987. The enhanced water quality models: QUAL2E and QAL2E_UNCAS documentation and user manual. EPA/600/3-87/007, USEPA, Athens, GA.

Di Luzio, M., R. Srinivasan, and J.G. Arnold. (2002). “Integration of Watershed Tools and SWAT model into BASINS.” J. American Water Resources Assoc. 38(4),1127-1141.

Donigian, A.S., J.C. Imhoff, and B.R. Bicknell. (1983). Predicting Water Quality Resulting from Agricultural Nonpoint Source Pollution via Simulation – HSPF. In Agricultural Management and Water Quality,200-249. Ames, Iowa: Iowa State University Press.

Duan, Q.D. (2003). “Global optimization for watershed model calibration.” In: Calibration of Watershed Models, Water Sci. Appl. Ser., Vol 6, edited by Q. Duan et al., AGU, Washington, D.C. 89-104.

Duan, Q., V.K.Gupta, and S. Sorooshian. (1992). “Effective and efficient global optimization for conceptual rainfall-runoff models.” Water Resources Research 28, 1015-1031.

Green, W.H. and G.A. Ampt. (1911). “Studies on soil physics, 1. The flow of air and water through soils.” J. Agricultural Sciences 4,11-24.

Gupta, H.V., S. Sorooshian, and P.O. Yapo. (1999). “Status of automatic calibration for hydrologic models: comparison with multilevel expert calibration.” J. Hydrologic Engineering. 4(2),135-143.

Hargreaves, G.H. (1975). “Moisture availability and crop production.” Trans. ASAE 18:980-984.

Harmel, R.D., R. J. Cooper, R.M. Slade, R.L. Haney, and J. G. Arnold. (2006). Error propagation in measured streamflow and water quality data for small rural watersheds. Trans. Of the ASABE

In press.

Knisel, W.G. (1980). CREAMS, a field scale model for chemicals, runoff and erosion from agricultural managment systems. USDA Conservation Research Report No. 26.

Leonard, R.A., W.G. Knisel, and D.A. Still. (1987). “GLEAMS: Groundwater loading effects on agricultural management systems.” Trans. ASAE 30(5),1403-1428.

Motovilov, Y.G., L. Gottschalk, K. Engeland, and A. Rodhe. (1999). “Validation of distributed hydrological model against spatial observations.” Agricultural and Forest Meteorology 98,257-277.

Nash, J.E. and J.V. Sutcliffe. (1970). “River flow forecasting through conceptual models, Part 1 - A discussion of principles.” J. Hydrology 10(3),282-290.

Nelder, J.A. and R.A. Mead. (1965). “Simplex method for function minimization.” Computer J. 7,308-313.

Neitsch, S.L., A.G.Arnold, J.R. Kiniry, J.R. Srinivasan, and J.R. Williams. (2002). Soil and Water Assessment Tool User's Manual: Version 2000. GSWRL Report 02-02, BRC Report 02-06, Published by Texas Water Resources Instititue TR-192, College Station, TX.

Rabus, B., M. Eineder, A. Roth, R. Bamler. 2003. The shuttle radar topography mission- a new class of digital elevation models acquired by spaceborne radar, Photogramm. Rem. Sens., v. 57, p. 241-262.

Priestly, C.H.B. and R.J. Taylor. (1972). “On the assessment of surface heat flux and evaporation using large-scale measurements.” Mon. Weather Rev. 100(2),81-92.

Sevat, E. and A. Dezetter. (1991). “Selection of calibration of objective functions in the context of rainfall-runoff modeling in a Sudanese savannah area.” Hydrological Sciences Journal 36,307-330.

USDA Soil Conservation Service. (1986). Urban hydrology for small watersheds. Technical Release No. 55 (TR-55). Washington, D.C.

Van Griensven, A. (2002). Developments towards integrated water quality modeling for river basins. Dept. of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel. Publication No. 40.

Van Griensven, A. and W. Bauwens. (2003). “Multiobjective autocalibration for semidistributed water quality models.” Water Resources Research 39(12),1348.

Williams, J.R., A.D. Nicks, and J.G. Arnold. (1985). “Simulator for water resources in rural basins.” Journal of Hydraulic Engineering 111(6),970-986.

Williams, J.R., C.A. Jones, and P.T. Dyke. (1984). "A modeling approach to determining the relationship between erosion and soil productivity." Trans. ASAE 27(1),129-144.

APPENDIX E
STREAM BANK EROSION INVENTORY

In September 2006, in conjunction with a base parameter assessment, field crews inventoried eroding banks to determine the amount of sediment they contribute to the overall sediment load.

Data Collection

The bank erosion inventory recorded the location and characteristics of stream banks with discernable bank erosion on assessed reaches. These data provided the basis for developing a sediment source assessment and load allocation from eroding banks. For tributary streams, this inventory was performed on 1000 foot transects along both banks of the stream coincident with base parameter data collection.

The erosion site assessment includes a description of each eroding bank within each assessment reach, including the following:

- length
- height
- location (mapped)
- unadjusted BEHI rating
- unadjusted BEHI condition
- adjusted BEHI rating
- adjusted BEHI condition
- topbank vegetation type
- topbank vegetation density
- proximal land use
- bank materials

The bank condition evaluation utilized the BEHI method (Rosgen, 2000) and incorporated the following parameters into numerical ratings.

- Bank height/bankfull height ratio
- Root depth/bank height ratio
- Root density percent
- Bank angle
- Surface protection percent

Field crews measured eroding bank lengths with a tape measure along the thalweg of the stream. Bank height was measured using a stadia rod extended from the toe of the eroding bank to the top of the bank. Location is recorded using the continuous stationing method. The Bank Erosion Hazard Index (Rosgen, 2000), which allows the determination of the severity of mapped eroding streambanks, was performed according to procedures Specified in the Quality Assurance Project Plan and Sampling and Analysis Plan.

Data Analysis

Analysis of stream bank erosion inventory data involved five tasks:

- Calculation of erosion rates based on condition and distribution of eroding banks mapped at assessment sites
- Extrapolation of these rates to reaches of 303(d) streams not assessed
- Determination of erosion rates of streams not on the 303(d) List

- Calculation of the total sediment load from bank erosion
- Estimation of the natural and anthropogenic components of the sediment load

Calculation of Erosion Rates

The BEHI bank condition evaluation generated a cumulative rating that provides a qualitative erosion severity assessment (very low to extreme). A literature review provided a range of probable bank retreat rates corresponding to the severity assessment. Retreat rates developed by Zaroban and Sharp (2001) for the Palisades TMDL in Idaho were most applicable (**Table E-1**).

Table E-1. Eroding Bank Retreat Rates Used for the Sediment Source Assessment

Zaroban and Sharp (2001) Condition	Zaroban and Sharp (2001) Bank Retreat Rate (feet/yr)	Lower Blackfoot Eroding Bank Condition Rating	Lower Blackfoot Bank Retreat Rate (feet/yr)
Slight	0.1	Very low	0.10
		Low	0.17
Moderate	0.23	Moderate	0.23
		High	0.31
		Very High	0.39
Severe	0.47	Extreme	0.47

Multiplying eroding bank length times height times retreat rate yielded a yearly volume of sediment from eroding banks. Multiplying these volumes by the density of soils from SSURGO soils data yields a yearly tonnage of sediment from bank erosion for each stream.

Extrapolation of Bank Erosion to Reaches Not Assessed

Calculating the bank erosion rate for each stream on the 303(d) List, required extrapolating erosion rates to reaches not assessed. This required identifying a list of controlling factors on bank erosion, supported by existing data that are simple enough to use for this extrapolation (**Table E-2**). This approach required using one of two processes:

- Identify assessed reaches with similar upstream precipitation, geology, vegetation, and land use as those not assessed and assign the same erosion rate to the un-assessed streams
- If no directly analogous assessed stream exists, average the erosion rate of assessed upstream and downstream reaches

Table E-2. Criteria Used to Extrapolate Bank Erosion Rates to Un-Assessed Reaches

Controlling Factor on Bank Erosion	Effect on Sediment Loads	Available data
Stream Power	Stream power directly influences stress on stream banks and is a function of discharge and slope.	A surrogate for stream power is the amount of average annual precipitation upstream from a given reach.
Geology	Geology and derived soils directly influence erodibility of stream banks	Generalized geologic mapping and NRCS soils mapping data are available for the project area.
Vegetation	Vegetation density and type influence stream bank resilience.	Topbank vegetation type density data was collected during the field assessment at the reach and eroding bank scale
Land Use	Land use can influence vegetation density, which influences bank resilience. Upland vegetation	Land use data was collected during the field assessment at the reach and individual eroding bank scales.

Table E-2. Criteria Used to Extrapolate Bank Erosion Rates to Un-Assessed Reaches

Controlling Factor on Bank Erosion	Effect on Sediment Loads	Available data
	clearing can increase runoff and stream power. Roads can directly contribute sediment loads. Mining can influence bank resilience (e.g. placer tailings), and vegetation.	DEQ data provides stream scale land use information.

Determination of Background Bank Erosion Rates

Streams not on the 303(d) List are also a source of sediment from bank erosion. To estimate this portion of the sediment load, the relationships between upstream precipitation, channel type, geology, woody vegetation density, and land use with measured bank erosion rate were examined. The comparison of upstream precipitation with bank erosion rate has the clearest relationship. **Figure E-1** illustrates this relationship for the Lower Blackfoot Planning Area. Note that this is an assumed linear relationship. Non-linear relationships may also provide a suitable fit. The linear relationship provides an R^2 value of 0.68, which represents reasonably good agreement between bank erosion and upstream precipitation.

A continuous grid dataset for the study area that represents the upstream average annual precipitation for each cell in the grid was developed to apply the numerical relationship between upstream precipitation and bank erosion rates. Only grid cells that intersect stream channels have values. Multiplying each grid cell by 0.002 yields a bank erosion grid. The bank erosion grid was then summarized for non-303(d) streams.

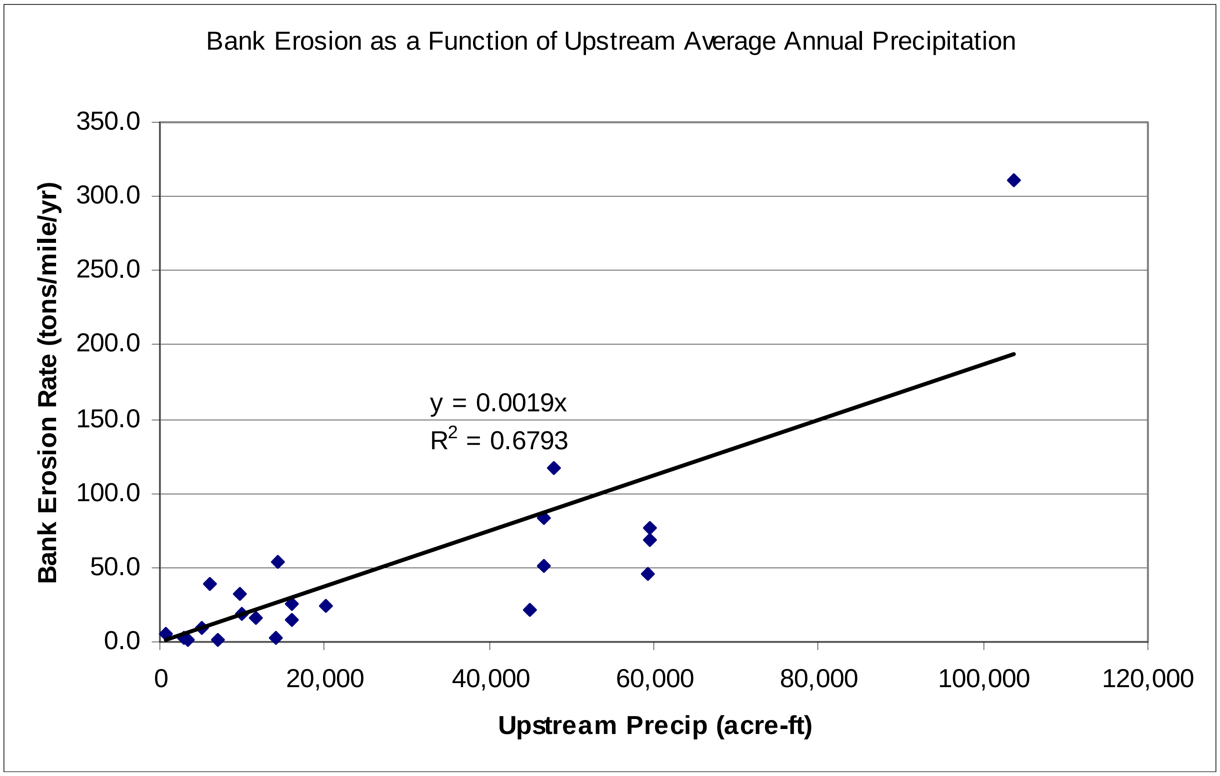


Figure E-1. Scatter Plot of Upstream Precipitation vs. Measured Bank Erosion Rate, Nevada Creek Planning Area

The formula defined in **Figure E-1** is:

Bank Erosion Rate = 0.0019 * (Upstream Precipitation)

This formula was then applied to the grid, along with a unit conversion multiplier, to yield a stream network grid where each cell represents the predicted bank erosion rate of a portion of a stream. Summarizing the grid cell values for the Lower Blackfoot Creek planning area yielded a modeled sediment contribution for the entire watershed. The sediment contribution for non-303(d) List streams is then the modeled sediment contribution minus the measured and extrapolated sediment contribution from 303(d) List streams.

Total Sediment Load from Bank Erosion

The total sediment load from bank erosion is the sum of the three components described above:

- The sediment load from eroding banks measured on 303(d) streams
- The sediment load from eroding banks extrapolated to un-assessed reaches on 303(d) streams
- The background sediment load from eroding banks on non-303(d) List streams.

Table E-3 identifies the loading estimate methods and results for each assessment reach.

Table E-3. Measured and Extrapolated Streambank Erosion Rates by Listed Stream Segment and Assessment Reach.

Stream	Reach	Length (ft)	Assessed Site	Measured Erosion Rate (ft^3/1000ft /yr)	Erosion Rate (tons/mile /yr)	Basis for Extrapolation	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Keno Creek	Keno1	2,357			0.5	Modeled Background Rate	0.2	4.3
	Keno2	6,653			2.1	Similar to Keno3	2.6	
	Keno3	2,057	Keno3	5.0	2.1		0.8	
	Keno4	4,685	Keno4	1.9	0.8		0.7	
Elk Creek, Upper	Elk1	3,389			0.5	Modeled Background Rate	0.3	91.9
	Elk2	9,915			2.1	Similar to Keno3	3.9	
	Elk3	8,972	Elk3	44.9	18.5		31.4	
	Elk4	4,354			18.5	Average of Elk 3 and Elk 5	15.2	
	Elk5	12,618	Elk5	10.5	4.3		10.4	
	Elk6	8,642			18.5	Similar to Elk3	30.3	
Elk Creek, Lower	Elk7	15,887	Elk7	201.5	67.4	Average of 2 assessments	202.7	449.9
			Elk7b	125.4				
	Elk8	4,496	Elk8	283.1	116.6		99.3	
	Elk9	7,241	Elk9	111.1	45.8		62.8	
	Elk10	6,224	Elk10	165.8	72.3	Average of 2 assessments	85.2	
			Elk10b	185.0			0.0	
Belmont Creek	Bel1	10,606			0.5	Modeled Background Rate	1.0	83.0
	Bel2	23,540	Bel2	6.4	2.6		11.7	
	Bel3	16,348			12.1	Average of Bel2 and Bel4	37.6	
	Bel4	7,962	Bel4	52.6	21.7		32.7	

Table E-3. Measured and Extrapolated Streambank Erosion Rates by Listed Stream Segment and Assessment Reach.

Stream	Reach	Length (ft)	Assessed Site	Measured Erosion Rate (ft^3/1000ft /yr)	Erosion Rate (tons/mile /yr)	Basis for Extrapolation	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Washoe Creek	Washoe 1	4,579			0.5	Modeled Background Rate	0.4	115.3
	Washoe 2	22,957			18.5	Similar to Elk3	80.4	
	Washoe 3	6,949			18.5	Similar to Elk3	24.3	
	Washoe 4	1,633	Washoe4	79.3	32.7		10.1	
Ashby Creek, East	EAshb1	3,778			0.5	Modeled Background Rate	0.4	6.5
	EAshb2	8,331			1.7	Similar to EAshb3	2.7	
	EAshb3	10,814	EAshb3	4.1	1.7		3.4	
Ashby Creek, West	WAshb1	5,946			0.5	Modeled Background Rate	0.6	15.7
	WAshb2	3,540			1.7	Similar to EAshb3	1.1	
	WAshb3	7,903	WAshb3	22.6	9.3		14.0	
Camas Creek	Cam1	5,074			0.5	Modeled Background Rate	0.5	468.0
	Cam2	10,577	Cam2	266.2	109.7		219.7	
	Cam3	4,167			82.0	Average of Cam2 and Cam4	64.8	
	Cam4	9,224	Cam4	132.1	54.4		95.1	
	Cam5	4,971			24.0	Similar to Cam6	22.6	
	Cam6	10,357	Cam6	58.3	24.0		47.1	
	Cam7	4,023			24.0	Similar to Cam6	18.3	

Table E-3. Measured and Extrapolated Streambank Erosion Rates by Listed Stream Segment and Assessment Reach.

Stream	Reach	Length (ft)	Assessed Site	Measured Erosion Rate (ft^3/1000ft /yr)	Erosion Rate (tons/mile /yr)	Basis for Extrapolation	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Union Creek	Union1	27,069	Union1	93.2	38.4		196.9	3221.3
	Union2	7,513			18.5	Similar to Washoe3 and Elk3	26.3	
	Union3	7,461			18.5	Similar to Washoe3 and Elk3	26.1	
	Union4	2,576	Union4	40.0	16.5		8.0	
	Union5	7,776	Union5	387.7	159.8		235.3	
	Union6	14,080			54.4	Similar to Cam4	145.1	
	Union7	4,200			24.0	Similar to Cam6	19.1	
	Union8	6,487	Union8	62.5	20.1	Average of 2 assessments	24.7	
	Union8	6,487	Union8b	35.2				
	Union9	4,605			99.5	Estimated bank height and condition from photographs	86.8	
	Union10	25,840			310.7	Similar to Union11	1520.7	
	Union11	15,821	Union11	754.2	310.7		931.1	
	Union12	4,401	Union12	3.4	1.4		1.2	
							TOTALS:	4456

ft^3 to tons conversion: ft^3 * 28316.8cm3/ft3 * 2.5g/cm3 * 1lb/453.6g * 1ton/2000lb

Natural vs. Anthropogenic Components of Bank Erosion Sediment

The approach used to estimate the anthropogenic component of bank erosion for eroding banks with a recorded human influence was to estimate a reduced severity of bank erosion without human impacts. A reduced human impact would improve vegetation density on both the topbank and eroding bank surface, as well as improve the root depth and density in the eroding bank. Bank height should be unaffected and bank angle may improve slightly over time.

Estimating of the amount of change in the five BEHI rating parameters likely from passive restoration for a series of representative eroding banks evaluated the potential change in bank condition from removing the human influence. This allowed calculation of an estimated cumulative BEHI rating for eroding banks rated extreme, very high, high, moderate, low, and very low if human influence was absent. This difference in severity translated to a change in bank retreat rates. The resultant change between the measured and estimated values represents the reduction in sediment load from removing the human influence (i.e. the anthropogenic component). The estimated rates for each eroding bank were then applied to all banks and the anthropogenic component calculated for all assessed reaches. Reaches where bank erosion rates were extrapolated from an assessed reach were assigned the anthropogenic percentage of the assessed reach.

APPENDIX F
SEDIMENT LOADING ANALYSIS

This appendix summarizes the methods used to determine the sediment load estimates from hillslopes, stream banks and roads in the Lower Blackfoot planning area. Hillslope erosion loading was estimated using the Soil Water Assessment Tool (SWAT) model to obtain an initial estimate of loading by listed segment. **Appendix D** contains a description of the SWAT model, its setup, calibration, and validation for use in the Blackfoot River watershed.

Stream bank erosion was estimated for sediment impaired stream segments using field data collected from selected assessment sites within each segment. A modified version of Rosgen's (2000) Bank Erosion Hazard Index (BEHI) method was used for the field assessment. The details of the methodology and procedures for extrapolation from surveyed sites to non-surveyed stream reaches are described in **Appendix E**.

Sediment loading from unpaved roads was estimated by extrapolating annual means (tons/yr/crossing), developed from field survey results for the Middle Blackfoot TPA, to similar crossings in the Lower Blackfoot. Annual loading from road culvert failure also extrapolates per crossing means, used in the Middle Blackfoot, to Lower Blackfoot crossings.

Hillslope Erosion Loading Estimates and Adjustments

Sediment loading from hillslope erosion was estimated using the SWAT model. The model provided values for hillslope sediment delivered annually (in tons) from each HRU within 65 subbasins that make up the Blackfoot watershed. As discussed in **sections 5.6.1** and **8.1.1**, the model consistently simulated hillslope sediment yields for rangeland and pasture HRUs that greatly exceeded values for such cover types as suggested in the literature (Elliot and Robichaud 2001, Meeuwig 1970, USDA 2000). The disparity between SWAT predicted yields and those reported in the literature (**Table 5-17**) as being characteristic of rangeland and pasture is due to the model's use of a single mean land surface slope value for each subbasin. The mean subbasin slope in a mountain setting is typically much greater than that for valley floors or land adjacent to stream channels. The exaggerated sediment yields prevented the calibration of sediment yields with measured values for suspended sediment. To derive more realistic sediment yield estimates, the SWAT values were multiplied, outside of the model, by the proportion of each subbasin area that conceivably could deliver sediment to the stream channel via sheet erosion.

SWAT's surface erosion component uses the modified universal soil loss equation (MUSLE) to quantify sediment transported by overland flow as sheet erosion. Overland flow is water moving down slope as an irregular sheet before it concentrates in defined channels. Though estimates vary, the slope length over which overland flow occurs is usually less than 400 feet (McCuen 1998). A distance of 350 feet and a slope of greater than 3 percent were used to derive the fraction of each subbasin area likely to contribute sediment through sheet erosion. GIS tools were used to define a 350-foot buffer and classify slopes greater than 3 percent on sediment impaired streams and their tributaries. Using Keno Creek as an example, a 350-foot buffer applied to both banks of Keno Creek and its tributaries has an area of 417 acres. No slope adjustment to the buffer area is needed because all slopes within the buffer exceed 3 percent. The entire Keno Creek watershed is 1630 acres. The fraction, calculated by dividing the buffer area by the total subbasin area (417 acres/1630 acres = 0.26) was used to adjust the SWAT subbasin sediment yields downward. These values are labeled as Adjusted Sheetflow Area Load for listed stream segments in **Table F-1**.

Next, the adjusted loads were apportioned into naturally occurring and controllable components. The naturally occurring load was assumed to be that delivered even when adequate vegetative filter conditions exist on contributing land cover types. Field and aerial photo reconnaissance of the Blackfoot watershed suggested no need to refine SWAT's globally assigned C-factor values; therefore, default C-factors for each land type were assumed to be valid.. The factor controlling hillslope sediment delivery was assumed to be vegetative cover conditions within the potential sheetflow area next to the channels. A sediment reduction efficiency of 75 percent was assumed to represent naturally occurring loading conditions for this analysis. This value better reflects those reported in the general literature (Castelle and Johnson 2000) and is closer to results reported for Montana settings (Hook 2003) while also allowing for some hillslope loading from human activities. With 75 percent removal, 25 percent of the adjusted hillslope sediment yield becomes the assumed naturally occurring load representing the annual maximum loads from hillslope erosion. Thus, 75 percent of the adjusted hillslope load is assumed to be controllable by land management activities.

Table F-1 lists the initial SWAT hillslope sediment yields and the adjusted sheetflow area loads for each stream segment. The modified SWAT estimates reflect the degree of yield adjustment according to the fraction of total subbasin area that is within the sheetflow area. The adjusted sheetflow area loads are partitioned into naturally occurring loads and controllable loads based on literature values for expected sediment load reductions with healthy stream bank vegetative filters. The naturally occurring load is delivered from background hillslope erosion and from erosion on developed land with assumed application of all reasonable land, soil, and water conservation practices.

Again, using the Keno Creek values as an example, the SWAT model estimated load of 4 tons/yr is reduced by the sheetflow area fractions of 0.26 to one ton/yr. Considering the assumptions described above regarding naturally occurring hillslope erosion, 0.25 tons/yr (rounded to 0.3) and 0.75 tons/yr (rounded to 0.8) become the annual naturally occurring and controllable fractions of current loading.

Table F-1. Hillslope Sediment Yield Adjustment and Partitioning into Naturally Occurring and Controllable (human-caused) Components

Stream Name	Initial SWAT Sediment Load Estimate (tons/yr)	Sheetflow Source Area Fraction	Adjusted Sheetflow Area Load (tons/yr)	Naturally Occurring Load (tons/yr)	Controllable Load (tons/yr)
Keno Creek	4.0	0.26	1.0	0.3	0.8
Upper Elk Creek	279.0	0.34	95.0	24.0	71.0
Lower Elk Creek	44.0	0.32	14.0	3.5	10.5
Belmont Creek	1727.0	0.30	510.0	127.5	382.5
East Ashby Creek	125.0	0.27	34.0	8.5	25.5
West Ashby Creek	56.0	0.38	21.0	5.3	15.8
Camas Creek	535.0	0.29	155.0	39.0	116.0
Washoe Creek	8.0	0.25	2.0	0.5	1.5
Union Creek	822.0	0.29	241.0	60.0	180.0
Totals	3,600		1,073	268	805

With the adjustments, the total SWAT subbasin yield of 3,600 tons/yr (**Table 5-18**) for the Lower Blackfoot planning area was reduced by 70 percent to 1,073 tons/yr. The noticeably lower values for adjusted sheetflow yield for Keno and Washoe creeks reflect the low hillslope yields estimated by the SWAT model in these forested subbasins.

Existing ground cover conditions within the sheet erosion source areas were assumed to have some sediment filtering capacity. The 2006 streambank assessment in the Lower Blackfoot TPA recorded Rosgen channel type, vegetation density, bank erosion condition, land use, local sediment sources, substrate composition and entrenchment degree. With these field observations as guidance, DEQ interpreted 2005 aerial and ground photos to estimate an existing sediment filtering efficiency value for each stream. These values range from 0.50 to 0.87 and represent estimates of the effect of current vegetation management on sediment removal. The product of each value multiplied by the controllable load gives the controllable load reduction needed to reflect naturally occurring conditions on developed land. The reductions are applied to the controllable loads in **Table F-2**. Reductions are not estimated for streams determined to be fully supporting.

Table F-2. Controllable Loads, Sediment Removal Efficiency and Needed Reductions to Controllable Load Reductions for Listed Stream Segments in the Lower Blackfoot-Planning Area

Stream Name	Controllable Load (tons/yr)	Existing Sediment Removal Efficiency	Needed Reductions to Controllable Load (tons/yr)
Keno Creek	0.8	0.70	0.2
Upper Elk Creek	71.3	0.70	21.4
Lower Elk Creek	10.5	0.60	4.2
Belmont Creek	382.5	0.87	49.7
East Ashby Creek	25.5	0.50	12.8
West Ashby Creek	15.8	0.70	4.7
Camas Creek	116.3	0.55	52.3
Washoe Creek	1.5	0.80	0.3
Union Creek	180.8	0.73	48.8
Totals	805		194

The existing sediment removal capacity reduces the controllable load by 76 percent from 805 to 194 tons per year.

Stream Bank Erosion Loading

The base parameter and stream bank erosion inventory project undertaken in 2006 included direct measurement of sediment from eroding banks on representative reaches of 303(d) Listed streams. **Section 5** of this document and **Appendix C** describe the assessment methodology and results. The Bank Erosion Hazard Index method of Rosgen (2000) was used to obtain measured values for reach specific stream bank erosion rates. Measurements of total bank erosion were partitioned into controllable and background components by assuming a degree of improvement in selected stream bank dimensional and condition parameters that would occur in the absence of human influence. The difference between the measured rate and the rate reflecting no human influence defined the human-caused load. **Table F-3** contains an accounting of the total stream bank loads, human-caused loads, and background loading for assessed reaches of listed segments in the Lower Blackfoot TPA.

The estimated stream bank sediment load of 1,326 tons/yr from human-caused sources in the Lower Blackfoot planning areas is 30 percent of the total annual stream bank load of 4,456 tons/yr.

Table F-3. Lower Blackfoot Planning Area Stream Bank Sediment Load Estimates by Assessment Reach and 303 (d) Listed Stream Segment

Stream Name	Reach Code	Reach Load (Tons/Yr)	Human Caused Fraction	Human Caused Reach Load (Tons/ Yr)	Background Reach Load (Tons/Yr)	Total Segment Load (Tons/ Yr)
Keno Creek	Keno1	0.2	26%	0.1	0.2	4.4
	Keno2	2.6	26%	0.7	2.0	
	Keno3	0.8	26%	0.2	0.6	
	Keno4	0.7	36%	0.3	0.4	
Elk Creek. Upper	Elk1	0.3	26%	0.1	0.2	91.6
	Elk2	3.9	26%	1.0	2.9	
	Elk3	31.4	26%	8.2	23.2	
	Elk4	15.2	41%	6.3	9.0	
	Elk5	10.4	41%	4.3	6.1	
	Elk6	30.3	41%	12.4	17.9	
Elk Creek. Lower	Elk7	202.7	33%	66.9	135.8	449.9
	Elk8	99.3	26%	25.8	73.5	
	Elk9	62.8	37%	23.2	39.5	
	Elk10	85.2	28%	23.9	61.3	
Belmont Creek	Bel1	1.0	38%	0.4	0.6	83.0
	Bel2	11.7	38%	4.5	7.3	
	Bel3	37.6	26%	9.8	27.8	
	Bel4	32.7	26%	8.5	24.2	
Washoe Creek	Washoe1	0.4	31%	0.1	0.3	115.3
	Washoe2	80.4	31%	24.9	55.5	
	Washoe3	24.3	31%	7.5	16.8	
	Washoe4	10.1	31%	3.1	7.0	
Ashby Creek, East	EAshb1	0.4	31%	0.1	0.2	6.5
	EAshb2	2.7	31%	0.8	1.9	
	EAshb3	3.4	41%	1.4	2.0	
Ashby Creek, West	WAshb1	0.6	29%	0.2	0.4	15.7
	WAshb2	1.1	29%	0.3	0.8	

Table F-3. Lower Blackfoot Planning Area Stream Bank Sediment Load Estimates by Assessment Reach and 303 (d) Listed Stream Segment

Stream Name	Reach Code	Reach Load (Tons/Yr)	Human Caused Fraction	Human Caused Reach Load (Tons/ Yr)	Background Reach Load (Tons/Yr)	Total Segment Load (Tons/ Yr)
	WAshb3	14.0	29%	4.1	9.9	
Camas Creek	Cam1	0.5	26%	0.1	0.4	468.0
	Cam2	219.7	26%	57.1	162.6	
	Cam3	64.8	26%	16.8	47.9	
	Cam4	95.1	33%	31.4	63.7	
	Cam5	22.6	33%	7.5	15.1	
	Cam6	47.1	33%	15.6	31.6	
	Cam7	18.3	33%	6.0	12.3	
Union Creek	Union1	196.9	32%	63.0	133.9	3221.3
	Union2	26.3	32%	8.4	17.9	
	Union3	26.1	26%	6.8	19.3	
	Union4	8.0	26%	2.1	6.0	
	Union5	235.3	26%	61.2	174.1	
	Union6	145.1	26%	37.7	107.3	
	Union7	19.1	26%	5.0	14.1	
	Union8	24.7	26%	6.4	18.3	
	Union9	86.8	30%	26.0	60.7	
	Union10	1520.7	30%	456.2	1064.5	
	Union11	931.1	30%	279.3	651.7	
	Union12	1.2	30%	0.4	0.8	
TPA Totals		4455.7		1326.0	3129.7	4455.7

The passive restoration analysis divides the stream bank load into a human-caused component and a background component. Applying all reasonable land, soil and water conservation practices to developed land does not necessarily result in background sediment loading devoid of human influence. Therefore, a load reduction factor was developed for this analysis to reflect conservation practice effectiveness and the actual extent of stream banks affected by human land uses in each assessment reach. This achievable reduction multiplier is the product of two factors:

1. The percentage of stream bank length having a discernable land use,
2. A literature based coefficient of 0.8 representing the actual effectiveness of conservation practices in reducing sediment loading.

The multipliers range from 0 percent to 80 percent, with the lower percentages applying to more remote headwaters reaches having few human impacts and inherently stable channel types. Larger deductions are more common on lower reaches where human influence is more extensive. **Table F-4** lists the land use extent and the achievable reduction to the human caused component of stream bank erosion for each assessment reach. The right-most column in the table contains total achievable load reduction figures for the corresponding stream segment.

Table F-4. Lower Blackfoot Stream Bank Land Use Extent and Erosion Load Apportionment into Human Caused Loading, Background Loading and Achievable Reductions to Human Caused Loading

Listed Segment Name	Assessment Reach Name	Human Caused Load (tons/yr)	Stream Bank Land Use Extent (Percent)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)	Achievable Reduction in Human Caused Segment Load (tons/yr)
Keno Creek	Keno1	0.1	10.0%	8%	0.0	0.6
	Keno2	0.7	60.0%	48%	0.3	
	Keno3	0.2	60.0%	48%	0.1	
	Keno4	0.3	70.0%	56%	0.1	
Upper Elk Creek	Elk1	0.1	10.0%	0%	0.0	13.3
	Elk2	1.0	45.0%	36%	0.4	
	Elk3	8.2	50.0%	40%	3.3	
	Elk4	6.3	85.0%	68%	4.3	
	Elk5	4.3	40.0%	32%	1.4	
	Elk6	12.4	41.2%	33%	4.1	
Lower Elk Creek	Elk7	66.9	84.6%	68%	45.3	93.7
	Elk8	25.8	99.8%	80%	20.6	
	Elk9	23.2	99.6%	80%	18.5	
	Elk10	23.9	48.9%	39%	9.3	
Belmont Creek	Bel1	0.4	85.0%	68%	0.3	13.6
	Bel2	4.5	85.0%	68%	3.0	
	Bel3	9.8	80.1%	64%	6.3	
	Bel4	8.5	60.0%	48%	4.1	
Washoe Creek	Washoe1	0.1	60.0%	48%	0.1	10.8
	Washoe2	24.9	22.2%	18%	4.4	
	Washoe3	7.5	67.5%	54%	4.1	
	Washoe4	3.1	88.5%	71%	2.2	

Table F-4. Lower Blackfoot Stream Bank Land Use Extent and Erosion Load Apportionment into Human Caused Loading, Background Loading and Achievable Reductions to Human Caused Loading

Listed Segment Name	Assessment Reach Name	Human Caused Load (tons/yr)	Stream Bank Land Use Extent (Percent)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)	Achievable Reduction in Human Caused Segment Load (tons/yr)
East Ashby	EAshb1	0.1	5.0%	4%	0.0	1.1
	EAshb2	0.8	27.2%	22%	0.2	
	EAshb3	1.4	84.3%	67%	1.0	
West Ashby	WAshb1	0.2	62.7%	50%	0.1	2.6
	WAshb2	0.3	53.7%	43%	0.1	
	WAshb3	4.1	72.9%	58%	2.4	
Camas Creek	Cam1	0.1	34.2%	27%	0.0	87.1
	Cam2	57.1	63.4%	51%	29.0	
	Cam3	16.8	81.2%	65%	10.9	
	Cam4	31.4	97.8%	78%	24.6	
	Cam5	7.5	95.4%	76%	5.7	
	Cam6	15.6	97.3%	78%	12.1	
	Cam7	6.0	99.5%	80%	4.8	

Table F-4. Lower Blackfoot Stream Bank Land Use Extent and Erosion Load Apportionment into Human Caused Loading, Background Loading and Achievable Reductions to Human Caused Loading

Listed Segment Name	Assessment Reach Name	Human Caused Load (tons/yr)	Stream Bank Land Use Extent (Percent)	Achievable Reduction in Human Caused Load (Percent)	Achievable Reduction in Human Caused Load (tons/yr)	Achievable Reduction in Human Caused Segment Load (tons/yr)
Union Creek	Union1	63.0	63.3%	51%	31.9	677.8
	Union2	8.4	80.7%	65%	5.4	
	Union3	6.8	68.6%	55%	3.7	
	Union4	2.1	92.9%	74%	1.6	
	Union5	61.2	83.0%	66%	40.6	
	Union6	37.7	59.6%	48%	18.0	
	Union7	5.0	74.5%	60%	3.0	
	Union8	6.4	92.7%	74%	4.8	
	Union9	26.0	93.9%	75%	19.6	
	Union10	456.2	94.9%	76%	346.5	
	Union11	279.3	90.7%	73%	202.6	
	Union12	0.4	74.0%	59%	0.2	
		1,327.5			901.2	901.2

Sediment Loading From Culvert Failure

The estimation of sediment from roadways includes an analysis of sediment from culvert failure. Sediment at risk due to culvert failure is that saturated by ponded water at the upstream inlet of undersized culverts or from overflow of ponded water onto the road surface with subsequent erosion of the fill. Estimates of the fill volumes in the Lower Blackfoot planning area that are susceptible to culvert failure were made by extrapolation of per crossing means developed from surveyed crossings in the Middle Blackfoot TMDL planning area.

Seventy-three culverts were surveyed in the Middle Blackfoot-Nevada Creek planning area during the 2005 road sediment source assessment. The analysis associated risk of failure with a ratio of culvert width to bankfull channel width (constriction ratio) of less than one. Of the 73 survey sites, 55 had constriction ratios less than one. For the 38 sites in the Blackfoot with constriction ratios less than one, 4,393 tons were estimated as being at risk; a mean value of 115.6 tons per site (RDG, 2006). This mean value was extrapolated to the total of 789 crossings occurring on listed streams in the Lower Blackfoot. The estimated amount of fill at risk in the Lower Blackfoot is 91,208 tons (115.6 tons/site times 789 sites).

Annual loading was estimated assuming a one percent failure rate. Thus, the annual loading estimate equals 912 tons in the Lower Blackfoot. Lacking detailed analysis of failure rates, the one percent failure per year is an estimated point of departure for the purpose of calculating the at risk loads. Adjustments to this failure rate and the resulting loads are warranted when the results of more detailed culvert failure analysis are available for the planning area. Subtotals for watersheds of listed streams are given in **Table F-5**. The annual load is partitioned into controllable versus naturally occurring components by applying a percent reduction derived from an alternative, discharge based culvert failure analysis used in other forested watersheds in Montana.

Table F-5. Annual Loading from Culvert Failure for the Lower Blackfoot Planning Areas

Stream Name	Crossings	At Risk Mass (tons)	Annual Loading (tons/yr)	Controllable Load (tons/year)	Naturally Occurring Load (tons/yr)
Ashby Creek, East Fork	30	3,468	35	27	8
Ashby Creek, West Fork	34	3,930	39	30	9
Belmont Creek	202	23,351	234	180	54
Camas Creek	150	17,340	173	133	40
Elk Creek, Upper	50	5,780	58	45	13
Elk Creek, Lower	71	8,208	82	63	19
Keno Creek	15	1,734	17	13	4
Union Creek	229	26,472	265	204	61
Washoe Creek	4	462	5	4	1
Totals	785	90,745	908	698	210

In these analyses, regression equations developed by the USGS (Omang 1992) were used to estimate peak discharge (Q) for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals at surveyed stream crossings based on drainage area (square miles) and mean annual precipitation (inches). Survey data was used to calculate a ratio of ponded headwater depth to culvert inlet depth (Hw:D) at each culvert. Culverts exceeding a Hw:D ratio of 1.4 were considered at risk for failure. The annual probability of modeled discharge, Hw:D ratio and road fill volume subject to erosion at failure were used to quantify annual loading from failure. The existing loading condition assumed that failed culverts were replaced with culverts of the same size. An appropriate reduction from the current loading condition was based on a scenario where failed culverts were upgraded to those passing the Q100 discharge. This scenario follows the guidance from the U.S. Forest Service (USFS), Inland Native Fish Strategy (INFISH) recommendations which call for all culverts on USFS land to be able to pass the Q100 flow event. The sediment yields and reductions from the surveyed locations were extrapolated to unsurveyed culverts at the watershed scale. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent. The Q100 replacement BMP and assumed loading reduction were applied to the annual loading estimates to define the controllable and naturally occurring loads. The culvert upgrade scenario was assumed to represent application of all reasonable land, soil, and water conservation practices addressing culvert failure.

The naturally occurring loading is that assumed with the replacement of failed culverts with culverts passing the 100 year discharge (Q100). This long-term strategy for culvert replacement follows the guidance from the USFS, INFISH recommendations that call for all culverts on USFS land to be able to pass the Q100 flow event. The Q100 replacement scenario resulted in annual loading reductions ranging from 70 to 80 percent less than loading when failed culverts were replaced with ones of similar size. Of the estimated total of 908 tons annually from failed culverts, 210 tons result with the Q100 replacement scenario. The estimated load reduction with BMP implementation is 698 tons per year.

Allocations for Sediment Loading

The estimated annual load reductions are allocated to land uses within the watersheds of impaired streams. The allocation for each land use is expressed as a percentage of the needed annual reduction for the listed water body and converted to annual reductions in tons per year. The annual reduction allocations given in **Table 8.6** are a composite of those determined separately for hillslope, stream bank and road erosion.

Annual hillslope allocations to land uses are based upon their proportional extent within the stream buffer area assumed as the hillslope source of sediment to stream channels. Values were determined for each stream assessment reach during the 2006 field assessment and verified through interpretation of aerial imagery showing 2005 conditions. The tabulated data for each reach is given in **Table F-6**

Table F-6. Percentage of Land Use Extent within Hillslope Sheetwash Areas of Listed Segments and Corresponding Hillslope Loading Reduction Allocations in the Lower Blackfoot TPA

Segment Name	Livestock Grazing		Irrigated Hay		Silviculture		Rural Residential	
	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)
Ashby East	93	11.9	0	0	4	1.20	3	0.45
Ashby West	68	3.40	0	0	15	0.75	17	0.85
Belmont	85	42.50	0	0	15	7.5	0	0
Keno	0	0	0	0	100	0.10	0	0
Elk Upper	3	0.63	0	0	97	20.37	0	0
Elk Lower	14	0.49	33	1.16	47	1.65	6	0.21
Washoe	8	0.02	3	0.01	78	0.23	11	0.03
Camas	50	26.00	30	15.60	8	4.16	12	6.24
Union	31	14.94	28	13.50	26	12.53	15	7.23

Similar to the hillslope allocations, those for stream bank erosion were allocated according to the percentage of the total stream bank length exhibiting a specific land use as identified during the 2006 field assessment. These percentages are given in **Table F-7**.

The values for land use extent along stream banks do not sum to 100 percent in all cases because clear evidence of discernable land use did not always extend throughout the reach. The land use extent values in **Table F-7** reflect the extent of stream bank over which the corresponding use was judged as contributing sediment. For example, the first row in the table specifies that 10 percent of stream banks in reach Ken1 had a discernable land use that consisted solely of silvicultural practices. The remainder of the reach had no particular land use and contributed minimal sediment loading. Ten percent of the annual loading to Keno1 (0.1 tons/yr) is about 20 pounds per year, not a meaningful allocation considering the project scope and analysis methods. Therefore, there is no sediment reduction allocation in **Table F-7** for Keno1. The remaining three reaches of Keno Creek have reductions allocated to silvicultural practices totaling 0.6 tons per year.

The reduction allocations for roads are the sum of those for road surface erosion and culvert failure. A sediment load reduction of 30 percent was assumed with implementation of construction and maintenance BMPs to reduce loading at crossings. The reduction in culvert failure loading is that assumed with replacement over time with culverts passing the Q100 flow event rather than one of similar diameter as discussed above.

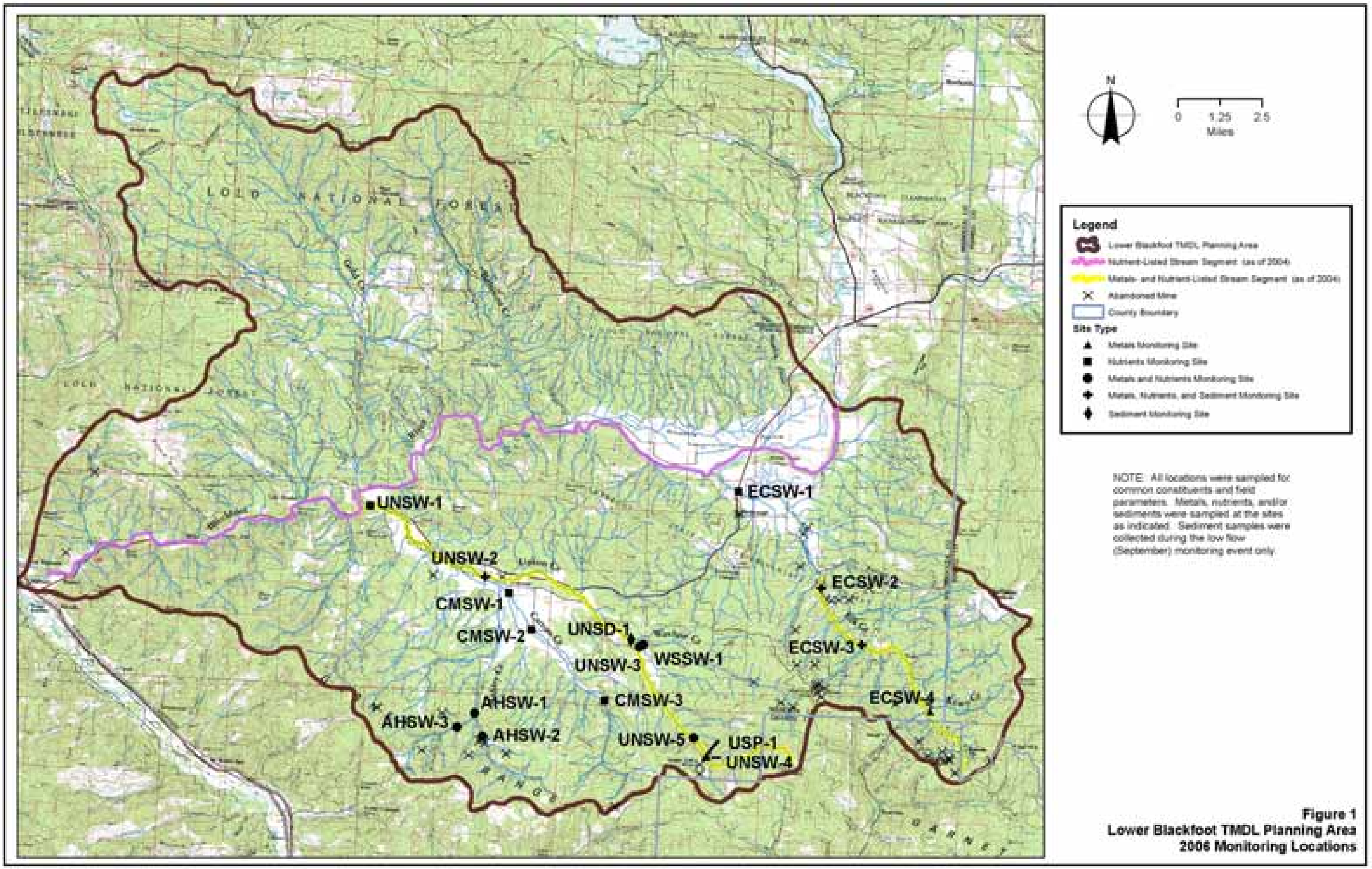
Table F-7. Stream Bank Land Use Extent and Corresponding Stream Bank Erosion Allocations for the Lower Blackfoot TPA.

Stream	Reach	Grazing		Irrigated Hay/Pasture)		Silviculture		Mining		Rural Residential		Total Reach Land Use Extent (%)	Total Reach Reduction Allocation	Total Segment Reduction Allocation
		Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)			
Keno	Keno1	0.0%	0.00	0.0%	0.00	10.0%	0.00	0.0%	0.00	0.0%	0.00	10.0%	0.00	0.6
	Keno2	0.0%	0.00	0.0%	0.00	60.0%	0.33	0.0%	0.00	0.0%	0.00	60.0%	0.33	
	Keno3	0.0%	0.00	0.0%	0.00	60.0%	0.10	0.0%	0.00	0.0%	0.00	60.0%	0.10	
	Keno4	0.0%	0.00	0.0%	0.00	70.0%	0.14	0.0%	0.00	0.0%	0.00	70.0%	0.14	
Upper Elk	Elk1	0.0%	0.00	0.0%	0.00	10.0%	0.03	0.0%	0.00	0.0%	0.00	10.0%	0.03	13.4
	Elk2	0.0%	0.00	0.0%	0.00	25.0%	0.21	20.0%	0.16	0.0%	0.00	45.0%	0.37	
	Elk3	0.0%	0.00	0.0%	0.00	30.0%	1.96	20.0%	1.31	0.0%	0.00	50.0%	3.27	
	Elk4	0.0%	0.00	0.0%	0.00	5.0%	0.25	80.0%	4.00	0.0%	0.00	85.0%	4.25	
	Elk5	0.0%	0.00	0.0%	0.00	0.0%	0.00	40.0%	1.36	0.0%	0.00	40.0%	1.36	
	Elk6	0.0%	0.00	1.2%	0.12	0.0%	0.00	40.0%	3.97	0.0%	0.00	41.2%	4.10	
Lower Elk	Elk7	20.0%	10.70	54.6%	29.22	0.0%	0.00	10.0%	5.35	0.0%	0.00	84.6%	45.27	93.7
	Elk8	20.0%	4.13	79.8%	16.48	0.0%	0.00	0.0%	0.00	0.0%	0.00	99.8%	20.61	
	Elk9	40.0%	7.43	59.6%	11.07	0.0%	0.00	0.0%	0.00	0.0%	0.00	99.6%	18.50	
	Elk10	0.0%	0.00	12.9%	2.47	0.0%	0.00	30.0%	5.72	6.0%	1.14	48.9%	9.34	
Belmont	Bel1	0.0%	0.00	0.0%	0.00	85.0%	0.26	0.0%	0.00	0.0%	0.00	85.0%	0.26	13.6
	Bel2	0.0%	0.00	0.0%	0.00	85.0%	3.03	0.0%	0.00	0.0%	0.00	85.0%	3.03	
	Bel3	0.0%	0.00	0.1%	0.01	80.0%	6.26	0.0%	0.00	0.0%	0.00	80.1%	6.26	
	Bel4	0.0%	0.00	20.0%	1.36	40.0%	2.72	0.0%	0.00	0.0%	0.00	60.0%	4.08	
Washoe	Washoe1	0.0%	0.00	0.0%	0.00	50.0%	0.05	10.0%	0.01	0.0%	0.00	60.0%	0.06	10.8
	Washoe2	0.0%	0.00	0.0%	0.00	15.0%	2.99	5.0%	1.00	2.2%	0.43	22.2%	4.42	
	Washoe3	20.0%	1.21	5.0%	0.30	0.0%	0.00	0.0%	0.00	42.5%	2.56	67.5%	4.08	
	Washoe4	20.0%	0.50	46.1%	1.15	0.0%	0.00	0.0%	0.00	22.4%	0.56	88.5%	2.22	

Table F-7. Stream Bank Land Use Extent and Corresponding Stream Bank Erosion Allocations for the Lower Blackfoot TPA.

Stream	Reach	Grazing		Irrigated Hay/Pasture)		Silviculture		Mining		Rural Residential		Total Reach Land Use Extent (%)	Total Reach Reduction Allocation	Total Segment Reduction Allocation
		Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)	Percent Land Use Extent	Allocation (tons/yr)			
Ashby East	EAshb1	0.0%	0.00	0.0%	0.00	5.0%	0.00	0.0%	0.00	0.0%	0.00	5.0%	0.00	1.1
	EAshb2	0.0%	0.00	2.2%	0.01	25.0%	0.17	0.0%	0.00	0.0%	0.00	27.2%	0.18	
	EAshb3	10.0%	0.11	0.0%	0.00	57.7%	0.65	10.0%	0.11	6.6%	0.07	84.3%	0.95	
Ashby West	WAshb1	0.0%	0.00	0.0%	0.00	52.7%	0.07	0.0%	0.00	10.0%	0.01	62.7%	0.08	2.6
	WAshb2	0.0%	0.00	0.0%	0.00	45.0%	0.12	0.0%	0.00	8.7%	0.02	53.7%	0.14	
	WAshb3	0.0%	0.00	0.0%	0.00	50.0%	1.62	0.0%	0.00	22.9%	0.74	72.9%	2.36	
Camas	Cam1	0.0%	0.00	0.0%	0.00	34.2%	0.03	0.0%	0.00	0.0%	0.00	34.2%	0.03	87.1
	Cam2	20.0%	9.14	11.9%	5.44	24.0%	10.96	0.0%	0.00	7.5%	3.42	63.4%	28.95	
	Cam3	0.0%	0.00	75.0%	10.10	0.0%	0.00	0.0%	0.00	6.2%	0.83	81.2%	10.93	
	Cam4	0.0%	0.00	70.0%	17.57	0.0%	0.00	0.0%	0.00	27.8%	6.99	97.8%	24.56	
	Cam5	30.0%	1.79	38.5%	2.30	0.0%	0.00	0.0%	0.00	27.0%	1.61	95.4%	5.69	
	Cam6	20.0%	2.49	73.3%	9.12	0.0%	0.00	0.0%	0.00	3.9%	0.49	97.3%	12.10	
	Cam7	0.0%	0.00	99.4%	4.80	0.0%	0.00	0.0%	0.00	0.1%	0.00	99.5%	4.80	
Union	Union1	0.0%	0.00	0.0%	0.00	63.3%	31.93	0.0%	0.00	0.0%	0.00	63.3%	31.93	677.8
	Union2	0.0%	0.00	27.9%	1.88	8.0%	0.54	0.0%	0.00	44.9%	3.03	80.8%	5.44	
	Union3	10.0%	0.54	25.0%	1.36	0.0%	0.00	0.0%	0.00	33.6%	1.83	68.6%	3.73	
	Union4	10.0%	0.17	50.0%	0.84	0.0%	0.00	0.0%	0.00	32.9%	0.55	92.9%	1.55	
	Union5	0.0%	0.00	11.6%	5.68	0.0%	0.00	0.0%	0.00	71.3%	34.91	83.0%	40.60	
	Union6	20.0%	6.03	33.3%	10.06	0.0%	0.00	0.0%	0.00	6.3%	1.89	59.6%	17.99	
	Union7	20.0%	0.79	54.5%	2.17	0.0%	0.00	0.0%	0.00	0.0%	0.00	74.5%	2.96	
	Union8	25.0%	1.29	63.8%	3.28	0.0%	0.00	0.0%	0.00	3.9%	0.20	92.7%	4.77	
	Union9	0.0%	0.00	92.0%	19.16	0.0%	0.00	0.0%	0.00	1.9%	0.40	93.9%	19.56	
	Union10	15.0%	54.75	78.3%	285.81	0.0%	0.00	0.0%	0.00	1.6%	5.90	94.9%	346.46	
	Union11	5.0%	11.17	75.7%	169.11	0.0%	0.00	0.0%	0.00	10.0%	22.35	90.7%	202.63	
	Union12	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	74.0%	0.21	74.0%	0.21	

APPENDIX G
METALS DATA AND SAMPLING LOCATIONS



NOTE: All locations were sampled for common constituents and field parameters. Metals, nutrients, and/or sediments were sampled at the sites as indicated. Sediment samples were collected during the low flow (September) monitoring event only.

Figure G-1. Lower Blackfoot TMDL Planning Area 2006 Monitoring Locations

Table G-1. Total Recoverable Trace Metal Concentrations

				cfs	SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Site	**Segment Name**	**Client Sample ID**	**Date**	**Flow**	**pH**	**Al***	**As**	**Cd**	**Cu**	**Fe**	**Pb**	**Mn**	**Zn**
AHSW-2	Ashby Creek, East Fork	LBF-0609-101	9/19/06	1.86	8.3	<0.03	<0.003	<0.00008	<0.001	0.06	0.0005	<0.005	0.01
AHSW-1	Ashby Creek, Lower	LBF-0606-106	6/21/06	3.71	8.33	<0.03	<0.003	<0.00008	<0.001	0.12	0.0017	0.015	0.01
AHSW-1	Ashby Creek, Lower	LBF-0609-100	9/19/06	2.4	8.32	<0.03	<0.003	<0.00008	0.002	0.2	0.0033	0.017	0.01
AHSW-3	Ashby Creek, West Fork	LBF-0609-200	9/19/06	0.29	6.35	<0.03	<0.003	<0.00008	0.001	<0.05	<0.0005	0.012	<0.01
CMSW-1	Camas Creek	LBF-0606-107	6/22/06	6.35	8.03	--	--	--	--	--	--	--	--
CMSW-1	Camas Creek	LBF-0609-105	9/19/06	2.26	8.21	--	--	--	--	--	--	--	--
CMSW-2	Camas Creek	LBF-0606-103	6/21/06	1.71	8.23	--	--	--	--	--	--	--	--
CMSW-2	Camas Creek	LBF-0609-106	9/19/06	1.1	8.23	--	--	--	--	--	--	--	--
CMSW-3	Camas Creek	LBF-0606-104	6/21/06	2.68	8.37	--	--	--	--	--	--	--	--
CMSW-3	Camas Creek	LBF-0609-107	9/19/06	2.61	8.47	--	--	--	--	--	--	--	--

Table G-1. Total Recoverable Trace Metal Concentrations

				cfs	SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Site	**Segment Name**	**Client Sample ID**	**Date**	**Flow**	**pH**	**Al***	**As**	**Cd**	**Cu**	**Fe**	**Pb**	**Mn**	**Zn**
ECSW-1	Elk Creek, Lower	LBF-0606-108	6/22/06	6.46	8.24	--	--	--	--	--	--	--	--
ECSW-1	Elk Creek, Lower	LBF-0609-110	9/19/06	2.91	8.47	--	--	--	--	--	--	--	--
ECSW-2	Elk Creek, Upper	LBF-0606-109	6/22/06	6.68	8.35	<0.03	<0.003	<0.00008	<0.001	0.12	<0.0005	0.011	<0.01
ECSW-2	Elk Creek, Upper	LBF-0609-111	9/19/06	3.19	8.35	<0.03	<0.003	<0.00008	<0.001	0.11	<0.0005	0.01	<0.01
ECSW-3	Elk Creek, Upper	LBF-0606-111	6/22/06	5.47	8.26	<0.03	<0.003	<0.00008	<0.001	0.16	<0.0005	0.017	<0.01
ECSW-3	Elk Creek, Upper	LBF-0609-112	9/19/06	3.45	8.35	<0.03	<0.003	<0.00008	<0.001	0.16	<0.0005	0.016	<0.01
ECSW-4	Elk Creek, Upper	LBF-0606-112	6/22/06	1.22	8.22	<0.03	<0.003	<0.00008	<0.001	<0.05	<0.0005	<0.005	<0.01
ECSW-4	Elk Creek, Upper	LBF-0609-114	9/19/06	2.18	8.23	<0.03	<0.003	<0.00008	<0.001	<0.05	<0.0005	<0.005	<0.01
UNSW-1	Union Creek	LBF-0606-100	6/21/06	9.71	7.9	--	--	--	--	--	--	--	--
UNSW-1	Union Creek	LBF-0609-104	9/19/06	2.32	7.98	--	--	--	--	--	--	--	--
UNSW-2	Union Creek	LBF-0606-106	6/22/06	8.24	7.87	<0.03	<0.003	<0.00008	<0.001	0.17	<0.0005	0.021	<0.01

Table G-1. Total Recoverable Trace Metal Concentrations

				cfs	SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Site	**Segment Name**	**Client Sample ID**	**Date**	**Flow**	**pH**	**Al***	**As**	**Cd**	**Cu**	**Fe**	**Pb**	**Mn**	**Zn**
UNSW-2	Union Creek	LBF-0609-103	9/19/06	3.75	8.11	<0.03	<0.003	<0.00008	0.001	0.31	<0.0005	0.02	<0.01
UNSW-3	Union Creek	LBF-0606-101	6/21/06	0.213	6.88	<0.03	<0.003	<0.00008	0.005	0.33	<0.0005	0.012	<0.01
UNSW-3	Union Creek	LBF-0609-108	9/19/06	0.43	8.18	<0.03	<0.003	<0.00008	0.004	0.28	<0.0005	<0.005	<0.01
UNSW-4	Union Creek	LBF-0606-105	6/21/06	0.474	8.03	<0.03	<0.003	<0.00008	<0.001	0.24	<0.0005	0.01	<0.01
UNSW-4	Union Creek	LBF-0609-202	9/19/06	0.25	6.71	<0.03	<0.003	<0.00008	0.002	0.3	<0.0005	0.012	<0.01
UNSW-5	Union Creek	LBF-0609-203	9/19/06	0.25	7.15	<0.03	0.005	<0.00008	0.008	1.2	<0.0005	0.029	0.01
USP-1	Union Creek	LBF-0606-200	6/21/06	7.5 gpm **	6.35	<0.03	0.021	<0.00008	0.009	12.77	<0.0005	0.254	0.03
USP-1	Union Creek	LBF-0609-201	9/19/06	10 gpm**	5.88	<0.03	0.021	<0.00008	0.004	12	<0.0005	0.237	0.02
WSSW-1	Washoe Creek	LBF-0609-109	9/19/06	0.48	8.26	<0.03	<0.003	<0.00008	0.001	0.15	<0.0005	<0.005	<0.01

Table G-2. Lower Blackfoot Sediment Trace Metal Analysis Results*

Site	Date	Date	As	Cd	Cu	Pb	Mn	Zn
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
UNSD-1	9/19/2006	9/19/2006	<5.0	<1.0	16.2	<5.0	63.4	15.8
UNSW-2	9/19/2006	9/19/2006	<5.0	<1.0	<5.0	<5.0	14	<5.0
ECSW-3	9/19/2006	9/19/2006	<5.0	<1.0	<5.0	<5.0	15.7	<5.0
ECSW-2	9/19/2006	9/19/2006	<5.0	<1.0	<5.0	<5.0	12.2	<5.0

Sites shown in upstream to downstream order
Mainstem sites shown in bold
*- Trace metals analyses are for total metals
Samples consist of 63 micron and finer sediment size fraction

APPENDIX H
STREAM TEMPERATURE MODELING

Methods: SNTEMP Modeling

The use of a temperature model allowed simulation of stream temperatures under varying target condition scenarios. Simulations included current conditions and naturally occurring conditions based on higher levels of streambank vegetation, flow augmentation, and reduced width to depth (W:D) ratios. Simulations determined the relative influence of streambank vegetation, flow augmentation, and reduced W:D ratios on stream temperature by modeling each one of these components individually.

SNTEMP, the Stream Network Temperature Model, is a mechanistic heat transport model that predicts daily mean and maximum water temperatures at the end of a stream network (Theurer et al., 1984, Bartholow, 2004). Model simulations occur over a single time step, such as a day, and evaluate the effects of changing shade, stream geometry, and flow on instream temperature. The model requires inputs describing stream geometry, hydrology, meteorology, and stream shading.

Input Parameters

The model requires a basic suite of input data describing stream conditions and other factors during the modeling period. Three broad categories of input data include meteorology, stream geometry, and hydrology.

Local weather stations at Ovando and Helmville supplied the meteorological data. Meteorological data are mean values for the modeling period, and consists of:

- Air temperature
- Relative humidity
- Wind speed
- Cloud cover, presented as a percent of possible sunshine
- Solar Radiation

Values for solar radiation were not available for the modeling periods from the local weather stations. In lieu of solar radiation values, the model calculates solar radiation if values for dust coefficient and ground reflectivity are available. Dust coefficient and ground reflectivity values representative of the season and ground cover for the modeling period were used (Tennessee Valley Authority, 1972).

Hydrologic data are mean values for the modeling period, and include stream discharge throughout the system and water temperature. Instantaneous flow measurements taken during the late summer of 2006, supplied low flow data. Temperature sensors deployed for the summer of 2006 supplied the temperature data. Sensors at 13 locations collected hourly stream temperature on the impaired streams and important tributaries. Nine sensors were on Union Creek and four were on Elk Creek. These temperature data allowed development of model input files representative of typical summer hot periods.

Analysis of temperature data consisted of displaying hourly temperature data, the medians and ranges of temperature measurements, and seven-day average maximum water temperatures in a series of graphs and box and whisker plots. The hourly temperature data throughout the summer illustrates the timing of temperature increases as well as diurnal fluctuations. The box and whisker plots illustrate changes in temperature between sites, and the seven-day average maximum temperature graphs show the period of highest temperatures and their duration. Together, these figures provide temporal, statistical, and spatial descriptions of summer water temperatures.

Initial flow at the beginning of the modeled stream, tributary flow, ground water flow, point sources into the stream, and any flow diversions characterize flow throughout the system. Water temperature is input into the model at the beginning of the network, at any locations where additional flow enters the network, and at calibration points.

Significant Stream Temperature Controls and Target Selection

Surface Diversion

Landowners in the Lower Blackfoot irrigate approximately 5,345 acres of cropland by a combination of sprinkler and flood methods. Reduced in-stream flow volume that results form diversion and warmed flood irrigation returns increase the human caused thermal loading to streams when naturally occurring temperatures are most limiting for fish and supporting aquatic life. In addition, conversion from flood to sprinkler irrigation methods over the past 25 years and simultaneous expansions in irrigated area have diminished return flows and reduced the thermal assimilative capacity of streams. Irrigation best management practices are available that increase the amount of diverted water actually consumed by the crop, reduce diversion requirements and improve the thermal assimilative capacity. Lacking a water budget based irrigation diversion plan for Elk or Union creeks, a conservatively low expectation of 15 percent flow augmentation is assumed to be available on these streams.

Shade

One of the datasets required by the temperature model describes the amount of total shade from topography, vegetation and channel morphology. Literature-based values for vegetation canopy, field data describing bank vegetation type and extent and interpretation of aerial and ground photos helped quantify channel shade from vegetation. The four vegetation shade parameters of average canopy height (Vh), canopy diameter (Vc), canopy offset from the channel (Vo), and canopy filtering value were estimated for each woody vegetation type. The measured extent of woody bankline vegetation types, with their characteristic shade values allowed calculation of a weighted average shade for each temperature impaired reach. Aerial photo interpretation identified vegetation type for reaches without measured base parameter data. Topographic shade was assessed by interpreting digital elevation data. Channel cross section data, collected as part of the 2006 sediment impairment investigation, helped estimate shade contributed by channel shape.

Reaches of both Union Creek and Elk Creek occur as narrow channels meandering through herbaceous meadows of grass and sedge cover. Some shading occurs within such reaches due to the height (2 to 3 feet) of these plants adjacent to narrow channels. Current condition shade values used in the temperature modeling include that provided by herbaceous cover in addition to shade derived solely from woody vegetation. Total shade values that are based on varying filter properties, bankline extent, canopy diameter and channel offset provide an accurate estimate of overall shade for use in the temperature model (Bartholow, 2004).

Along most of the temperature listed segments, riparian vegetation has degraded to the extent that corresponding increases in thermal loads are significant. Therefore, riparian vegetation shading, as represented by bankline vegetation extent, is the principal temperature target for streams on the 303(d) List in the Lower Blackfoot planning areas.

Channel Morphology

Channel morphology influences stream temperatures. Riparian vegetation overhanging a narrow stream has a larger cooling effect than equivalent vegetation along a wider stream. Wide streams are more susceptible to thermal heating than narrow ones simply due to larger exposure area. An increase in stream bank vegetation has a smaller mitigating effect on thermal gain than the same increase along a narrow channel. The naturally occurring condition for channel width to depth ratio is one that meets and maintains the ratio targets developed by channel type in **Section 5.0** for sediment and habitat impairments. Since some reaches currently meet width to depth targets, this parameter is not considered a significant source of increased temperature loading. From a restoration perspective, improvements to riparian cover that increase shade should allow establishment of stable geomorphic channel conditions.

In summary, the temperature target parameters include the following:

1. An extent of woody bank vegetation that prevents stream temperature increases above those allowed by the B-1 standard,
2. 15 percent increase in channel flow volume provided by irrigation system improvements,
3. Channel W:D ratios developed in response to sediment and habitat impairments.

Limitations within the SNTEMP model or lack of information prevent model consideration of other human or natural temperature controls such as turbidity, dissolved organics or beaver activity.

Naturally Occurring Shade Conditions

Thick stands of woody vegetation occur locally on stream banks in the Lower Blackfoot Planning area. Examples of these conditions respectively for valley bottom and upland channels occur at the following locations:

- Union Creek (reach Union2) in the NW ¼ Section 3, Township 12 North, Range 15 West.
- Camas Creek (reach Cam1) in the SW ¼ Section 8, Township 12 North, Range 15 West.

Figures H-1 and H-2 illustrate these examples.

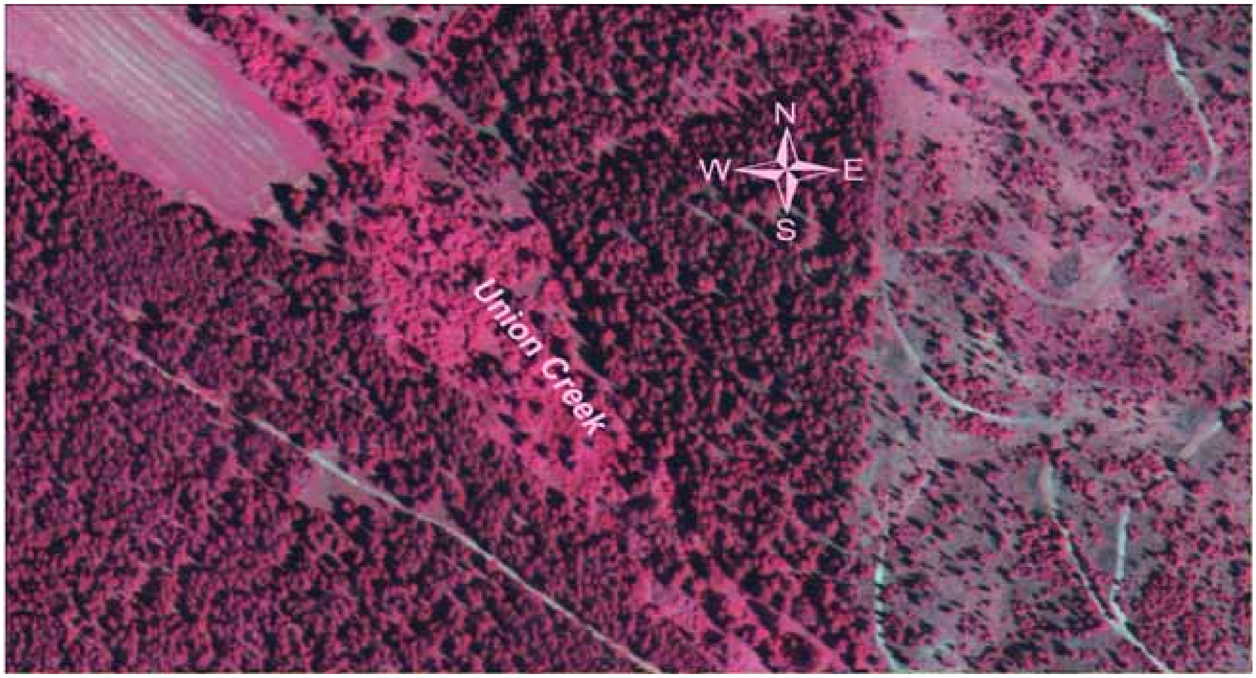


Figure H-1. Reference Valley Shade Conditions, Union Creek, Assessment Reach "Union2"

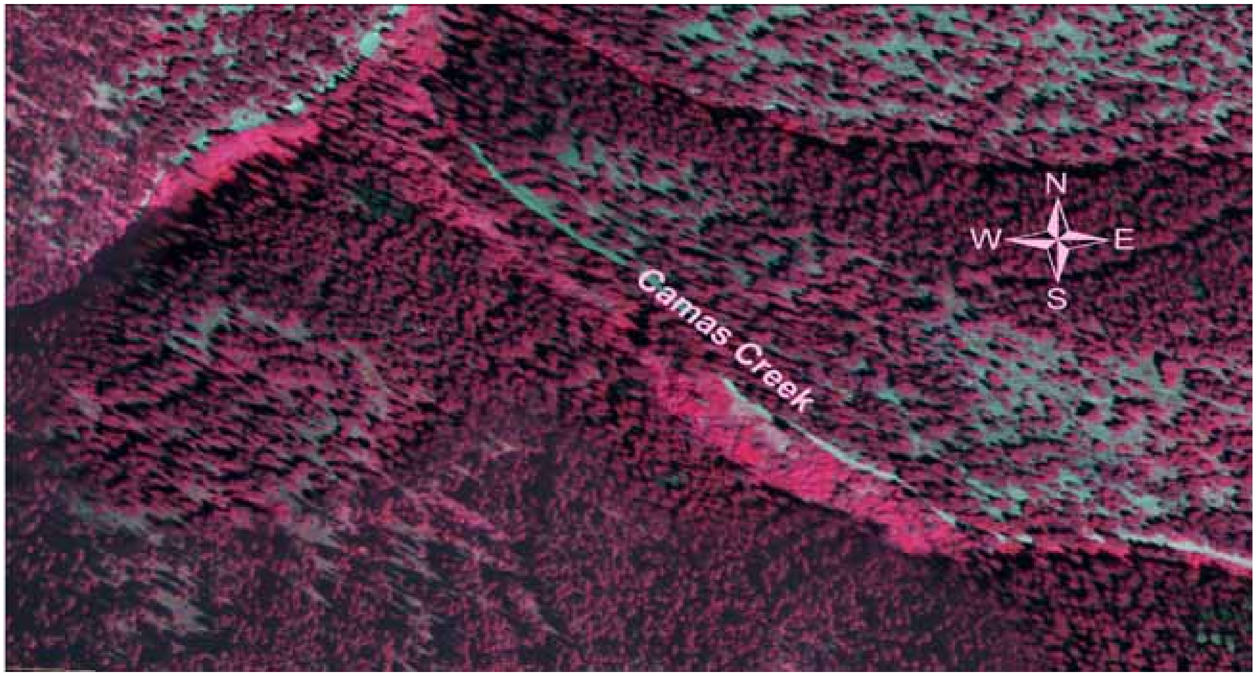


Figure H-2. Reference Mountain Shade Conditions, Upper Camas Creek

Through the process of developing bankline vegetation extent as a shade parameter, conditions along relatively undisturbed stream banks in valley areas were interpreted as representing 80 percent steam bank woody vegetation extent. Within mountain reaches, 90 percent stream bank woody vegetation cover occurs along undisturbed banks. These estimates of reference condition applied to temperature impaired streams and significant tributaries through the model markedly increased shade and reduced stream temperatures. These extents of woody bankline vegetation are considered achievable given successes reestablishing riparian areas where standard BMPs have been implemented.

A series of Stream Network Temperature (SNTEMP) models provide simulated stream temperatures under current conditions and under improved vegetation (shade), flow, and width conditions. Because 80 to 90 percent woody bankline vegetation was assumed as the naturally occurring shade condition for all temperature impaired tributary segments, the temperature changes simulated under this shade condition were selected as representing the naturally occurring temperature. In addition, a flow increase of 15 percent to current stream flows, and reductions in W:D ratio, where appropriate, define naturally conditions in Union Creek and Elk Creek.

Sections below pertaining to Elk Creek and Union Creek contain tables specifying input data for each of the models. These sections describe meteorological, hydrological, and stream geometry input data for each model. Conditions represent the modeling period.

Model Networks

Each model required development of a spatial model network consisting of multiple stream segments. Each stream segment is unique and has homogenous characteristics such as length, stream width, slope, channel roughness (Manning’s n), shade, and flow. Delineation of each segment occurs through identification of a series of nodes along the model network, and these nodes specify values for some or all of the segment characteristics (**Table H-1**).

Table H-1. SNTEMP model network nodes and stream characteristics described with each node

Node Type	Input Stream Characteristics
Headwater	Latitude, elevation, stream distance, water temperature, flow, stream width, Manning’s n, shade
Segment	Latitude, elevation, stream distance, stream width, flow, Manning’s n, shade
Point	Stream distance, water temperature, flow
Diversion	Stream distance, flow
Calibration	Stream distance, water temperature
Temperature Output	Stream distance
Flow	Stream distance, flow
End	Stream distance, flow

Headwater and segment nodes define the upstream point at which a stream segment begins, and that segment’s stream characteristics. Segment nodes also define the downstream extent of a stream segment, but not its characteristics. Point nodes are additions of flow to the modeled stream, and can define the location and flow of important tributaries. Diversion nodes specify flow removed from the network. Flow nodes redefine the quantity of instream flow, and account for lateral flow such as groundwater. End nodes define the downstream extent of a stream or the network. Temperature predictions occur at these nodes. Additionally, temperature predictions occur at any point in the network where a temperature output node exists.

Model Calibration

After model construction, calibration of simulated water temperatures with observed water temperature data is necessary. The goal of calibration is to ensure that the temperatures simulated with SNTEMP match well with observed conditions. The model is then suitable for assessing potential restoration efforts and conditions related to TMDLs.

To calibrate each model, observed daily mean and maximum water temperatures are assigned to calibration nodes at the end of each network and at various points within the network. A comparison of observed temperatures with simulated daily mean and maximum water temperatures at those points is used to assess how well the model is simulating temperatures. For SNTEMP, a model is accurate if the difference between observed and simulated temperatures is no greater than 0.5^{o} C (0.9^{o} F) (Bartholow, 1989).

Calibration of simulated to observed water temperatures is accomplished by changing model input parameters in successive calibration iterations until simulated temperatures match observed temperatures. Parameters can be modified singly or in combination. Parameters modified include those described in SNTEMP literature (Bartholow, 1989, Bartholow, 2004) and fit with the project team's knowledge of the modeled streams. The parameters considered for modification during calibration were:

- relative humidity,
- cloud Cover,
- wind,
- dust coefficient,
- ground reflectivity,
- thermal gradient, and
- Manning's n (for maximum temperatures only).

Sections below contain tables for Elk Creek and Union Creek specifying the parameters modified and the simulated temperatures for each calibration run. These sections also describe the rationale for each change in parameters. Calibration results at multiple nodes in a model network illustrate the accuracy of the model at multiple locations within each network.

Model Simulation

Once calibrated, the models can simulate resultant changes in water temperature from varying shade, flow, or channel width. Since lack of riparian shade is a large contributor to high temperatures in the modeled streams, changes in temperature were largely due to this parameter.

Output from the simulations was used to determine the change in temperature from current conditions due to changes in shade, flow, or width, and the amount of shade required to meet temperature targets. Simulations typically include:

- current stream conditions,

- natural stream conditions (defined by Montana DEQ, usually flow augmentation by 15 percent, decreased W:D ratio, and 80 percent or 90 percent streambank vegetation and corresponding increase in shade,
- several simulations that determined the change in stream temperature from, and therefore the relative influence of, changes in only shade, flow, or width, and
- one simulation of the target values for shade.

The temperature targets are those affecting mean daily temperatures due to uncertainty in the model’s ability to simulate maximum daily temperatures. The target simulation predicts a mean temperature that is no more than the allowable 1.0 °F or 0.5°F increase, depending upon the simulated mean temperature under naturally occurring conditions. Simulation results for mean daily maximum temperatures are reported as well. **Section 8.2** of the main document contains tables and graphs listing which parameters were changed in each simulation, the degree of change, and the resulting temperatures for each simulation.

Model Sensitivity and Sources of Uncertainty

The most sensitive meteorological inputs to the SNTEMP model are air temperature, relative humidity, solar radiation and wind speed (Bartholow 1989). The use of local weather stations to supply required meteorological inputs introduces uncertainty as to whether the station data reflects actual conditions throughout the modeled networks. Actual air temperatures, humidity and sunlight conditions vary throughout the planning area with elevation, vegetation effects on near surface wind velocity and drainage aspect. This variability is not precisely reflected in the weather station data that are mean values for the modeling period.

Percent shade is also a sensitive input parameter for which the vegetation component was derived from literature values for community types and aerial estimates of bankline vegetation. These indirect means of deriving vegetation shade will inherently vary from field measurements of canopy shade using a densiometer.

Stream temperature is highly sensitive to discharge. The model inputs for hydrologic data are mean values for the modeling period based upon instantaneous flow measurements taken during the late summer of 2006, when flows were low. Variation from these means as well as variations in estimated diversion and ground water recharge volumes and ground water recharge introduces additional uncertainty. These uncertainties can partially offset in defining the modeling period as hottest part of the growing season, approach likely to develop more restrictive target values for temperature controlling factors. The model’s use of mean input values for the modeling period limits the accuracy of output for daily maximum stream temperatures.

Elk Creek Model

The Elk Creek model simulated temperatures for a 6.2-mile stretch of Elk Creek from below Cap Wallace downstream to its confluence with the Blackfoot River. This segment of Elk Creek is listed as being temperature impaired on the 2006 303(d) List.

Construction

Nodes in the model identify where hydrology, stream geometry, and temperature data are input in the stream network. There are no point sources from tributary streams in the Elk Creek model (**Figure H-2**). Calibration points for Elk Creek are immediately below Sunset Hill Rd, below Route 200, and at the mouth. Two water diversion points exist for Elk Creek. One of these is located just downstream from the initiation point of the model, below Cap Wallace. Elk Creek also had water diverted below Sunset Hill Road.

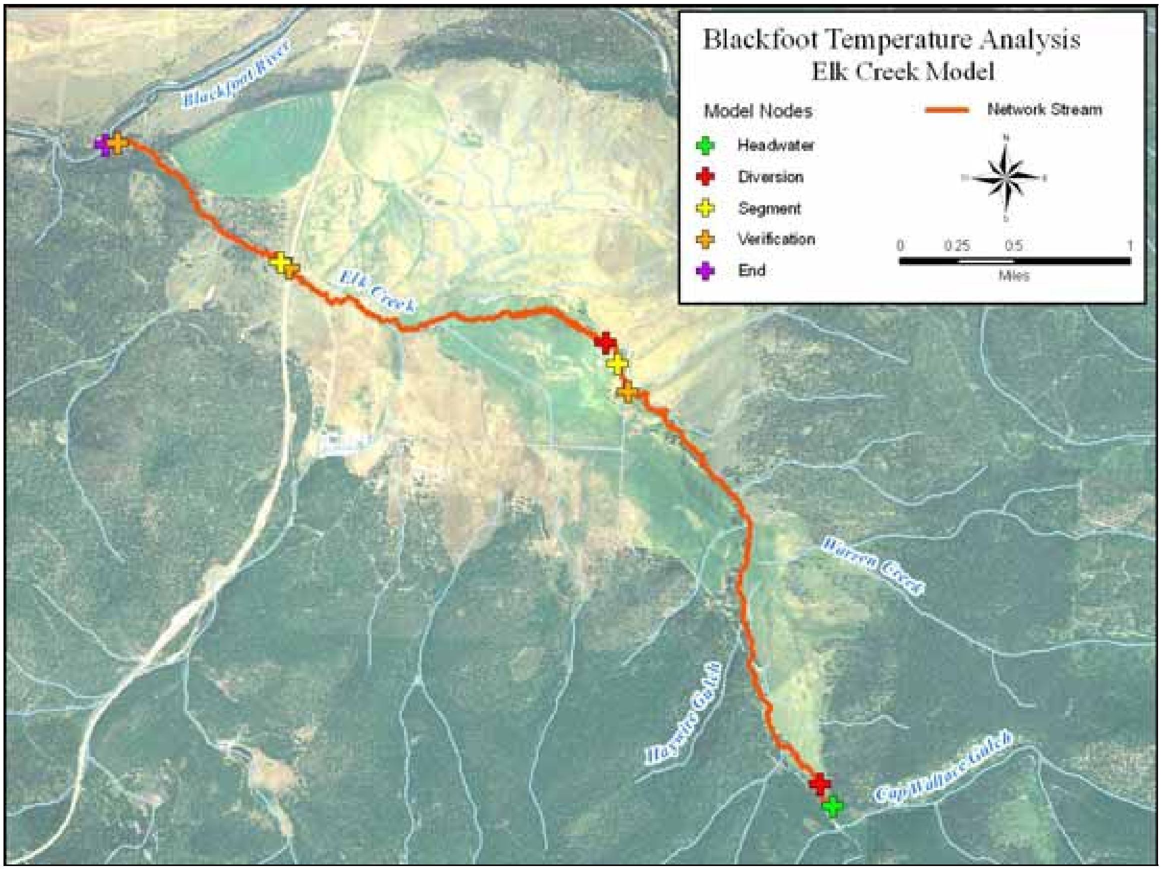


Figure H-1. Schematic of the Elk Creek model network and model nodes

Modeling of Elk Creek is for the period July 23 – July 24, 2006. A two-day modeling period ensured that water completed travel from the top to the bottom of the network. **Table H-2** lists stream geometry and general vegetation characteristics for the lower Nevada Creek model. About 8.5 percent of Elk Creek streambanks have woody vegetation. While the average low flow width is 8.9 feet, much of Elk Creek above Route 200 has a width of 5 feet or less. This accounts for roughly 5 miles of the total 6.1 miles of the stream length modeled.

Table H-2. Stream conditions for the Elk Creek SNTEMP model.

Stream	Modeling Period	Length (mi)	Average Low Flow Width (ft)	Average Bankline Vegetation (%)	Average Shade (%)
Elk Creek	July 23 - 24, 2006	6.2	8.9	8.5	19.9

Table H-3 lists data input into the model. For each segment and headwater node, flow, width, Manning's-n, and shade must be designated, while water temperature is required for headwater nodes. All other nodes require only water temperature and/or flow data.

Table H-3. Input data for the Elk Creek model

Stream	Segment	Node	Stream Mile	Water Temperature (F)	Flow (cfs)	Stream Width (ft)	Manning's n	Shade (%)	Comments
Elk Creek	Below Cap Wallace to Sunset Hill Rd	Headwater*	6.2	62.0	2.8	9.5	0.062	26.7	
		Diversion	6.0		0.4				Directly below Cap Wallace
		Calibration	3.6	67.0	2.5				At Sunset Hill Road
	Sunset Hill Rd to Route 200	Segment	3.4		2.5	8.4	0.062	12.0	
		Diversion	3.4		0.2				Directly below Sunset Hill Rd
		Calibration	1.2	71.7	2.3				At Route 200
	Route 200 to the Blackfoot Rive	Segment	1.1		2.3	8.5	0.062	19.2	
		Calibration	0.1	72.0	2.0				At mouth to Blackfoot River
		End	0.0		2.0				Blackfoot River

Meteorological data for the modeling period July 23 – July 24, 2006 were summarized and input into the model (**Table H-4**). These data are representative of hot and dry conditions that cause water temperature extremes. The average daily mean temperature, 77° F, represents a hot period in the summer of 2006.

Table H-4. Meteorological input data for the Elk Creek SNTEMP model

Modeling Period	Air Temperature (F) (mean)	Relative Humidity (%) (mean)	Wind (mph) (mean)	Possible Sun (%)	Dust Coefficient	Ground Reflectivity
July 23 - 24, 2006	77	43.2	3.3	90	0.05412	0.28110

Calibration

The Elk Creek model required a few iterations to complete calibration. The initial model run for Elk Creek simulated mean daily temperatures 3.17° F, 2.77° F, and 3.09° F greater than observed temperatures at the locations below Sunset Hill Rd, below Route 200, and at the mouth above the Blackfoot River, respectively (**Tables H-5 through H-7**). These differences between simulated and observed mean temperatures are not within the margin for calibration of 0.9° F, therefore calibration was necessary for the entire stream.

Meteorological data was least reliable in terms of characterizing conditions found on the stream, as the weather stations that provided data are located off the stream. To calibrate the model, relative humidity was decreased to 25 percent and sunshine was decreased to 85 percent. This resulted in mean daily temperatures below Route 200 and at the mouth that were within the 0.9° F margin for calibration. However, the simulated mean temperature at Sunset Hill Road was still too high. Increasing wind speed to 4 mph lowered temperatures further. This yielded simulated mean daily temperatures higher than observed temperatures by 0.79° F below Sunset Hill Road and lower by 0.54° F and 0.38° F below Route 200 and at the mouth, respectively. These values were within the margin for calibration for all sites.

To improve the model's performance for maximum temperature, Manning's n was increased from 0.062 to 0.080 for all segments in the model. Manning's n was adjusted because changes in this parameter only affect maximum temperatures in the model. The SNTEMP model uses the Manning's n parameter to capture the appropriate mixing depth and travel time of the stream. The result of changing Manning's n to 0.080 "speeds up" the stream and lowers simulated maximum temperature by 1.25° F at the mouth, 3.78 ° F above the observed maximum temperature. Further increases in Manning's n did not occur, however, as higher values for Manning's n are unrealistic. In addition, there is uncertainty in the capability of SNTEMP to predict daily maximum temperatures accurately (Bartholow, 2004).

Table H-5. Initial model and calibration results for Elk Creek at Sunset Hill Road

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	67.01	75.52	NA	NA	NA
Initial Model Run	70.18	81.81	3.17	6.29	Default Parameter Values
1	68.14	78.82	1.13	3.30	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85%
2	67.80	78.82	0.79	3.30	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85% Wind Speed Increase to 4.0 MPH
3	67.80	77.65	0.79	2.13	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85% Wind Speed Increase to 4.0 MPH Manning's n Increase to .08

Table H-6. Initial model and calibration results for Elk Creek at Route 200

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	71.71	80.13	NA	NA	NA
Initial Model Run	74.48	84.83	2.77	4.70	Default Parameter Values
1	71.76	81.05	0.05	0.92	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85%
2	71.17	79.63	-0.54	-0.50	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85% Wind Speed Increase to 4.0 MPH Manning's n Increase to .08

Table H-7. Initial model and calibration results for Elk Creek at the Blackfoot River

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	71.98	77.77	NA	NA	NA
Initial Model Run	75.07	85.57	3.09	7.80	Default Parameter Values
1	72.27	82.80	0.29	5.03	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85%
2	71.60	81.55	-0.38	3.78	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85% Wind Speed Increase to 4.0 MPH Manning's n Increase to .08
3	71.14	78.96	-0.84	1.19	Relative Humidity Decrease to 25%Percent Sunshine Decrease to 85%Wind Speed Increase to 4.0 Manning's n Increase to .08 Thermal Gradient Increased to 2.75

Upper Union Creek Model

The upper Union Creek model simulated temperatures on a 5.4-mile stretch of Union Creek from its headwaters downstream to Potomac Road. Below Potomac Road, Union Creek becomes dewatered. Therefore, modeling on Union Creek below this point was completed in a separate model beginning two miles downstream from Potomac Road. The Upper Union Creek model also includes a tributary, Washoe Creek, which extends for 0.9 miles upstream from its confluence with Union Creek.

Construction

The upper Union Creek model has one point source from a small tributary stream located a half mile downstream from the headwater of the model. This tributary increases flow in Union Creek from 1.2 to 2.4 cubic feet per second (CFS). A second tributary downstream, Washoe Creek, further augments flow by 1.1 CFS. Calibration points for Union Creek are located on Plum Creek Lumber property, above Washoe Creek, and at Potomac Road. Two water diversion points exist for Union Creek, one between the Plum Creek property boundary and Washoe Creek, and one below Washoe Creek.

Modeling of upper Union Creek is for the period July 29, 2006. **Table H-8** lists stream geometry and general vegetation characteristics for the upper Union Creek model. About 30.4 percent of Union Creek streambanks have woody vegetation. Upper Union Creek low flow widths are narrowest near the headwaters and widen to about seven feet by Potomac Road, resulting in an average low flow width of five feet.

Table H-8. Stream conditions for the Upper Union Creek SNTEMP model.

Stream	Modeling Period	Length (mi)	Average Low Flow Width (ft)	Average Bankline Vegetation (%)	Average Shade (%)
Upper Union Creek	July 29, 2006	8.5	5.0	30.4	47.2

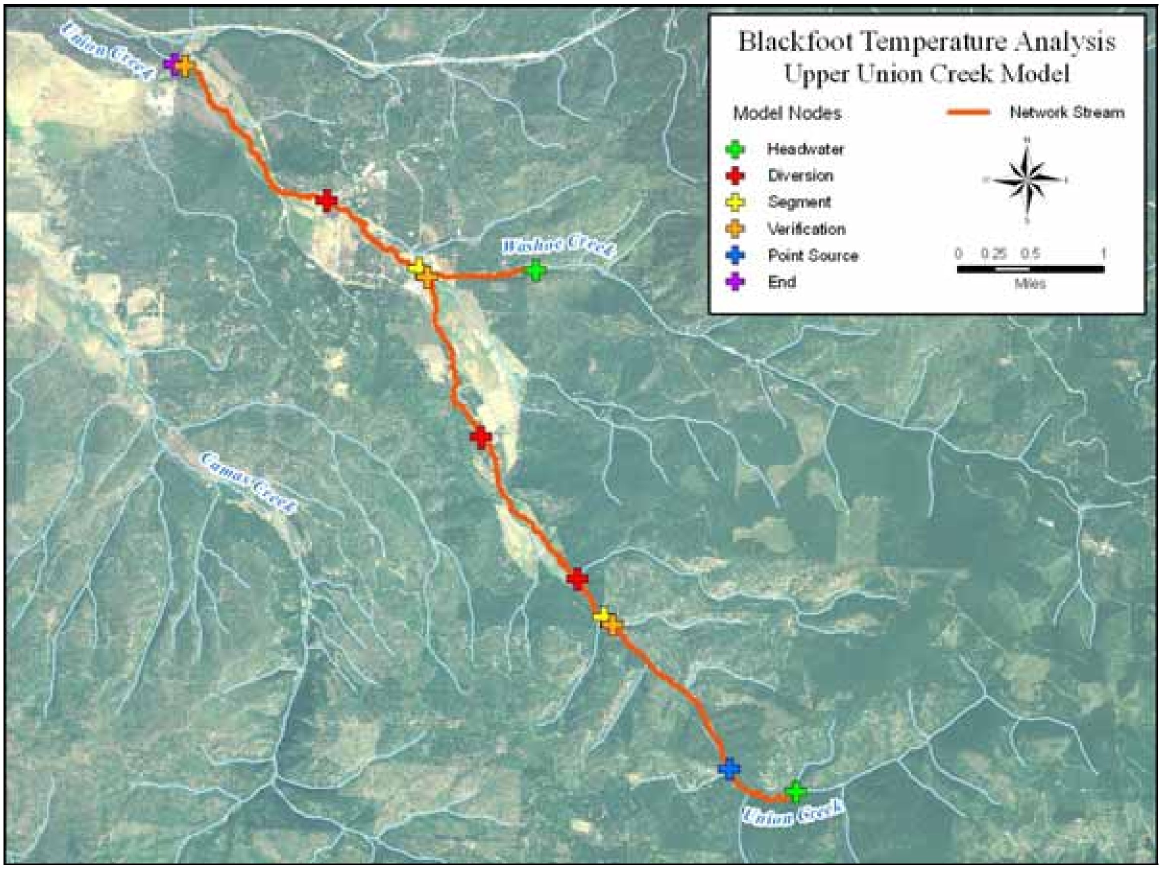


Figure H-2. Schematic of the Upper Union Creek model network and model nodes

Table H-9 lists data input into the model. For each segment and headwater node, flow, width, Manning’s-n, and shade must be designated, while water temperature is required for headwater nodes. All other nodes require only water temperature and/or flow data.

Table H-9. Input data for the Upper Union Creek model

Stream	Segment	Node	Stream Mile	Water Temperature (F)	Flow (cfs)	Stream Width (ft)	Manning's n	Shade (%)	Comments
Union Creek	Headwaters to Plum Creek Boundary	Headwater*	21.6	55.1	1.2	5.5	0.062	42.7	
		Point	21.0	55.4	1.2				Small Tributary near Headwaters
		Calibration	19.5	57.9	2.4				On Plum Creek Property
	Plum Creek to Confluence with Washoe Creek	Segment	19.4		2.4	2.5	0.062	61.7	
		Diversion	17.6		1.2				
		Calibration	16.3	57.7	1.2				Immediately above Washoe Creek
	Washoe Creek to Potomac Road	Segment	16.2		2.3	5.1	0.062	34.6	Confluence with Washoe Creek
		Diversion	15.1		1.8				
		Calibration	13.2	67.0	0.5				Above Potomac Road
		End	13.1		0.5				At Potomac Road
Washoe Creek	To the Mouth at Union Creek	Headwater*	17.1	62.8	1.1	4.2	0.062	30.0	One Mile above Confluence with Union Creek
		End	16.2		1.1				Confluence with Union Creek

Meteorological data for the modeling period July 29, 2006 were summarized and input into the model (**Table H-10**). The summarized data represent hot and dry conditions that cause water temperature extremes. The average daily mean temperature, 75° F, represents a hot period in the summer of 2006.

Table H-10. Meteorological input data for the Upper Union Creek SNTEMP model

Modeling Period	Air Temperature (F) (mean)	Relative Humidity (%) (mean)	Wind (mph) (mean)	Possible Sun (%)	Dust Coefficient	Ground Reflectivity
July 29, 2006	75	33	5.1	90	0.05514	0.28243

Calibration

The upper Union Creek model required little calibration. The initial model run for Union Creek simulated mean daily temperatures 2.66° F, 2.94° F, and 2.09° F greater than observed temperatures at the Plum Creek site, above Washoe Creek, and at Potomac Road, respectively (**Tables H-11 through H-13**). Therefore, calibration was required for the entire model.

To calibrate the model, relative humidity was decreased to 25 percent and sunshine was decreased to 80 percent. This resulted in mean daily temperatures at Potomac Road that were within the 0.9° F margin for calibration, 0.36° F lower than the observed temperature. However, the simulated mean temperature at the other two sites was still too high. Increasing wind speed to 6.7 mph lowered temperatures further, yielding simulated mean daily temperatures within the margin for calibration for all sites.

To improve the model's performance for maximum temperature, Manning's n was increased from 0.062 to 0.080 for the segment above the Plum Creek boundary in the model. The resulting "speeding up" of the stream lowered simulated maximum temperature by 1.19° F at Plum Creek, 6.53° F above the observed maximum temperature. Further increases in Manning's n were not input, as higher values for Manning's n are unrealistic and there is uncertainty in the capability of SNTEMP to predict daily maximum temperatures accurately (Bartholow, 2004).

Table H-11. Initial model and calibration results for Union Creek at Plum Creek Property

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	57.94	61.2	NA	NA	NA
Initial Model Run	60.60	72.63	2.66	11.43	Default Parameter Values
1	59.49	70.68	1.55	9.48	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80%
2	58.93	68.92	0.99	7.72	Relative Humidity Decrease to 23% Percent Sunshine Decrease to 75% Wind Speed Increase to 6.7 MPH
3	58.93	67.73	0.99	6.53	Relative Humidity Decrease to 23% Percent Sunshine Decrease to 75% Wind Speed Increase to 6.7 MPH Manning's n Increase to .08

Table H-12. Initial model and calibration results for Union Creek immediately above Washoe Creek

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	57.72	63.82	NA	NA	NA
Initial Model Run	60.66	68.56	2.94	4.74	Default Parameter Values
1	59.09	66.63	1.37	2.81	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80%
2	58.26	64.56	0.54	0.74	Relative Humidity Decrease to 23% Percent Sunshine Decrease to 75% Wind Speed Increase to 6.7 MPH

Table H-13. Initial model and calibration results for Union Creek at Potomac Rd

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	**Max**	**Mean**	**Max**	
Observed Temperature	67.01	79.68	NA	NA	NA
Initial Model Run	69.10	77.79	2.09	-1.89	Default Parameter Values
1	66.65	75.36	-0.36	-4.32	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 85%
2	66.36	75.09	-0.65	-4.59	Relative Humidity Decrease to 23% Percent Sunshine Decrease to 75% Wind Speed Increase to 6.7 MPH

Lower Union Creek Model

The lower Union Creek model simulated temperatures for an 11.1-mile stretch of Union Creek from the Hall property line below Potomac Road to the confluence with the Blackfoot River. Upstream from the Hall property line, from below Potomac Road downstream to where Union Creek initially crosses Route 200, Union Creek is dewatered. Replenishment of Union Creek occurs below Route 200 by groundwater recharge and a series of springs.

Construction

The lower Union Creek model has three different point sources contributing water throughout the network (**Figure H-3**). The first is a small spring located just downstream from the headwater of the model. This spring contributes relatively cold water at 52.7^{o} F, and doubles the flow in Union Creek from 0.9 cfs to 1.8 cfs. The second point source is Camas Creek, located 1.7 miles downstream from the headwater. Camas Creek contributes a significant amount of flow to Union Creek, increasing flow from 1.8 CFS to 4.2 CFS. The last point source is Ashby Creek and related return flow from irrigation activities, located about 2.2 miles downstream from the Camas Creek input. Calibration points for Union Creek are located at Route 200, at Morrison Road, and 0.3 miles above the mouth to the Blackfoot River. There are two water diversions present on lower Union Creek, both immediately below Morrison Road. These diversions remove a large proportion water from Union Creek, decreasing Union Creek flow from 4.2 CFS to 1.2 CFS.

Modeling of lower Union Creek is for the period July 22, 2006. **Table H-14** lists stream geometry and general vegetation characteristics for the lower Union Creek model. On average, about 12.1 percent of Union Creek streambanks have woody vegetation. Union Creek low flow widths average 9.2 feet, with some excessively widened sections present below Morrison Road.

Table H-14. Stream conditions for the Lower Union Creek SNTEMP model.

Stream	Modeling Period	Length (mi)	Average Low Flow Width (ft)	Average Bankline Vegetation (%)	Average Shade (%)
Upper Union Creek	July 22, 2006	11.1	9.2	12.1	25.9

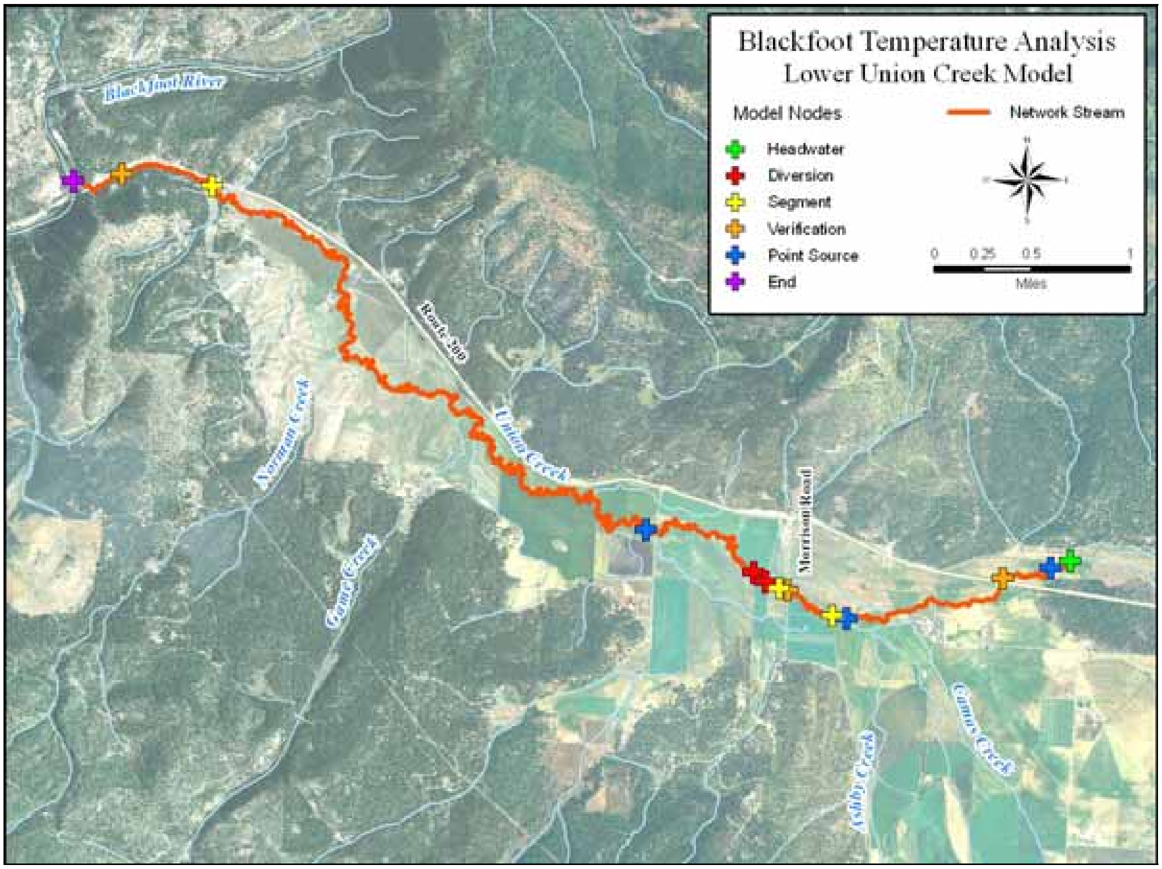


Figure H-3. Schematic of the Lower Union Creek model network and model nodes

Table H-15 lists data input into the model. For each segment and headwater node, flow, width, Manning’s-n, and shade must be designated, while water temperature is required for headwater nodes. All other nodes require only water temperature and/or flow data.

Table H-15. Input data for the Lower Union Creek model

Stream	Segment	Node	Stream Mile	Water Temperature (F)	Flow (cfs)	Stream Width (ft)	Manning's n	Shade (%)	Comments
Union Creek	Bill Hall's Land to Camas Creek	Headwater*	11.1	59.0	0.9	4.6	0.062	38.1	Bill Hall's Property Boundary
		Point	11.0	52.7	0.9				Spring on Hall's Land
		Calibration	10.5	56.7	1.8				At Route 200
		Point	9.4	60.4	2.3				Camas Creek Confluence
	Camas Creek to Morrison Road	Segment	9.4		4.2	8.6	0.062	28.7	
		Calibration	8.8	60.8	4.2				At Morrison Road
	Morrison Road to 0.8 Miles above Blackfoot River	Segment	8.8		4.2	9.5	0.062	23.8	At Morrison Road
		Diversion	8.7		1.5				
		Diversion	8.5		1.5				
		Point	7.2	68.0	0.2				Ashby Creek and Return Flow
	To Blackfoot River	Segment	0.8		1.4	16.2	0.062	18.9	Significant Change in Land Cover and Stream Morphology
		Calibration	0.3	74.0	1.4				
		End	0.0		1.4				Mouth to Blackfoot River

Meteorological data for the modeling period July 22, 2006 were summarized and input into the model (**Table H-16**). These data are representative of hot and dry conditions that cause water temperature extremes. The average daily mean temperature, 75^o F, represents a hot period in the summer of 2006.

Table H-16. Meteorological input data for the Lower Union Creek SNTEMP model

Modeling Period	Air Temperature (F) (mean)	Relative Humidity (%) (mean)	Wind (mph) (mean)	Possible Sun (%)	Dust Coefficient	Ground Reflectivity
July 22, 2006	75	33	2.3	90	0.05514	0.28243

Calibration

The lower Union Creek model required little calibration. The initial model run for Union Creek simulated mean daily temperatures 3.34^o F, 4.32^o F, and 3.78^o F greater than observed temperatures at Route 200, Morrison Road, and at the mouth, respectively (**Tables H-17 through H-19**).

To calibrate the model, relative humidity was decreased to 25 percent and sunshine was decreased to 80 percent. This resulted in mean daily temperatures that were still higher than actual measured temperatures. Increasing wind speed to 5.6 mph lowered temperatures further, yielding simulated mean daily temperatures within the margin for calibration for all sites.

To improve the model’s performance for maximum temperature, Manning’s n was increased from 0.062 to 0.080 for all segments in the model. The resulting “speeding up” of the stream lowers simulated maximum temperature at all sites. However, simulated temperatures are still higher than the margin for calibration. Further increases in Manning’s n did not occur for any of the segments in the model.

Table H-17. Initial model and calibration results for Union Creek at Route 200

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	56.7	62.26	NA	NA	NA
Initial Model Run	60.04	78.85	3.34	16.59	Default Parameter Values
1	59.40	76.95	2.70	14.69	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80%
2	57.40	69.89	0.70	7.63	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH
3	57.40	68.07	0.70	5.81	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH Manning's n - Increase to .80

Table H-18. Initial model and calibration results for Union Creek at Morrison Lane

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	60.78	68.36	NA	NA	NA
Initial Model Run	65.10	80.31	4.32	11.95	Default Parameter Values
1	63.36	77.85	2.58	9.49	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80%
2	61.18	71.38	0.40	3.02	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH
3	61.18	69.94	0.40	1.58	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH Manning's n - Increase to .80

Table H-19. Initial model and calibration results for Union Creek at the mouth to the Blackfoot River

Calibration Iteration	Temperature (F)		Difference from Observed Temp (F)		Parameter Changed
	Mean	Max	Mean	Max	
Observed Temperature	74.03	82.35	NA	NA	NA
Initial Model Run	77.81	88.32	3.78	5.97	Default Parameter Values
1	75.24	85.86	1.21	3.51	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80%
2	73.62	85.86	-0.41	3.51	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH
3	73.62	85.08	-0.41	2.73	Relative Humidity Decrease to 25% Percent Sunshine Decrease to 80% Wind Speed Increase to 5.6 MPH Manning's n - Increase to .80

APPENDIX I
DAILY TEMPERATURE LOADING

Daily Temperature Loading Approach

A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (**Equation I-1**). In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream.

Equation I-1. $\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}.$

Where:

ΣWLA = Waste Load Allocation = Pollutants from NPDES Point Sources
ΣLA = Load Allocation = Pollutants from Nonpoint Sources + Natural Sources
MOS = Margin of Safety

Total maximum daily loads are based on the loading of a pollutant to a water body. Federal Codes indicate that for each thermally listed water body the total maximum daily thermal load cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters. The following approach for setting numeric temperature TMDLs considers all of the factors listed above.

The numeric daily temperature TMDLs presented in this appendix apply to the temperature impaired waters in the Lower Blackfoot planning area that include Lower Elk Creek and Union Creek.

All waters in the Lower Blackfoot planning area are classified as B1. Montana's temperature standard for B1 classified waters is depicted in **Figure I-3**. An example of the temperature TMDL and instantaneous temperature load (ITL) application to a water body is provided at the end of this appendix.

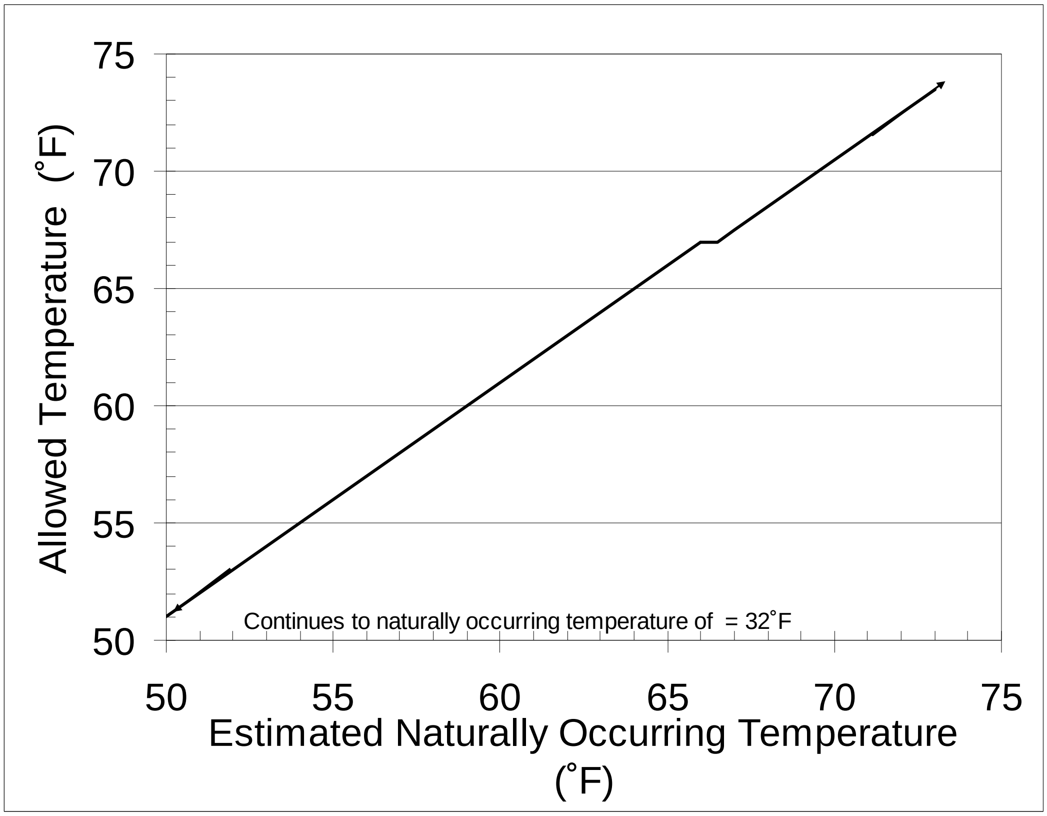


Figure I-3. In-Stream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

Daily Thermal Load

The allowed temperature can be calculated using Montana’s B1 classification temperature standards (**Figure I-3**) and using a modeled or estimated naturally occurring average daily temperature. The daily average total maximum load at any location in the water body is provided by **Equation I-2**. The daily allowable loading is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kilocalorie increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure I-3**.

Equation I-2

$$(\Delta-32)*(Q)*(1.36 \times 10^{6}) = \text{TMDL}$$

Where:

Δ = allowed temperatures from **Figure I-3** using any daily temperature condition
Q = average daily discharge in units of cubic feet per second (CFS)
TMDL = daily TMDL in Calories (kilocalories) per day above waters melting point
Conversion Factor = 1.36×10^{6}

There are no point sources, and therefore, no wasteload allocations in the Lower Blackfoot planning area. The TMDL load allocation for each stream is a combination of the 1.0 or 0.5 °F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The daily TMDL allocation is equal to the load allocation shared by all human-caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation I-3**.

Equation I-3

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(1.36 X 10^6)

Allowable Human Sources = (1°F)*(1.36 X 10^6)*(Discharge (CFS))

Instantaneous Thermal Load

Because of the dynamic temperature conditions during the course of a day, an instantaneous load is also provided for temperature. For temperature, the daily average thermal conditions are not always an effective indicator of impairment to fisheries. The heat of the day is usually the most stressful timeframe for salmonids and char. Also, in high altitudes, thermal impacts that heat during the day may produce advanced cooling conditions during the night so that the daily temperature fluctuations increase greatly with potentially significant negative impacts to fish without much impact on daily average temperature conditions. Therefore, Montana provides an instantaneous thermal load to protect during the hottest timeframes in mid to late afternoon when temperatures are most stressful to the fishery, which is the most sensitive use in reference to thermal conditions.

The instantaneous load is computed by the second. The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure I-3**) and using a modeled or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the water body is provided **Equation I-4**. The allowable loading over a second is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kCal increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure I-3**.

Equation I-4

(Δ-32)*(Q)*(15.7) = Instantaneous Thermal Load (ITL)

Where:

Δ = allowed temperatures from **Figure I-3** using daily temperature condition
Q = instantaneous discharge in CFS
ITL = Allowed thermal load per second in kilocalories per day above waters melting point
Conversion factor = 15.7

There are no point sources that increase water temperatures, and therefore, no wasteload allocations in the Lower Blackfoot planning area. The ITL load allocation for each stream is a combination of the 1.0 or 0.5 °F allowable loading shared between the human caused sources identified in the stream in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The ITL allocation is equal to the load allocation shared by all human caused sources plus the load allocated to naturally occurring temperatures as shown in **Equation I-5**.

Equation I-5

Load Allocation= Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios -32)*(Discharge (CFS))*(15.7)

Allowable Human Sources = (1°F)*(15.7)*(Discharge (CFS))

Numeric TMDL Application for Lower Elk Creek

Lower Elk Creek Daily Thermal Load Example Application

A calibrated SNTEMP thermal loading model was constructed for Lower Elk Creek. A model scenario used reference riparian shade conditions along the entire length of the stream to estimate naturally occurring temperatures. The monitoring and modeling effort is described **Sections 7.2.1 and 8.3.1**. Naturally occurring average daily temperature at the mouth of Elk Creek was estimated at 67°F. This temperature is used to determine the allowable temperature according to **Figure I-3**, Montana's temperature standard. The allowable mean daily temperature is estimated at 67.5°F. **Equation I-2** from above is used to calculate the Lower Elk Creek TMDL.

$(\Delta\text{-}32)*(Q)*(1.36\text{x}10^6) = \text{TMDL}$

Where:

Δ = allowed temperatures from **Figure I-3** using daily temperature condition = 67.5°F
Q = average daily discharge in units of cubic feet per second (CFS) = 2.5 cfs
TMDL = daily TMDL in Calories (kilocalories) per day above water's
melting point = $1.21\text{x}10^8$ kilocal/day.

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 0.5°F increase. The portion of the Lower Elk Creek TMDL represented by the 0.5°F allowable increase alone is:

$(0.5°\text{F})\ (2.5\ \text{cfs})\ (1.36\text{x}10^6) = 1.7 \text{ x } 10^6$ kilocalories per day

This portion of the TMDL is appropriated to the human caused sources combined that are identified in **Section 8.3.1** of the main document. The remainder of the TMDL is appropriated to naturally occurring thermal load that includes human sources with reasonable land, soil, and water conservation practices applied. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the TMDL is apportioned to naturally occurring thermal loading. Currently the daily total maximum daily load is not being met because the current temperature exceeds the naturally occurring temperature by more than 4°F.

The mean daily temperature of the site was 71.6.1°F, which equates to a thermal load of $2.43\text{x}10^8$ kilocal/day and exceeds standard and the TMDL when a daily averaged timeframe is considered. Because this site on Lower Elk Creek is not meeting Montana's temperature standard during an average daily condition, it exceeds the average daily TMDL. Montana's temperature standard is applied to any timeframe because no duration is provided in the standard. Therefore, we can also investigate the instantaneous thermal load. The instantaneous load will consider heating during the warm summer afternoons when the fishery is the most stressed.

Lower Elk Creek Instantaneous Thermal Load

The instantaneous thermal load (ITL) is described as the heat passing a monitoring location per second. The most sensitive timeframe for the fishery occurs during the heat of the day for the hottest period of the year. The same modeling described in this appendix was used to model daily maximum temperatures. The naturally occurring daily maximum temperature at the mouth of Lower Elk Creek was estimated at 74.6°F using a SNTEMP model. This temperature is used to determine the allowable temperature according to **Figure I-3**, Montana's temperature standard. Therefore, the allowable maximum temperature during this timeframe is estimated at 75.1°F (74.6°F plus an additional 0.5°F for this temperature range).

Equation I-4 from above is used to calculate the Lower Elk Creek ITL.

$(\Delta\text{-}32)*(Q)*(15.7) = \text{Instantaneous Thermal Load (ITL)}$

Where:
Δ = allowed temperatures from **Figure I-3** using daily temperature condition = 75.1°F
Q = average daily discharge in units of cubic feet per second (CFS) = 2.5cfs
ITL = Allowed thermal load per second in kilocalories per day above water's melting point = 2,948 kilocal/second

This load represents that from natural background sources, plus human caused sources where all reasonable land, soil, and water conservation practices area applied, plus the additional loading allowed by the 0.5°F increase. The portion of the Lower Elk Creek TMDL represented by the 0.5°F allowable increase alone is:

$$(0.5°\text{F})\ (2.5\text{ cfs})\ (15.7) = 20\text{ kilocal/second}$$

The Lower Elk Creek load allocation for the ITL is 2,948 kilocalories per second and is appropriated to all human caused sources combined that are identified in **Section 8.3.1** of the main document. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the load allocation for the ITL is apportioned to naturally occurring thermal loading.

The hottest temperature estimated for current conditions at this site was 81.6°F, which equates to a thermal load of 3,203 kilocal/sec. The temperature is above the State's temperature standard and the thermal load is above the allowable instantaneous load when considered during a one second timeframe. Because this site on Lower Elk Creek is not meeting Montana's temperature standard during a one second timeframe, the thermal load during a one second timeframe is also above the ITL. This scenario would also hold true for an hourly time step. This indicates that Montana's temperature standard at this site is not being met during an important timeframe for the most sensitive use.

Numeric TMDL Application for Union Creek

Similar calculations are made for each of the three modeled reaches of Lower Union Creek. The restoration temperature goals for each of the reaches (**Table 8-9)** and the reach flows (**Table H-15**) inserted into **Equation I-2** give the example Maximum Daily Thermal Loads in **Table I-1**.

Table I-1. Total Maximum Daily Thermal Loads for the Three Modeled Reaches of Lower Union Creek.

Modeled Reach	Allowable Temperature (°F)	Flow (cfs)	Maximum Daily Thermal Load (kcal/day)
Washoe Creek to Potomac Road	63.4	1.8	7.7×10^7
Potomac Road to Morrison Road	68.8	4.2	2.1×10^8
Morrison Road to Mouth	70.4	1.4	7.3×10^7

The high temperatures and low flows in the downstream-most segment make this the most temperature limiting portion of the stream. Achieving the maximum thermal load in the lowest reach would require mitigation of upstream thermal loading conditions. Therefore, the example temperature TMDL for Union Creek is stated as that for the most critical reach, or 7.3 X 10^7 kcal/day.

Modeled naturally occurring temperature conditions in Lower Union Creek are such that the temperature standard allows for a 0.5° increase. Using **Equation I-3**, the portion of the Union Creek TMDL represented by the 0.5°F allowable increase alone is:

$$(0.5°\text{F})\ (1.4\ \text{cfs})\ (1.36\text{x}10^6) = 1.2\ \text{x}\ 10^6\ \text{kilocalories per day}$$

Using **Equation I-4** from above, the example instantaneous total maximum load for the lowest reach of Union Creek is:

$$(70.4°\text{F}-32°\text{F})\ (1.4\ \text{cfs})\ (15.7) = 844\ \text{kcal/second.}$$

The portion of the Union Creek instantaneous total maximum load represented by the 0.5°F allowable increase alone is:

$$(0.5°\text{F})\ (1.4\ \text{cfs})\ (15.7) = 11\ \text{kcal/second}$$

APPENDIX J
CONSERVATION PRACTICES/BEST MANAGEMENT PRACTICES

The information presented in this appendix is intended to supplement the Restoration and Monitoring Plan for the Lower Blackfoot TMDL planning area (**Section 9**).

Conservation Practices/BMPS

The following is a list and description of conservation practices presented by Best Management Practice (BMP) category. These BMP categories correspond to the management recommendations and applicable treatments presented in **Section 9**. The majority of conservation practices come directly from the Natural Resource Conservation Service (NRCS) Field Office Technical Guide for Powell County and referenced by the NRCS practice standard number. Others sources of information are cited by name.

There are eight different BMP categories: Stream BMPs, Riparian Area BMPs, Upland BMPs, Grazing BMPs, Water Conservation BMPs, Forestry BMPs, Road BMPs, and Other Land Uses and BMPs. Each BMP category is described in terms of water quality impairments they are intended to address and how and where they can be applied. Each BMP category contains a list of several different conservation practices giving landowners and land managers numerous options for implementation.

Implementation of conservation practices should be determined on a site specific basis. Water quality restoration objectives as well as landowner or land manager objectives should be evaluated prior to implementation. The conservation practices have been categorized to assist in this evaluation. Multiple practices from multiple categories may be needed to meet management objectives. Additional practices not listed in this Appendix may also be applicable. NRCS practice standards, specifications, job sheets, and other information sources should be consulted prior to implementation to achieve maximum effectiveness.

For private landowners, cost-share and technical assistance resources for implementation of conservation practices are often available. A “resource guide” is included in this appendix following the discussion of the BMP categories. For public land managers, partnerships with local watershed groups, Conservation Districts, and other pubic agencies have proven to be an effective tool in implementing desired conservation practices.

Stream BMPs – these conservation practices/BMPs have the primary purpose of affecting sediment, habitat, and metals impairments. Nutrients attached to sediment, primarily phosphorous, and temperature impairments are also addressed by this group of practices. Stream BMPs focus specifically on the stream channel and address impairments caused by alteration of the stream channel through active channel restoration or manipulation. When applied these practices are intended to have the following effects:

1. Reduction in sediment (as well as sediment bound metals and nutrients) from bank erosion through restoration, protection, or stabilization of streambanks,

2. Improved or restored in-stream fish and aquatic habitat through the installation or restoration of habitat structures and features
3. Reduction in water temperatures through improved vegetation cover and improved or restored channel form (width to depth ratio)
4. Improvement or restoration of channel form and function
5. Improved capacity for sediment and flow conveyance

Stream BMPs include the following:

- **Open Channel (582) –** Constructing, improving, re-creating, or restoring a channel in which water flows with a free surface. This practice may be applied to support the re-establishment or improvement of a channel to accommodate flows; provide for riparian vegetation establishment and growth on the flood plain; reduce bed and bank erosion; improve flood plain function and stability; modify sediment transport; provide improved water quality and habitat for aquatic species and improved riparian habitat for upland species.
- **Stream Crossing (578) –** A stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. This practice applies to all land uses where an intermittent or perennial watercourse exists and a ford, bridge, or culvert type crossing is desired for livestock, people, and/or equipment. The purpose of this practice is to improve water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream; reduce streambank and streambed erosion; providing for flood flows; reducing risk of washout and subsequent delivery of fill material; facilitating aquatic life passage; and provide crossing for access to another land unit.
- **Stream Habitat Improvement and Management (395) –** Maintain, improve, or restore physical, chemical, and biological functions of a stream. This practice applies to streams where habitat deficiencies limit survival, growth, reproduction, and/or diversity of aquatic species in relation to the potential of the stream. The purpose of this practice is to provide suitable habitat for desired aquatic species and diverse aquatic communities; provide channel morphology and associated riparian characteristics important to desired aquatic species; and provide aesthetic values and recreation opportunities associated with stream habitats such as angling and fish viewing.
- **Fish Passage (396) –** Modification or removal of barriers that restrict or impede movement or migration or fish or other aquatic organisms. The purpose of this practice is to improve or provide upstream or downstream passage for desirable fish and aquatic organisms.
- **Streambank and Shoreline Protection (580) –** Treatments used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries. This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion where the problem can be solved with relatively simple structural measures (vegetation or upland erosion control practices). The purpose of this practice is to maintain the flow or storage capacity of the water body or to reduce the offsite or downstream effects of excessive sediment resulting from bank erosion; improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation; and to prevent, control, or minimize the loss of land or damage to land uses, or other facilities adjacent to the banks

including the protection of known historical, archeological, and traditional cultural properties.
- **Channel Stabilization (584) –** Measures used to stabilize the bed or bottom of a channel in the beds of existing or newly constructed channels, alluvial or non-alluvial, undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, by the installation of bank protection, or by the installation of upstream water control measures. The purpose of this practice is to maintain or alter channel bed elevation or gradient; modify sediment transport or deposition; and to manage surface water and groundwater levels in floodplains, riparian areas, and wetlands.
- **Grade Stabilization Structure (410) –** A structure used to stabilize the grade and control erosion in natural or artificial channels; prevent the formation or advance of gullies; and enhance environmental quality and reduce pollution hazards in areas where the concentration and flow velocity of water requires stabilization. Special attention shall be given to maintaining or improving habitat for fish and wildlife when applied.
- To maximize the efficacy of any Stream BMP, the concurrent implementation of one or several **Riparian Area BMPs** is recommended. Similarly, where Stream BMPs have been implemented in areas where either grazing or timber harvesting occurs, **Grazing BMPs** and **Forestry BMPs** are recommended.

Riparian Area BMPs – these conservation practices/BMPs have the primary purpose of affecting sediment, habitat, and temperature impairments. Nutrient impairments are indirectly addressed through implementation of these practices as are metals. Riparian Area BMPs focus on those areas adjacent to the stream channel and involve restoring vegetation communities. These practices are a more passive approach to restoration allowing the riparian areas and stream channel to recover over a period of time. Implementation is strongly encouraged in conjunction with Stream BMPs. Implementation of these practices is intended to have the following effects:

1. Reduction in sediment delivery (as well as sediment bound metals and nutrients) from bank erosion through stabilization or protection of streambanks
2. Reduction in sediment yield (as well as sediment bound nutrients and metals) from upland sources through increased filtering and infiltration capacity
3. Reduction in water temperatures through increased shading capabilities and reduction in water surface area
4. Improved or restored in-stream fish and aquatic habitat through the recruitment and retention of large woody debris
5. Improvement or restoration of channel form and function through streambank stabilization

Riparian Area BMPs include the following:
- **Channel Bank Vegetation (322) –** The purpose and definition of this practice is establishing and maintaining vegetative cover on channel banks, berms, spoils, and associated areas. The purpose of this practice is to stabilize channel banks and adjacent areas and reduce erosion and sedimentation; and to maintain or enhance the quality of the environment, including fish and wildlife habitat.
- **Fence (382) –** A constructed barrier to animals or people. This practice is applied on any area where management of animal or people movement is needed. This practice can

also be used to facilitate the application of other conservation practices as a means to control movement of animals and people.

- **Use Exclusion (472) –** The temporary or permanent exclusion of animals, people, or vehicles from an area. This practice can be applied on all land uses and can also be used to facilitate the application of other conservation practices. The purpose of this practice is to prevent, restrict, or control access to an area; maintain or improve the quantity and quality of natural resources; and minimize liability and human health concerns.
- **Riparian Forest Buffer (391) –** An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies. Riparian forest buffers are applied on areas adjacent to permanent or intermittent streams, lakes, ponds, and wetlands. They are not applied to stabilize streambanks or shorelines. The purpose of this practice is to create shade to lower or maintain water temperatures to improve habitat for aquatic organisms; create or improve riparian habitat and provide a source of detritus and large woody debris; reduce excess amounts of sediment, organic material, nutrients, and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow; reduce pesticide drift entering the water body; restore riparian plant communities; increase carbon storage in plant biomass and soils.
- **Riparian Herbaceous Cover (390) –** Grasses, grass-like plants and forbs that are tolerant of intermittent flooding or saturated soils and that are established or managed in the transitional zones between terrestrial and aquatic habitats. This practice is applicable in areas adjacent to perennial and intermittent watercourses or water bodies where the natural plant community is dominated by herbaceous vegetation; where riparian areas have been altered and the potential natural plant community has changed or converted to cropland, pastureland, rangeland, or other commercial/agricultural uses; and where channel and streambank stability is adequate to support this practice. Related purposes of this practice include improving and protecting water quality by reducing the amount of sediment and other pollutants, such as pesticides, organic materials, and nutrients in surface runoff as well as nutrients and chemicals in shallow groundwater flow; help stabilize streambanks and shorelines; provision of food, shelter, shading, substrate, access to adjacent habitats, nursery habitat and pathways for movement by resident and nonresident aquatic, semi-aquatic, and terrestrial organisms.
- **The Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA) –** see discussion under Forestry BMPs.
- When Riparian Area BMPs have been applied in areas where grazing and timber harvesting occur, it is strongly recommended that **Grazing BMPs** and **Forestry BMPs** are implemented to maximize the efficacy of riparian area conservation measures.

Upland BMPs – these conservation practices have the primary purpose of affecting nutrient and sediment impairments. These practices focus on upland areas which for the purposes of this document are defined as the area within 350 feet of streams and water bodies. The practices emphasize improving vegetation conditions in these upland areas. While most of these practices are tied to agricultural land uses, many can be applied to other land uses. Implementation of these practices is intended to have the following effects:

1. Reduced delivery of sediment, sediment bound nutrients, and sediment bound metals; and nutrients from upland soil erosion sources through improved upland vegetation conditions and increased filtering and infiltration capacity.

Upland BMPs include the following:

- **Conservation Cover (327) –** Establishing and maintaining permanent vegetative cover to protect soil and water resources and applies on land to be retired from agricultural production requiring permanent protective cover, and other lands needing permanent protective cover. The purpose of this practice is to reduce soil erosion and sedimentation; improve water quality; enhance wildlife habitat.
- **Critical Area Planting (342) –** Establishment of permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices and if left untreated could be severely damaged by erosion or sedimentation or could cause significant off-site damage. The purpose of this practice is to stabilize areas with existing or expected high rates of soil erosion by water or wind; restore degraded sites that cannot be stabilized through normal methods.
- **Filter Strip (393) –** A strip or area of herbaceous vegetation situated between cropland, grazing land, animal confinement areas, or disturbed land (including forest land) and environmentally sensitive areas such as streams or riparian areas. The purpose of this practice is to reduce sediment, particulate organics, and sediment absorbed contaminant loadings in runoff; to reduce dissolved contaminant loadings in runoff; to reduce sediment, particulate organics, and sediment absorbed contaminant loadings in surface irrigation tailwater; restore, create, or enhance herbaceous habitat for wildlife and beneficial insects; maintain or enhance watershed functions and values; utilize excess nutrients found in runoff water and groundwater; manage bacteria in runoff from livestock confinement areas
- **Forage Harvest Management (511) –** The timely cutting and removal of forages from the field as hay, green-chop or ensilage on all land uses where machine harvested forage is grown. The purpose of this practice is to optimize yield and quality of forage at the desired level; promote vigorous plant re-growth; maintain stand life; manage for the desired species composition; use forage plant biomass as a soil nutrient uptake tool; control insects, diseases, and weeds; maintain and/or improve wildlife habitat.
- **Grazing Land Mechanical Treatment (548) –** Modifying physical soil and/or plant conditions with mechanical tools by treatments such as pitting, contour furrowing, and ripping or sub-soiling. This practices may be applied on pasturelands, rangeland, grazed forest, and native pastures where slopes are less than 15 percent for the purposes of fracturing compacted soil layers and improve soil permeability; reduce water runoff and increase infiltration; renovate and stimulate plant community for greater productivity yield.
- **Heavy Use Area Protection (561) –** The stabilization of areas frequently and intensively used by people, animals, or vehicles by establishing vegetative cover, by surfacing with suitable materials, and/or by installing needed structures in agricultural, recreational, urban, or other frequently and intensively used areas requiring treatment to address one or more resource concerns. The purpose of this practice is to reduce soil

erosion; improve water quantity and quality; improve livestock health; improve air quality; improve aesthetics.

- **Nutrient Management (590) –** Managing the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments where applied. The purpose of this practice is to budget and supply nutrients for plant production; properly utilize manure or organic by-products as a plant nutrient source; minimize agricultural nonpoint source pollution of surface and groundwater resources; maintain or improve the physical, chemical, and biological condition of soil; and protect air quality by reducing nitrogen emissions and the formation of atmospheric particulates.
- **Pasture and Hay Planting (512)** – Establishing native or introduced forage species where forage production and/or conservation are needed and feasible. The purpose of this practice is to establish adapted and compatible species, varieties, or cultivars for forage production; improve or maintain livestock nutrition and/or health; balance forage supply and demand during periods of low forage production; reduce soil erosion and improve water quality; provide food and cover for wildlife; improve soil quality/health; and increase carbon sequestration.
- **Range Planting (550) –** Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees on rangeland, native or naturalized pasture, grazed forest, or other suitable locations where the principal method of vegetation management will be herbivores and where desirable vegetation is below the acceptable level for natural reseeding or grazing management is unsatisfactory. The purpose of this practice is to restore a plant community similar to its historic climax or the desired plant community; provide or improve forages for livestock; provide or improve forage, browse, or cover for wildlife; reduce erosion by wind and/or water; improve water quality and quantity; and increase carbon sequestration.
- **Upland Wildlife Habitat Management (645) –** Provide and manage upland habitats and connectivity within the landscape for wildlife. Treating upland wildlife habitat concerns identified during the conservation planning process that enable movement, or provide shelter, cover, food in proper amounts, locations and times to sustain wild animals that inhabit uplands during a portion of their life cycle.
- **Wetland Restoration (657) –** The rehabilitation of a degraded wetland or the re-establishment of a wetland so that soils, hydrology, vegetative community and habitat are in close approximation of the original natural condition that existed prior to modification to the extent practicable. The purpose of this practice is to restore wetland function, value, habitat diversity, and capacity by restoring hydric soils, restoring hydrology (depth duration and season of inundation, and/or duration and season of soil saturation), and restoring vegetation (including the removal of undesired species, and/or seeding or planting of desired species).
- **Integrated Weed Management –** The control of noxious and invasive weed species of foreign origin that directly or indirectly adversely impact agriculture, navigation, fish and wildlife, or public health. Integrated weed management involves the use of several control techniques in a well planned, coordinated, and organized strategy to reduce the impacts of weeds. Strategies include chemical, biological, and cultural control methods (Blackfoot Challenge, Draft 2006). **Pest Management (595)** is also applicable to weed management.

Grazing BMPs – these conservation practices have the primary purpose of affecting sediment, habitat, nutrient, and temperature impairments. Where livestock are present, Grazing BMPs can be implemented to reduce impacts to resources and sensitive areas while improving forage conditions for livestock. Where grazing occurs (i.e. irrigated or dry pastures, upland areas, or forests) implementation of these BMPs is highly recommended. Implementation of Grazing BMPs is strongly encouraged in areas where other conservation practices/BMPs (**Stream BMPs, Riparian Area BMPs, Upland BMPs**) have been implemented and where grazing occurs. Implementation of these practices is intended to have the following effects:

1. Reduction in sediment delivery (as well as sediment bound metals and nutrients) from bank erosion through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
2. Improved in-stream fish and aquatic habitat through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
3. Improvement of channel form and function through controlling the timing, intensity, duration, and frequency of grazing in sensitive areas
4. Reduction in sediment (and sediment bound nutrients and metals) and nutrient yield from upland sources through improved upland and riparian vegetation conditions, increased filtering and infiltration capacity; and uniform utilization of upland and riparian vegetation by livestock
5. Reduction in water temperatures through improved riparian vegetation conditions and increased shading capabilities

Grazing BMPs include the following:

- **Prescribed Grazing (528) –** Managing the controlled harvest of vegetation with grazing animals on all lands where grazing animals are managed. The purpose of this practice is to improve or maintain the health and vigor of plant communities; improve or maintain quantity and quality of forage for livestock health and productivity; improve or maintain water quality and quantity; reduce accelerated erosion, and maintain or improve soil condition; improve or maintain the quantity and quality of food and/or cover available for wildlife; promote economic stability through grazing land sustainability. Specific activities associated with prescribed grazing include:
- Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species. Maintain adequate vegetative cover to prevent accelerated soil erosion, protect stream banks and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants. (**Best Management Practices for Grazing in Montana, MT DNRC 1999**; NRCS 2002)
    - Create riparian buffer exclosures (**Use Exclusion – 472**) through fencing (**Fence – 382**) or develop riparian pastures to be managed as a separate unit through fencing. Fencing should be incorporated only where necessary. Water gaps can be included in riparian fencing. (MT DNRC 1999)
    - Ensure adequate residual vegetative cover and regrowth and rest periods. Periodically rest or defer riparian pastures during the critical growth period of plant species. (MT DNRC 1999, Mosely et. al. 1997)

- Distribute livestock to promote dispersion and decomposition of manure and to prevent the delivery of manure to water sources. (MT DNRC 1999)
- Provide off-site high quality water sources (MT DNRC 1999). **Watering Facility (614) –** A trough or tank installed to provide livestock watering facilities supplied from spring, reservoir, well, or other sources where there is a need for new or improved watering places to permit the desired level of grassland management, to reduce health hazards for livestock and to reduce livestock waste in streams. The purpose of this practice is to protect vegetative cover through proper distribution of grazing or through better grassland management for erosion control; reduce or eliminate the need for livestock to be in streams, which reduces livestock waste there. **Pipeline (516), Spring Development (574),** and **Water Well (642)** are also applicable practices for off-site water sources.
- Periodically rotate feed and mineral sites. Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing). Keep salt in troughs and locate salt and minerals in areas where soils are less susceptible to wind or water erosion. (MT DNRC 1999, Mosely et. al. 1997)
- Create hardened stream crossings for livestock to reduce the number of crossing areas and reduce erosion at crossings. (MT DNRC 1999)
- Encourage the growth of woody species (willow, alder, etc.) along the stream bank, which will limit animal access to the stream and provide root support to the bank. (MT DNRC 1999)
- Alternate season of use from year to year in a given allotment or pasture. Time grazing to reduce impacts based on limiting factors for system recovery. For example, early spring use can cause trampling and compaction damage when soils and stream banks are wet. Fall and early winter grazing can encourage excessive browse on willows. (MT DNRC 1999, NRCS 2002).
- **Animal Trails and Walkways (575) –** A travel facility for livestock and/or wildlife to provide movement through difficult or ecologically sensitive terrain such as steep rough terrain, across rock outcrops, through dense timber or brush, over lava beds, on marsh rangelands, and grazing lands susceptible to overflow by water. The purpose of this practice is to provide or improve access to forage, water, and/or shelter; improve grazing efficiency and distribution; and divert travel away from ecologically sensitive and/or erosive sites.
- Monitor livestock forage use and adjust strategy accordingly. (MT DNRC 1999)
- **Range Planting (550) –** Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees on rangeland, native or naturalized pasture, grazed forest, or other suitable locations where the principal method of vegetation management will be herbivores and where desirable vegetation is below the acceptable level for natural reseeding or grazing management is unsatisfactory. The purpose of this practice is to restore a plant community similar to its historic climax or the desired plant community; provide or improve forages for livestock; provide or improve

forage, browse, or cover for wildlife; reduce erosion by wind and/or water; improve water quality and quantity; and increase carbon sequestration.

Water Conservation BMPs – these conservation practices/BMPs have the primary purpose of affecting temperature, flow, and habitat impairments. Nutrient and sediment impairments are also addressed through these practices but to a lesser extent. These practices promote water conservation and improving water use efficiency to meet in-stream flow needs of water quality beneficial uses while providing sufficient water for agricultural and industrial production. Implementation of these BMPs in intended to have the following effects:

1. Reduction in water temperatures through increased in-stream flows
2. Improved capacity for sediment and flow conveyance
3. Improved in-stream fish and aquatic habitat through maintenance of in-stream flows
4. Improved migration capabilities of fish and other aquatic species through the maintenance of in-stream flows
5. Reduction in water temperature through reduced tailwater/return flows through increased efficiency in water application
6. Reduced delivery of sediment, sediment bound nutrients, and nutrients from overland flow through increased efficiency in water application

Water Conservation BMPs include the following:

- **Water Banking (Blackfoot Challenge 2003)** – A water bank is simply an administrative mechanism by which water users may trade water among themselves in a given drainage. Water banks transfer water, not water rights. The “Temporary Change in Appropriation Right” provisions (85-2-407 MCA 2001) were developed in response to drought conditions in 1989. Again, relying upon the concept and criteria found in the Change of Appropriation Water Right section, this allows a water right holder to move his right temporarily to a new use, new user or new place of use and automatically revert to its original operation at the end of the temporary use. Although this section cannot be utilized to provide for instream flow it may be an effective water conservation and water efficiency tool, especially as linked to low water planning.
- **Leasing Water Rights and/or Converting Water Rights to In-Stream Flows (Blackfoot Challenge 2003)** – Sections 85-2-407 MCA, 85-2-408, MCA, 85-2-436, MCA and 85-2-439, MCA all allow for the temporary transfer of water rights. The last three of these provide for the transfer of water rights from a consumptive use to instream flows to protect the fishery resource. An appropriator may make a temporary change by simply changing the purpose and place of use, or by leasing the water right to another party. The instream leasing programs are all statutes operating under a sunset provision. Also, temporary changes can only be granted for a term not exceeding ten years or thirty years, if water is made available by a storage or conservation project. Water leasing/conversion are affect tools for supplementing and maintaining in-stream flows. Channel restoration and in-stream habitat improvements (**Stream BMPs**) used in conjunction with water leasing/conversion can greatly enhance results.
- **Irrigation Water Management (449)** – determining and controlling the volume, frequency, and application of water in a planned, efficient manner to manage soil moisture to promote desired crop response; optimize use of available water supplies;

minimize irrigation induces soil erosion; decrease non-point source pollution of surface and groundwater resources; manage salts in the crop root zone; and manage air, soil, or plant micro-climate. Irrigation Land Leveling (464) and Land Smoothing (466) which involve reshaping land surface can also be used to increase water application efficiency.

- **Irrigation Water Conveyance (Blackfoot Challenge 2003, NRCS 2007) –** Ditches and canals serve as integral parts of irrigation water distribution or conveyance systems. Ditches and canals can be lined with a variety of materials including Flexible Membrane (428B), Nonreinforced Concrete (428A), fabrics, polymers (Anionic Polyacrylamide: PAM (450)), chemicals or clay to improve management of irrigation water, prevent waterlogging of land; maintain water quality; prevent erosion; and reduce water loss. Clearing and Snagging (326) or removal of snags, drifts, or other obstructions can increase flow capacity of a ditch or canal as well. Pipelines (430AA, 430BB, 430CC, 430DD, 430EE, 430FF, 430GG, 430HH) are also used in irrigation water conveyance to prevent erosion or loss of water quality or damage to land; make possible proper water use; and reduce water conveyance losses.
- **Irrigation System Efficiency (Blackfoot Challenge 2003, NRCS 2007) –** Improving irrigation system efficiency is intended to efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment. Irrigation water management (449) can improve water use efficiency. In some cases however, improvements to infrastructure is also necessary. The most common change in irrigation infrastructure is conversion of flood or wheel-line irrigation systems to low pressure center pivot or sprinkler systems (442). Where these systems already exist, regular maintenance and replacement of worn equipment can maintain the intended system efficiency. Where center pivot or sprinkler systems are not feasible, additional surface and subsurface water-control structures can be installed for the efficient distribution of water (443 and 587).

Forestry BMPs – The Montana Department of Natural Resources and Conservation (MT DNRC) is charged with providing landowners and operators in Montana with information on BMPs that have been adopted to minimize non-point source water pollution from forest practices such as timber harvesting through preventing erosion and reducing delivery of sediment to streams. MT DNRC is also charged with monitoring the application and effectiveness of those BMPs. Two documents guide Forestry BMPs in Montana:

- **The Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA) –** prohibits certain timber harvest activities within at least 50 feet of any stream, lake, or other water body including broadcast burning; operating wheeled are tracked vehicles except on established roads; clear cutting; constructing roads in the SMZ except when necessary to cross a stream or wetland; handling, storing, applying, or disposing of hazardous or toxic material in a manner that pollutes streams, lakes, or wetlands or that may cause damage or injury to humans, land, animals, or plants; casting road material into a stream, wetland, or watercourse; depositing slash in streams or other water bodies. This law must be followed for all commercial timber harvest activities. MT DNRC must approve any exceptions to these prohibited activities. While the law is intended to guide commercial timber harvesting activities in streamside areas, the principles behind the law (riparian area protection) can be applied to numerous land management activities (i.e. timber harvest for personal use, agriculture, development). This plan promotes the use of SMZ practices across all land ownerships and streamside management activities.

- **Best Management Practices for Forestry in Montana** (MT DNRC/MT BMP Work Group – January 2006) – are a voluntary set of practices recommended for timber harvest activities outside of SMZs. These BMPs cover timber harvesting and site preparation, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. The Montana Logging Association and MT DNRC offer regular Forestry BMP training sessions for private landowners and contract loggers. **Water Quality BMPs for Montana Forests** (MSU, 2001) is another excellent resource for information on forestry related BMPs.

In addition to these guiding documents, forestry related conservation practices described by NRCS include:

- **Prescribed Forestry (490) –** Managed forested areas for health, wood, and/or fiber, recreation, water, aesthetics, wildlife, habitat, and plant biodiversity. The purpose of this practice is to maintain or improve forest health, protect soil quality and condition, maintain or enhance water quality and quantity; maintain or improve forest productivity; maintain or improve plant diversity; improve aesthetic and recreational values; improve wildlife habitat; and achieve or maintain a desired understory plant community for forest products, grazing, and browsing. Prescribed Burning (338) can also be used as part of a forest management plan.

Road BMPs – Road BMP guidance is contained in the **Best Management Practices for Forestry in Montana** (MT DNRC/ MT BMP Work Group – January 2006). These BMPs are voluntary and are related to road construction and maintenance for timber harvesting activities but can generally be applied to all roads. Road related BMPs covered include planning and location, design, road drainage, construction, maintenance, stream crossings, and road construction and harvesting considerations. These BMPs were designed to limit sediment delivery from roads to streams, limit impacts of roads on stream habitat and water temperatures, and to maintain fish passage and migration corridors. Road construction is also addressed in the **Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA)** which prohibits constructing roads in the SMZ except when necessary to cross streams or wetlands. **Water Quality BMPs for Montana Forests** (MSU, 2001) contains additional road related BMP information.

Other Land Uses and Best Management Practices – Grazing, Forestry, Water Conservation, and Road BMPs described in this Appendix cover the primary land uses in the Lower Blackfoot planning area affecting water quality. Mining and residential/commercial development are less prevalent in these planning areas but still warrant some discussion.

- **Mining –** Historically mining played a larger role in the development and economy of the Blackfoot watershed. Current mining activities are fairly minimal (although many residual effects still linger), however, the potential for new mining activities is always present. All new mining activities must be approved through a permit authorized by the Montana Department of Environmental Quality. The standards and requirements set by these permits provide protection or mitigation of water quality degradation as a result of new mining activities.

- **Residential/Commercial Development –** On a whole the Blackfoot watershed remains largely rural and undeveloped. Development has and will continue to increase over time and left unguided can significantly impact water quality. The Montana Non Point Source Management Plan (2007) speaks to controlling non-point source pollution from development. While the recommended BMPs focus more on an urban setting, the practices described (floodplain buffers, setbacks, conservation easements, etc) can generally be applied to all development activities and should be considered especially when sensitive areas and/or water quality are of concern.

Resource Guide

The following is a list of resource contacts for private landowners. These organizations can provide assistance to landowners interested in conservation planning or conservation practice implementation.

Blackfoot Challenge
Contact: Brian McDonald
Phone: (406) 793-3900
Email: brian@blackfootchallenge.org
Web: www.blackfootchallenge.org

Big Blackfoot Chapter of Trout Unlimited (BBCTU)
Contact: Ryen Aashiem
Phone: (406) 543-6454
Email: ryen@montanatu.org

Montana Fish, Wildlife, and Parks
Contact: Ron Pierce
Phone: (406) 542-5532
Email: rpierce@mt.gov
Web: www.fwp.mt.gov

North Powell Conservation District
Contact: Brad Weltzien
Phone: (406) 244-4420
Email: weltzienb@yahoo.com

Missoula County Conservation District
Contact: Tara Comfort
Phone: (406) 829-3395 Ext. 113
Email: tara.comfort@mt.nacdnet.net

U.S. Fish & Wildlife Service
Contact: Greg Neudecker
Phone: (406) 793-7400
Email: greg_neudecker@fws.gov
Web: http://ecos.fws.gov/partners/viewContent.do?viewPage=home

Natural Resources Conservation Service – Missoula
Contact: John Bowe
Phone: (406) 829-3395 Ext. 121
Email: john.bowe@mt.usda.gov
Web: www.mt.nrcs.usda.gov

APPENDIX K
EXAMPLE OF DAILY SEDIMENT TMDLS, BELMONT CREEK

As described in **Section 8.1.8**, a current annual sediment load of 1,068 tons per year was estimated for Belmont Creek. This value is the sum of 510 tons from hillslope erosion 83 tons from bank erosion, 241 tons from road surface erosion, and 234 tons from culvert failure. **Figure K-1** below illustrates the current and total maximum daily sediment loading for Belmont Creek.

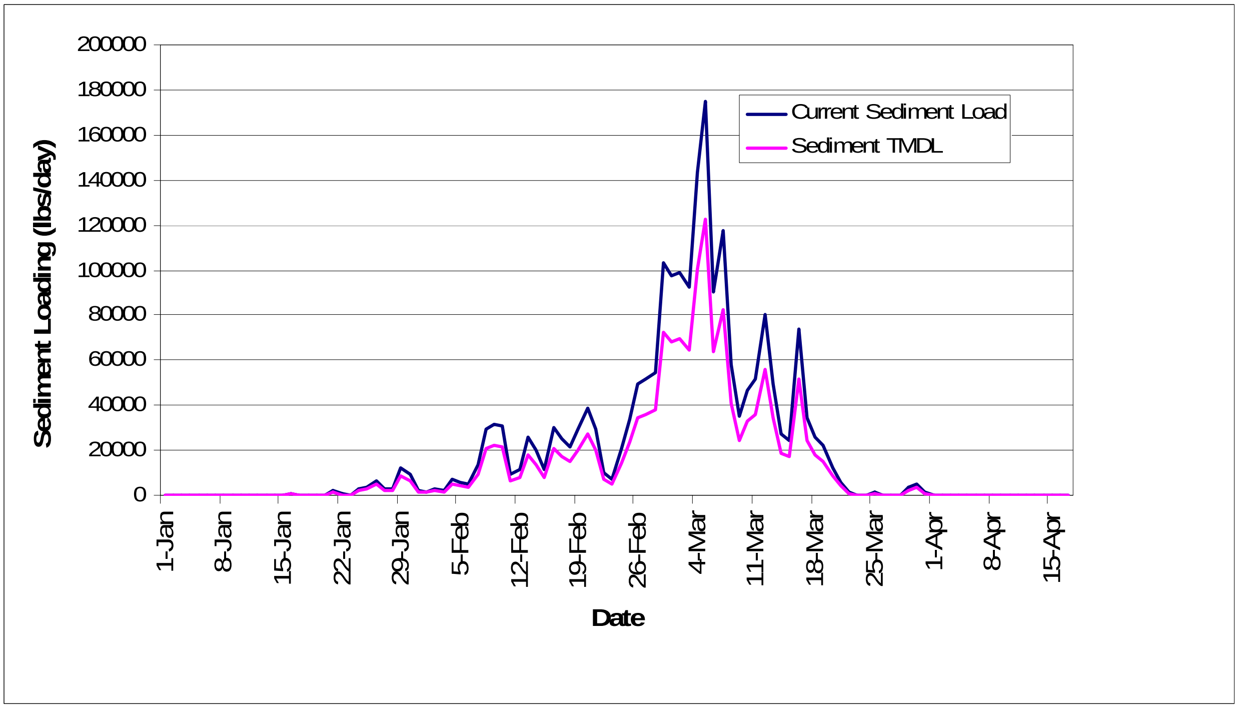


Figure K-1. Current and Maximum Daily Sediment Loading For Belmont Creek

The sediment TMDL for upper Nevada Creek is a 30 percent reduction in annual loading. The reduction is allocated to each of four land use categories as specified in **Table 8-6**. To satisfy the requirement for daily loads and allocations, the reduction in sediment loading needed each day is calculated for each of the five land use categories according to the values in **Table 8-6. Table K-1** below contains the daily sediment load reductions allocated to each land use category. **Table K-1** serves as an example of daily load reductions allocated to land uses. Daily sediment reduction allocations for other sediment impaired streams and land uses can be produced in a similar fashion. The upper Nevada Creek example is used here to demonstrate the daily allocation process while saving the material costs required for such a table for each of the remaining 30 sediment impaired streams.

Table K-2 contains example TMDLs and land use allocations for the remaining eight sediment impaired stream segments. For each segment the TMDLs and allocations are given for mid-winter, peak runoff, and mid-summer dates.

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	0	0	0
59	0	0	0	0	0	0
60	0	0	0	0	0	0
61	0	0	0	0	0	0
62	0	0	0	0	0	0
63	0	0	0	0	0	0
64	0	0	0	0	0	0
65	0	0	0	0	0	0
66	0	0	0	0	0	0
67	0	0	0	0	0	0
68	0	0	0	0	0	0
69	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	0	0	0	0	0	0
73	0	0	0	0	0	0
74	0	0	0	0	0	0
75	0	0	0	0	0	0
76	0	0	0	0	0	0
77	0	0	0	0	0	0
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	0	0	0	0	0	0
81	0	0	0	0	0	0
82	0	0	0	0	0	0
83	0	0	0	0	0	0
84	0	0	0	0	0	0
85	0	0	0	0	0	0
86	0	0	0	0	0	0
87	0	0	0	0	0	0
88	0	0	0	0	0	0
89	3	1	0	0	0	1
90	956	287	40	1	17	227
91	237	71	10	0	4	56
92	56	17	2	0	1	13
93	13	4	1	0	0	3
94	25	8	1	0	0	6
95	1879	564	79	2	34	445
96	510	153	21	0	9	121
97	287	86	12	0	5	68
98	3209	963	135	3	58	760
99	3778	1133	159	3	68	895
100	6697	2009	281	6	121	1587
101	2877	863	121	3	52	682
102	2711	813	114	2	49	642
103	12286	3686	516	11	221	2912
104	9082	2725	381	8	163	2152

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
105	2118	635	89	2	38	502
106	1579	474	66	1	28	374
107	2935	880	123	3	53	696
108	2118	635	89	2	38	502
109	7311	2193	307	7	132	1733
110	5826	1748	245	5	105	1381
111	5162	1548	217	5	93	1223
112	13298	3989	559	12	239	3152
113	29740	8922	1249	27	535	7048
114	31357	9407	1317	28	564	7432
115	30917	9275	1299	28	557	7327
116	9565	2870	402	9	172	2267
117	11385	3416	478	10	205	2698
118	25634	7690	1077	23	461	6075
119	19836	5951	833	18	357	4701
120	11545	3463	485	10	208	2736
121	29782	8935	1251	27	536	7058
122	24889	7467	1045	22	448	5899
123	21424	6427	900	19	386	5078
124	29101	8730	1222	26	524	6897
125	38762	11629	1628	35	698	9187
126	29144	8743	1224	26	525	6907
127	9819	2946	412	9	177	2327
128	7115	2135	299	6	128	1686
129	20808	6243	874	19	375	4932
130	34040	10212	1430	31	613	8067
131	49608	14882	2084	45	893	11757
132	51686	15506	2171	47	930	12249
133	54602	16381	2293	49	983	12941
134	103172	30952	4333	93	1857	24452
135	97605	29281	4099	88	1757	23132
136	99014	29704	4159	89	1782	23466
137	92135	27641	3870	83	1658	21836
138	143287	42986	6018	129	2579	33959
139	175243	52573	7360	158	3154	41533

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
140	90677	27203	3808	82	1632	21491
141	117833	35350	4949	106	2121	27926
142	57926	17378	2433	52	1043	13728
143	35176	10553	1477	32	633	8337
144	46774	14032	1965	42	842	11085
145	51665	15500	2170	46	930	12245
146	80047	24014	3362	72	1441	18971
147	49135	14741	2064	44	884	11645
148	26948	8084	1132	24	485	6387
149	24295	7288	1020	22	437	5758
150	73864	22159	3102	66	1330	17506
151	34668	10400	1456	31	624	8216
152	25949	7785	1090	23	467	6150
153	21890	6567	919	20	394	5188
154	12426	3728	522	11	224	2945
155	5875	1762	247	5	106	1392
156	1491	447	63	1	27	353
157	357	107	15	0	6	85
158	86	26	4	0	2	20
159	1282	384	54	1	23	304
160	298	89	13	0	5	71
161	70	21	3	0	1	17
162	17	5	1	0	0	4
163	3268	981	137	3	59	775
164	4846	1454	204	4	87	1148
165	1107	332	46	1	20	262
166	259	78	11	0	5	61
167	62	19	3	0	1	15
168	15	4	1	0	0	4
169	4	1	0	0	0	1
170	1	0	0	0	0	0
171	0	0	0	0	0	0
172	0	0	0	0	0	0
173	0	0	0	0	0	0
174	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
175	0	0	0	0	0	0
176	0	0	0	0	0	0
177	0	0	0	0	0	0
178	0	0	0	0	0	0
179	0	0	0	0	0	0
180	0	0	0	0	0	0
181	0	0	0	0	0	0
182	0	0	0	0	0	0
183	0	0	0	0	0	0
184	0	0	0	0	0	0
185	0	0	0	0	0	0
186	0	0	0	0	0	0
187	0	0	0	0	0	0
188	0	0	0	0	0	0
189	0	0	0	0	0	0
190	0	0	0	0	0	0
191	0	0	0	0	0	0
192	0	0	0	0	0	0
193	0	0	0	0	0	0
194	0	0	0	0	0	0
195	0	0	0	0	0	0
196	0	0	0	0	0	0
197	0	0	0	0	0	0
198	0	0	0	0	0	0
199	0	0	0	0	0	0
200	0	0	0	0	0	0
201	0	0	0	0	0	0
202	0	0	0	0	0	0
203	0	0	0	0	0	0
204	0	0	0	0	0	0
205	0	0	0	0	0	0
206	0	0	0	0	0	0
207	0	0	0	0	0	0
208	0	0	0	0	0	0
209	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
210	0	0	0	0	0	0
211	0	0	0	0	0	0
212	12	3	0	0	0	3
213	3	1	0	0	0	1
214	1	0	0	0	0	0
215	0	0	0	0	0	0
216	0	0	0	0	0	0
217	0	0	0	0	0	0
218	0	0	0	0	0	0
219	0	0	0	0	0	0
220	0	0	0	0	0	0
221	0	0	0	0	0	0
222	0	0	0	0	0	0
223	0	0	0	0	0	0
224	0	0	0	0	0	0
225	0	0	0	0	0	0
226	0	0	0	0	0	0
227	0	0	0	0	0	0
228	0	0	0	0	0	0
229	0	0	0	0	0	0
230	0	0	0	0	0	0
231	0	0	0	0	0	0
232	0	0	0	0	0	0
233	0	0	0	0	0	0
234	0	0	0	0	0	0
235	0	0	0	0	0	0
236	0	0	0	0	0	0
237	0	0	0	0	0	0
238	0	0	0	0	0	0
239	0	0	0	0	0	0
240	0	0	0	0	0	0
241	0	0	0	0	0	0
242	0	0	0	0	0	0
243	0	0	0	0	0	0
244	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
245	0	0	0	0	0	0
246	0	0	0	0	0	0
247	0	0	0	0	0	0
248	0	0	0	0	0	0
249	0	0	0	0	0	0
250	28	8	1	0	0	7
251	7	2	0	0	0	2
252	2	0	0	0	0	0
253	0	0	0	0	0	0
254	0	0	0	0	0	0
255	0	0	0	0	0	0
256	0	0	0	0	0	0
257	0	0	0	0	0	0
258	0	0	0	0	0	0
259	0	0	0	0	0	0
260	0	0	0	0	0	0
261	0	0	0	0	0	0
262	0	0	0	0	0	0
263	0	0	0	0	0	0
264	0	0	0	0	0	0
265	0	0	0	0	0	0
266	0	0	0	0	0	0
267	0	0	0	0	0	0
268	0	0	0	0	0	0
269	0	0	0	0	0	0
270	0	0	0	0	0	0
271	0	0	0	0	0	0
272	0	0	0	0	0	0
273	0	0	0	0	0	0
274	910	273	38	1	16	216
275	217	65	9	0	4	51
276	52	16	2	0	1	12
277	13	4	1	0	0	3
278	3	1	0	0	0	1
279	1	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
280	0	0	0	0	0	0
281	0	0	0	0	0	0
282	0	0	0	0	0	0
283	0	0	0	0	0	0
284	0	0	0	0	0	0
285	0	0	0	0	0	0
286	0	0	0	0	0	0
287	0	0	0	0	0	0
288	0	0	0	0	0	0
289	0	0	0	0	0	0
290	0	0	0	0	0	0
291	0	0	0	0	0	0
292	0	0	0	0	0	0
293	0	0	0	0	0	0
294	0	0	0	0	0	0
295	0	0	0	0	0	0
296	0	0	0	0	0	0
297	0	0	0	0	0	0
298	0	0	0	0	0	0
299	0	0	0	0	0	0
300	0	0	0	0	0	0
301	0	0	0	0	0	0
302	207	62	9	0	4	49
303	49	15	2	0	1	12
304	12	4	0	0	0	3
305	3	1	0	0	0	1
306	1	0	0	0	0	0
307	0	0	0	0	0	0
308	0	0	0	0	0	0
309	0	0	0	0	0	0
310	0	0	0	0	0	0
311	0	0	0	0	0	0
312	0	0	0	0	0	0
313	0	0	0	0	0	0
314	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
315	0	0	0	0	0	0
316	0	0	0	0	0	0
317	0	0	0	0	0	0
318	0	0	0	0	0	0
319	0	0	0	0	0	0
320	0	0	0	0	0	0
321	0	0	0	0	0	0
322	0	0	0	0	0	0
323	0	0	0	0	0	0
324	0	0	0	0	0	0
325	0	0	0	0	0	0
326	0	0	0	0	0	0
327	0	0	0	0	0	0
328	0	0	0	0	0	0
329	0	0	0	0	0	0
330	0	0	0	0	0	0
331	0	0	0	0	0	0
332	0	0	0	0	0	0
333	0	0	0	0	0	0
334	0	0	0	0	0	0
335	0	0	0	0	0	0
336	0	0	0	0	0	0
337	0	0	0	0	0	0
338	0	0	0	0	0	0
339	0	0	0	0	0	0
340	0	0	0	0	0	0
341	0	0	0	0	0	0
342	0	0	0	0	0	0
343	0	0	0	0	0	0
344	0	0	0	0	0	0
345	0	0	0	0	0	0
346	0	0	0	0	0	0
347	0	0	0	0	0	0
348	0	0	0	0	0	0
349	0	0	0	0	0	0

Table K-1. Daily Allocation of Sediment Load Reductions for Belmont Creek

Julian Day	Daily Load from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction from Hillslope, Stream Bank and Road Erosion (lbs/day)	Daily Load Reduction Allocation for Livestock Grazing (lbs/day)	Daily Load Reduction Allocation for Hay Production (lbs/day)	Daily Load Reduction Allocation for Silviculture (lbs/day)	Daily Load Reduction Allocation for Road Erosion (lbs/day)
350	0	0	0	0	0	0
351	0	0	0	0	0	0
352	0	0	0	0	0	0
353	0	0	0	0	0	0
354	0	0	0	0	0	0
355	0	0	0	0	0	0
356	0	0	0	0	0	0
357	0	0	0	0	0	0
358	0	0	0	0	0	0
359	0	0	0	0	0	0
360	0	0	0	0	0	0
361	0	0	0	0	0	0
362	0	0	0	0	0	0
363	0	0	0	0	0	0
364	0	0	0	0	0	0
365	0	0	0	0	0	0
Total (lbs/yr)	2136000	640800	89712	1922	38448	506232
Total (tons/yr)	1068	320	45	1	19	253

Table K-2. Sediment TMDLs and Load Allocations by Listed Segment for Mid-Winter, Peak Runoff and Mid-Summer Dates

Stream Name	TMDLs (lbs/day) Mid-Winter Peak Runoff Mid-Summer	Land Use Allocations as Allowable Loading (lbs/day)					
		Livestock Grazing	Hay Production	Silviculture	Placer Mining	Road Erosion	Rural Residential
Ashby Creek, East Fork	1.6E-03	6.3E-05	NA	3.5E-05	5.8E-06	1.8E-03	5.8E-06
	7778	257	NA	140	23	7342	23
	13.8	0.45	NA	0.25	0.04	12.99	0.04
Ashby Creek, West Fork	2.1E-03	8.3E-05	NA	1.0E-04	NA	1.8E-03	6.2E-05
	8405	336	NA	420	NA	7397	252
	14.9	0.60	NA	0.7	NA	13.1	0.70
Camas Creek	2.1E-02	1.5E-03	3.5E-03	8.3E-04	NA	1.4E-02	1.0E-03
	84333	5903	14337	3373	NA	56503	4217
	149.1	10.4	25.4	5.9	NA	99.9	7.5
Upper Elk Creek	1.3E-02	1.3E-04	NA	3.1E-03	1.4E-03	8.4E-03	NA
	11876	119	NA	2850	1306	7601	NA
	1.5E-02	1.5E-04	NA	3.5E-03	1.6E-03	9.4E-03	NA
Lower Elk Creek	1.7E-05	2.2E-06	5.5E-06	1.7E-07	1.0E-06	7.7E-06	1.7E-07
	8549	1111	2821	85	513	3932	85
	5.2E-01	6.7E-02	1.7E-01	5.2E-03	3.1E-02	2.4E-01	5.2E-03
Keno Creek	1.7E-03	NA	NA	5.0E-05	NA	1.6E-03	NA
	1519	NA	NA	46	NA	1474	NA
	1.9E-03	NA	NA	5.6E-05	NA	1.8E-03	NA
Union Creek	2.7E-04	2.4E-05	1.4E-04	1.1E-05	NA	7.5E-05	2.2E-05
	375336	33780	191421	15013	NA	105094	30027
	252	23	128	10	NA	71	20
Washoe Creek	1.7E-01	1.9E-02	1.7E-02	4.7E-02	NA	4.9E-02	4.2E-02
	4803	528	480	1297	NA	1345	1153
	1.7E-01	1.9E-02	1.7E-02	4.7E-02	NA	4.8E-02	4.1E-02