Beaverhead Sediment Total Maximum Daily Loads and Framework Water Quality Protection Plan

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ACRONYM LIST

Acronym	Definition
AFO	Animal Feeding Operation
AGI	Applied Geomorphology Inc.
AML	Abandoned Mine Lands
ARM	Administrative Rules of Montana
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (federal)
BMP	Best Management Practices
BOR	Bureau of Reclamation
BWC	Beaverhead Watershed Committee
CAFO	Concentrated (or Confined) Animal Feed Operations
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EPA	Environmental Protection Agency (US)
EQIP	Environmental Quality Initiatives Program
FWP	Fish, Wildlife, and Parks (Montana)
GIS	Geographic Information System
HSI	Hydro Solutions Inc.
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LAI	Luzenac America, Inc.
LFSC	Left Fork Stone Creek
LWD	Large Woody Debris
MARS	Montana Aquatic Resources Services
MCA	Montana Code Annotated
MDT	Montana Department of Transportation
MGD	Million Gallons per Day
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
NBS	Near Bank Stress
NHD	National Hydrography Dataset
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NRDP	Natural Resource Damage Program
NTU	Nephelometric Turbidity Unit
PIBO	PACFISH/INFISH Biological Opinion
PWS	Public Water System (or Supply)
RIT/RDG	Resource Indemnity Trust/Reclamation and Development Grants Program
RSI	Riffle Stability Index

Acronym	Definition
SAP	Sampling and Analysis Plan
SMZ	Streamside Management Zone
SSC	Suspended Sediment Concentrations
SSURGO	Soil Survey Geographic database
SWAT	Soil & Water Assessment Tool
SWPPP	Storm Water Pollution Prevention Plan
TIE	TMDL Implementation Evaluation
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VFS	Vegetated Filter Strips
WARD	Water quality Assessment, Reporting, and Documentation system
WEPP:Road	Water Erosion Prediction Project Methodology
WLA	Wasteload Allocation
WMS	Watershed Management Section
WRP	Watershed Restoration Plan
WWTF	Wastewater Treatment Facility

DOCUMENT SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for 18 stream segments, including the Beaverhead River (lower), Blacktail Deer Creek, Clark Canyon Creek, Dyce Creek, Farlin Creek, French Creek, Grasshopper Creek, Rattlesnake Creek (upper and lower), Reservoir Creek, Scudder Creek, Spring Creek, Steel Creek, Stone Creek (upper and lower), Taylor Creek, West Fork Blacktail Deer Creek, and West Fork Dyce Creek. (see **Map A-1** found in **Appendix A**).

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

The Beaverhead TMDL planning area is located in Beaverhead County, with a small portion in Madison County and includes the towns of Dillon and Twin Bridges. The Beaverhead TPA encompasses the Beaverhead River watershed (fourth-code hydrologic unit code 10020002), which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The TPA is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south.

Sediment was identified as impairing aquatic life and coldwater fishes in 18 stream segments. The scope of the TMDLs in this document addresses problems with sediment (see **Table DS-1**). Although DEQ recognizes that there are other pollutant listings for this TPA, this document addresses only sediment.

Sediment is affecting beneficial uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration goals for sediment were established on the basis of fine sediment levels in trout spawning areas and the stability of streambanks. DEQ believes that once these water quality goals are met, all water uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, and roads. The most significant sources include: bank and hillslope erosion from current and historic rangeland grazing and hay production within the riparian (streamside) area. The Beaverhead TPA watershed sediment TMDLs indicate that reductions in sediment loads ranging from 55% to 74% will satisfy the water quality restoration goals.

Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include best management practices (BMPs) for grazing, small acreages, cropland, and irrigation. In addition, they include BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian and wetland vegetation.

Implementation of most water quality improvement measures described in this plan, with the exception of permitted facilities, is based on voluntary actions of watershed stakeholders. For permitted facilities, water quality improvement measures will be met by adherence to permit requirements.

Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

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

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Beaverhead TPA with Completed Sediment TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Beaverhead River (lower), Grasshopper Creek to mouth (Jefferson River)	Sediment	Sedimentation/ Siltation	Aquatic Life
Blacktail Deer Creek, headwaters to mouth (Beaverhead River)	Sediment	Sedimentation/ Siltation	Aquatic Life
Clark Canyon Creek, headwaters to mouth (Beaverhead River)	Sediment	Sedimentation/ Siltation	Aquatic Life
Dyce Creek, confluence of East and West Forks to Grasshopper Creek	Sediment	Sedimentation/ Siltation	Aquatic Life
Farlin Creek, headwaters to mouth (Grasshopper Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
French Creek, headwaters to mouth (Rattlesnake Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
Grasshopper Creek*, headwaters to mouth (Beaverhead River)	Sediment	No Listing in the 2012 Water Quality Integrated Report	
Rattlesnake Creek (upper), headwaters to Dillon PWS off-channel well T7S R10W S11	Sediment	Sedimentation/ Siltation	Aquatic Life
Rattlesnake Creek (lower), from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	Sediment	Sedimentation/ Siltation & Solids (Suspended/ Bedload)	Aquatic Life
Reservoir Creek, headwaters to mouth (Grasshopper Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
Scudder Creek, headwaters to mouth (Grasshopper Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
Spring Creek, headwaters to mouth (Beaverhead River)	Sediment	Sedimentation/ Siltation	Aquatic Life
Steel Creek, headwaters to mouth (Driscol Creek)	Sediment	Sedimentation/ Siltation & Solids (Suspended/Bedload)	Aquatic Life & Primary Contact Recreation
Stone Creek (upper), Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	Sediment	Sedimentation/ Siltation & Turbidity	Aquatic Life & Primary Contact Recreation
Stone Creek (lower), confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	Sediment	Sedimentation/ Siltation	Aquatic Life
Taylor Creek, headwaters to mouth (Grasshopper Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life
West Fork Dyce Creek, headwaters to mouth (Dyce Creek)	Sediment	Sedimentation/ Siltation	Aquatic Life

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment problems in the Beaverhead TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Map A-1,** found in **Appendix A,** shows a map of waterbodies in the Beaverhead TPA with sediment pollutant listings.

1.1 BACKGROUND

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

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

Each waterbody has a set of designated uses. Montana has established water quality standards to protect these uses. Waterbodies that do not meet one or more standards are called impaired waters. Every two years DEQ must file a Water Quality Integrated Report (IR), which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

Montana's biennial IR identifies all the state's impaired waterbody segments. All waterbody segments within the IR are indexed to the National Hydrography Dataset (NHD). The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL. TMDLs are not required for non-pollutant impairments. **Table A-1** in **Appendix A** identifies impaired waters for the Beaverhead TPA from Montana's 2012 303(d) List, as well as non-pollutant impairment causes included in Montana's "2012 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:
- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Quantifying the magnitude of pollutant contribution from their sources

- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

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

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

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists all of the impairment causes from the "2012 Water Quality Integrated Report" that are addressed in this document (also see **Map A-1** in **Appendix A**). This document contains pollutant impairments within the sediment TMDL pollutant category.

New data assessed during this project identified new sediment impairment causes for 1 waterbody. This impairment cause is identified in **Table 1-1** as not being on the 2012 303(d) List (within the integrated report): Grasshopper Creek.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 18 TMDLs (**Table 1-1**). There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 6.1**. **Section 6.1** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Although DEQ recognizes that there are other pollutant listings for this Beaverhead TPA without completed TMDLs (**Table A-1** in **Appendix A**), this document only addresses those identified in **Table 1-1**. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. **Table A-1** in **Appendix A** includes impairment causes with completed TMDLs, as well as non-pollutant impairment causes that were addressed by those TMDLs.

Table 1-1. Water Quality Impairment Causes for the Beaverhead TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in IR 2012 Integrated Report*
BEAVERHEAD RIVER, Clark Canyon Dam to Grasshopper Creek	MT41B001_010	Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed via restoration plan (see **Sections 6** and **7**)	Yes
BEAVERHEAD RIVER, Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Partially addressed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
BLACKTAIL DEER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_030	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
CLARK CANYON CREEK, headwaters to mouth (Beaverhead River), T9S R10W S28	MT41B002_110	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
DYCE CREEK, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
EAST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_040	Alteration in streamside or littoral vegetative covers	Sediment	Addressed via restoration plan (see **Sections 6** and **7**)	Yes
FARLIN CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S7	MT41B002_020	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
FRENCH CREEK, headwaters to mouth	MT41B002_100	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes

Table 1-1. Water Quality Impairment Causes for the Beaverhead TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in IR 2012 Integrated Report*
(Rattlesnake Creek)		littoral vegetative covers			
GRASSHOPPER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_010	Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
RATTLESNAKE CREEK, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Solids (Suspended/Bedload)	Sediment	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
RATTLESNAKE CREEK, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
RESERVOIR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
SCUDDER CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S19	MT41B002_180	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
SPRING CREEK, headwaters to mouth (Beaverhead River)	MT41B002_080	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
STEEL CREEK, headwaters to mouth (Driscol Creek), T6S R12W S18	MT41B002_160	Solids (Suspended/Bedload)	Sediment	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes

Table 1-1. Water Quality Impairment Causes for the Beaverhead TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in IR 2012 Integrated Report*
STONE CREEK, confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
STONE CREEK, Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	Turbidity	Sediment	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Low flow alterations	Not Applicable; Non-Pollutant	Not yet addressed by a TMDL or restoration plan	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
TAYLOR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_170	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
WEST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes
WEST FORK DYCE CREEK, headwaters to mouth (Dyce Creek)	MT41B002_070	Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Addressed by sediment TMDL	Yes

*Impairment causes not in the “2012 Water Quality Integrated Report” were recently identified and will be included in the 2014 Integrated Report.

1.3 Document Layout

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

Section 2.0 Beaverhead Watershed Description:
Describes the physical characteristics and social profile of the watershed.

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

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

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

Section 6.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 7.0 Restoration Objectives and Implementation Plan:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 8.0 Monitoring for Effectiveness:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the Beaverhead Sediment Total Maximum Daily Loads and Framework Water Quality Protection Plan

Section 9.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 BEAVERHEAD WATERSHED DESCRIPTION

This section includes a summary of the physical characteristics and social profile of the Beaverhead watershed. An extended watershed description is contained in the DEQ Library (2003).

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Beaverhead watershed.

2.1.1 Location

The Beaverhead TMDL planning area is located in Beaverhead County, with a small portion in Madison County and includes the towns of Dillon and Twin Bridges (**Appendix A, Map A-2**). The Beaverhead TPA encompasses the Beaverhead River watershed (fourth-code hydrologic unit code 10020002), which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The TPA is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south.

The TPA is located in the Middle Rockies Level III Ecoregion. Eight Level IV Ecoregions are mapped within the TPA (Woods, et al., 2002), as shown on **Map A-3 (Appendix A)**. These include: Barren Mountains (17e), Alpine Zone (17h), Dry Intermontane Sagebrush Valleys (17aa), Dry Gneissic-Schistose-Volcanic Hills (17ab), Big Hole (17ac), Forested Beaverhead Mountains (17ae), Pioneer-Anaconda Ranges (17ag), and Eastern Pioneer Sedimentary Mountains (17ah).

2.1.2 Topography

Elevations in the planning area range from 4,600 feet above mean sea level at the confluence of the Beaverhead and Jefferson Rivers, to nearly 10,600 feet at the summit of Baldy Peak in the Pioneer Range. The majority of the planning area is between 5,000 and 7,000 feet, as shown on **Map A-4 (Appendix A)**.

2.1.3 Climate

Average precipitation in the watershed varies with elevation, from 9 inches/year in the valley to 39 inches/year at the highest elevations (**Appendix A, Map A-5**). Average snowfall ranges from 9 inches/year in the valley to 85.8 inches/year at higher elevations. May and June are consistently the wettest months of the year and winter precipitation is dominated by snowfall. Temperature patterns reveal that July is the hottest month and January is the coldest throughout the watershed (**Table 2-1**). Summertime highs are typically in the high seventies to low eighties F, and winter lows average 11 degrees F.

Table 2-1. Monthly Climate Summary: Dillon Airport

Dillon, Montana (242404) Period of Record: 1/1/1940 to 10/31/2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (F)	32.1	37.6	44.2	54.5	63.9	72.2	83.1	81.4	70.3	58.3	42.5	33.2	56.1
Ave. Min. Temp. (F)	10.9	15.0	20.2	28.4	36.4	43.4	49.1	47.4	39.4	30.9	20.2	12.6	29.5
Ave Tot. Precip. (in.)	0.26	0.24	0.50	0.93	1.71	1.93	0.98	0.94	1.01	0.62	0.38	0.26	9.76

Table 2-1. Monthly Climate Summary: Dillon Airport
Dillon, Montana (242404) Period of Record: 1/1/1940 to 10/31/2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Snowfall (in.)	4.9	3.8	7.1	6.2	2.3	0.1	0.0	0.0	1.3	2.5	4.1	4.1	36.4
Ave Snow Depth (in.)	1	1	1	0	0	0	0	0	0	0	1	1	0

2.1.3 Hydrology
The Beaverhead River begins at the confluence of Horse Prairie Creek and the Red Rock River, since 1964 inundated by the Clark Canyon Reservoir. The Bureau of Reclamation built the dam and associated irrigation infrastructure in order to irrigate the bench east of Dillon. Below the dam, the Beaverhead River flows about 15 miles through a canyon before entering the Beaverhead Valley. Major tributary streams are Grasshopper Creek, Blacktail Deer Creek, and Rattlesnake Creek. The Ruby River drains into the Beaverhead River slightly over a mile south of Twin Bridges. The Big Hole River meets the Beaverhead River just north Twin Bridges. The confluence of the Beaverhead and Big Hole Rivers marks the start of the Jefferson River.

The Bureau of Reclamation's East Bench Unit irrigates 49,800 acres via the diversion dam at Barretts (Rogers, 2008). Minimum discharges usually occur during late summer and often result in late-season shortages of irrigation water (Kendy and Tresch, 1996).

Operation of the Clark Canyon Reservoir influences the flow regime in the Beaverhead River. This is demonstrated graphically in a hydrograph of Beaverhead River discharge, measured at USGS gaging station 06016000 (Beaverhead River at Barretts). The peak of the hydrograph is shifted later in the year, reflecting controlled release of stored water. The low flow regime is fairly stable, reflecting average low-flow discharge from the reservoir. Diversion of river water to the East Bench Unit irrigation system is reflected at gaging stations further downstream, such as 0601700 (Beaverhead River at Dillon). Reduced flows are distinct between April and November, resulting in an inverted hydrograph.

The State of Montana Fish, Wildlife and Parks (MT FWP) maintains a list of Montana streams that support important fisheries or contribute to important fisheries (i.e. provide spawning and rearing habitats) that are significantly dewatered. Dewatering refers to a reduction in streamflow below the point where stream habitat is adequate for fish. The list was initially prepared by MT FWP in 1991 from field observations and revised in December 1997. The revised list includes a total of 207 streams and 2,614 stream miles which are chronically dewatered and 87 streams and 1,242 stream miles which are periodically dewatered. The 2 categories of dewatering are "chronic" – streams where dewatering is a significant problem in virtually all years and "periodic" – streams where dewatering is a significant problem only in drought or water-short years.

Most man-made dewatering occurs during the irrigation season (July-September) and although most dewatering is the result of irrigation withdrawals, a few of the streams listed are dewatered through dam regulation for agriculture or power production, or by natural causes. The number of miles of a given stream may vary from year to year depending on the amount of water available in the stream system. Dewatered streams identified in the Beaverhead planning area include: the Beaverhead River (62.5 miles), Blacktail Deer Creek (38.6 miles), Rattlesnake Creek (7.9 miles) and Grasshopper Creek (28.3 miles). A total of 137.3 miles of stream are reported dewatered in the planning area. This includes both chronic and periodic dewatering. Chronic dewatering is limited to the lower reaches of Rattlesnake and Blacktail Deer Creeks and the Beaverhead River below Dillon. Dewatered streams are shown on **Map A-6 (Appendix A)**.

2.1.4 Geology, Soils, and Stream Morphology

The planning area includes a diverse assemblage of geologic units, and is representative of the geology of southwestern Montana in general. The planning area's physiography includes high alpine mountains, broad pediments or terraces, and wide alluvial valleys. Detailed discussion of the bedrock geology exposed in the mountains is beyond the scope of this report. Tertiary valley fill deposits and Quaternary alluvium dominate the planning area, as shown on the simplified geologic map (**Appendix A, Map A-7**).

The USGS Water Resources Division created a dataset of hydrology-relevant soil attributes (Schwarz and Alexander, 1995), based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data. The soil attributes considered in this characterization are erodibility and slope. Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier and Smith, 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Map A-8 (Appendix A)**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Low susceptibility soils compose 10% of the TPA; moderate-low susceptibility soils comprise 73% of the TPA, and the remaining 17% is mapped with moderate-high susceptibility soils. No high susceptibility soils are mapped in the TPA. Low susceptibility soils are associated with the Pioneer Range and the Tertiary sediments on the pediment flanking the Ruby Range.

2.2 Ecological Parameters

2.2.1 Vegetation and Fire History

The majority of the planning area is mapped with shrub/scrub and grassland landcover. The lowland areas are dominated by hay/pasture and small grain cultivation, and the upland areas are covered with evergreen forest. The National Land Cover Dataset (2001) is shown on **Map A-9 (Appendix A)**.

The planning area experienced a relatively large fire in 2006, the Clark Canyon fire, which burned 15,345 acres in the Blacktail Mountains. The Sweetwater fire burned 7,566 acres of the Ruby Mountains in 1988. These and other fires of greater than 400 acres are shown on **Map A-10 (Appendix A)**.

2.2.2 Aquatic Life

Montana Fish, Wildlife and Parks report Westslope cutthroat trout in the planning area, generally in upland tributary streams. The sediment-listed streams with western cutthroat trout reported include Stone, Spring, French, Farlin, Dry, Taylor and Reservoir creeks. Fish distribution is shown on **Map A-11 (Appendix A)**.

2.3 Social Profile

The following describes the cultural profile of the Beaverhead planning area.

2.3.1 Land Use

Historic land uses included mining, fur trapping and agriculture, primarily ranching. Current land use in the watershed is dominated by agricultural cattle production, with less significant grain cropping and potato production. A large portion of the upper watershed is used for rangeland. The floodplains of the major tributaries are irrigated for hay and alfalfa production and pasture. Irrigation canals installed in the mid to late twentieth century provide water for irrigation from the Beaverhead River, much of which is derived from Clark Canyon Reservoir **(Appendix A, Map A-12).**

Other land uses in the basin are recreation, logging, and mining. The most intensive recreation use is fall big game hunting, especially in the upper Blacktail Deer Creek drainage. Mining has been and is still an important land use in the basin and a potential source of impairment to water quality. A large operating talc mine is located in the Stone Creek watershed.

Major transportation corridors in the planning area include Interstate 15 and Highway 41. The network of paved and unpaved roads is discussed in detail in the source assessment (**Section 5.6.3**).

2.3.2 Land Ownership

Roughly 39% of the planning area is under federal management (24% BLM; 15% USFS), 15% is state lands (including FWP managed lands and surface waters), and about 46% is in private ownership (**Appendix A, Map A-13**). In general, USFS lands occupy the higher, timbered areas, and the lower elevations are mostly private lands with some BLM and State Trust Lands. The US Bureau of Reclamation owns and manages the Clark Canyon Reservoir.

2.3.3 Population

As of the 2010 census, 9,246 people resided in Beaverhead County (**Appendix A, Map A-14**). Dillon is the largest municipality in the Beaverhead Watershed. As of the 2010 census, the population of Dillon was 4,134, a modest increase from the 2000 census. Other towns in the watershed include Bannack, Polaris, Argenta, Grant, and Twin Bridges. Twin Bridges is the second largest population center, with 400 residents.

2.3.4 Point Sources

As of January 19, 2012, there were seventeen Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within the Beaverhead TPA (**Appendix A, Map A-15**):

- City of Dillon WWTF (MT0021458),
- Beaverhead Talc Mine (MT0027821)
- Barretts Minerals Inc (MT0029891)
- Two Concentrated Animal Feeding Operations (MTG010165 and MTG010212)
- Three Storm Water Mining Permits (MTR300135, MTR300136, and MTR300160), and
- Nine general permits for construction stormwater

2.3.5 Wastewater

The city of Dillon is sewered. The City of Dillon wastewater treatment plant discharges to the Beaverhead River under a MPDES permit. The town of Twin Bridges is also sewered, but its treatment plant discharges to the Jefferson River. Outside of these communities, wastewater treatment and disposal is provided by individual onsite septic systems.

3.0 MONTANA WATER QUALITY STANDARDS

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

Montana's water quality standards include four main parts:

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

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Beaverhead TPA streams can be found **Appendix B.**

3.1 BEAVERHEAD TPA STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. With the exception of the upper segment of Rattlesnake Creek which is an A-1, all streams within the Beaverhead TPA are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses: growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix B.**

Nineteen waterbody segments in the Beaverhead TPA are listed in the "2012 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). Waterbodies that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL. TMDLs are written to protect all designated uses for a waterbody and not just those identified as being non or partially supported. DEQ describes impairment as either partially supporting or not supporting, based on assessment results. Not supporting is applied to not meeting a drinking water standard, and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana's use support categories can be found in DEQ's water quality assessment methods (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2011).

Table 3-1. Impaired Waterbodies and their Designated Use Support Status on the "2012 Water Quality Integrated Report" in the Beaverhead TPA

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Drinking Water	Primary Contact Recreation
BEAVERHEAD RIVER, Clark Canyon Dam to Grasshopper Creek	MT41B001_010	B-1	F	N	N	P
BEAVERHEAD RIVER, Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	B-1	F	N	F	N
BLACKTAIL DEER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_030	B-1	F	N	F	N
CLARK CANYON CREEK, headwaters to mouth (Beaverhead River), T9S R10W S28	MT41B002_110	B-1	F	P	F	F
DYCE CREEK, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	B-1	F	P	F	P
EAST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_040	B-1	F	P	F	F
FARLIN CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S7	MT41B002_020	B-1	F	P	F	F
FRENCH CREEK, headwaters to mouth (Rattlesnake Creek)	MT41B002_100	B-1	F	P	F	F
GRASSHOPPER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_010	B-1	F	P	F	P
RATTLESNAKE CREEK, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	B-1	F	P	N	P
RATTLESNAKE CREEK, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	A-1	F	P	N	F
RESERVOIR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_120	B-1	F	P	F	F
SCUDDER CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S19	MT41B002_180	B-1	F	P	F	F
SPRING CREEK, headwaters to mouth (Beaverhead River)	MT41B002_080	B-1	P	P	N	P
STEEL CREEK, headwaters to mouth (Driscol Creek), T6S R12W S18	MT41B002_160	B-1	P	N	N	N
STONE CREEK, confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	B-1	P	P	N	P
STONE CREEK, Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	B-1	F	P	F	N
TAYLOR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_170	B-1	F	P	F	F
WEST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	B-1	N	P	N	P
WEST FORK DYCE CREEK, headwaters to mouth (Dyce Creek)	MT41B002_070	B-1	F	P	F	F

3.2 Beaverhead TPA Water Quality Standards

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

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

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

The specific sediment narrative water quality standards that apply to the Beaverhead TPA are summarized in **Appendix B**.

4.0 DEFINING TMDLS AND THEIR COMPONENTS

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

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

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

A TMDL is expressed by the equation: $TMDL = \Sigma WLA + \Sigma LA$, where:

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

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

Development of each TMDL has four major components:

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

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

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

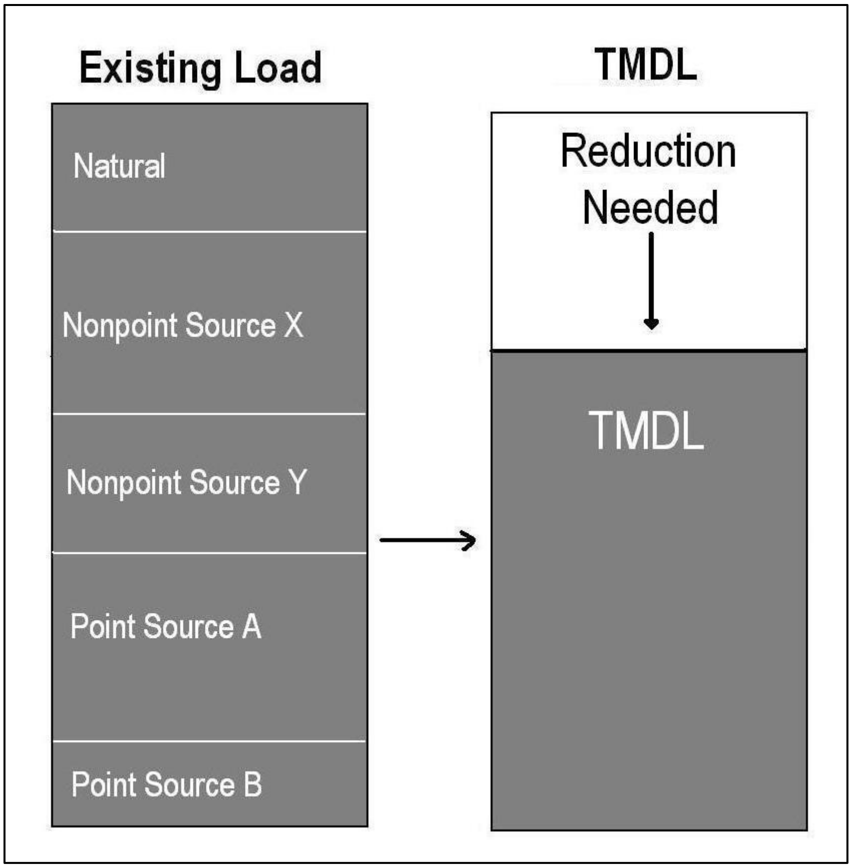

Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

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

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

4.2 Quantifying Pollutant Sources

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

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories (e.g., unpaved roads) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, pollutant sources in a sub-watershed or source area can be combined for quantification purposes.

Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 Establishing the Total Allowable Load

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

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

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

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

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. In addition to basic technical and environmental analysis, DEQ also considers economic and social costs and benefits when developing allocations. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

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

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

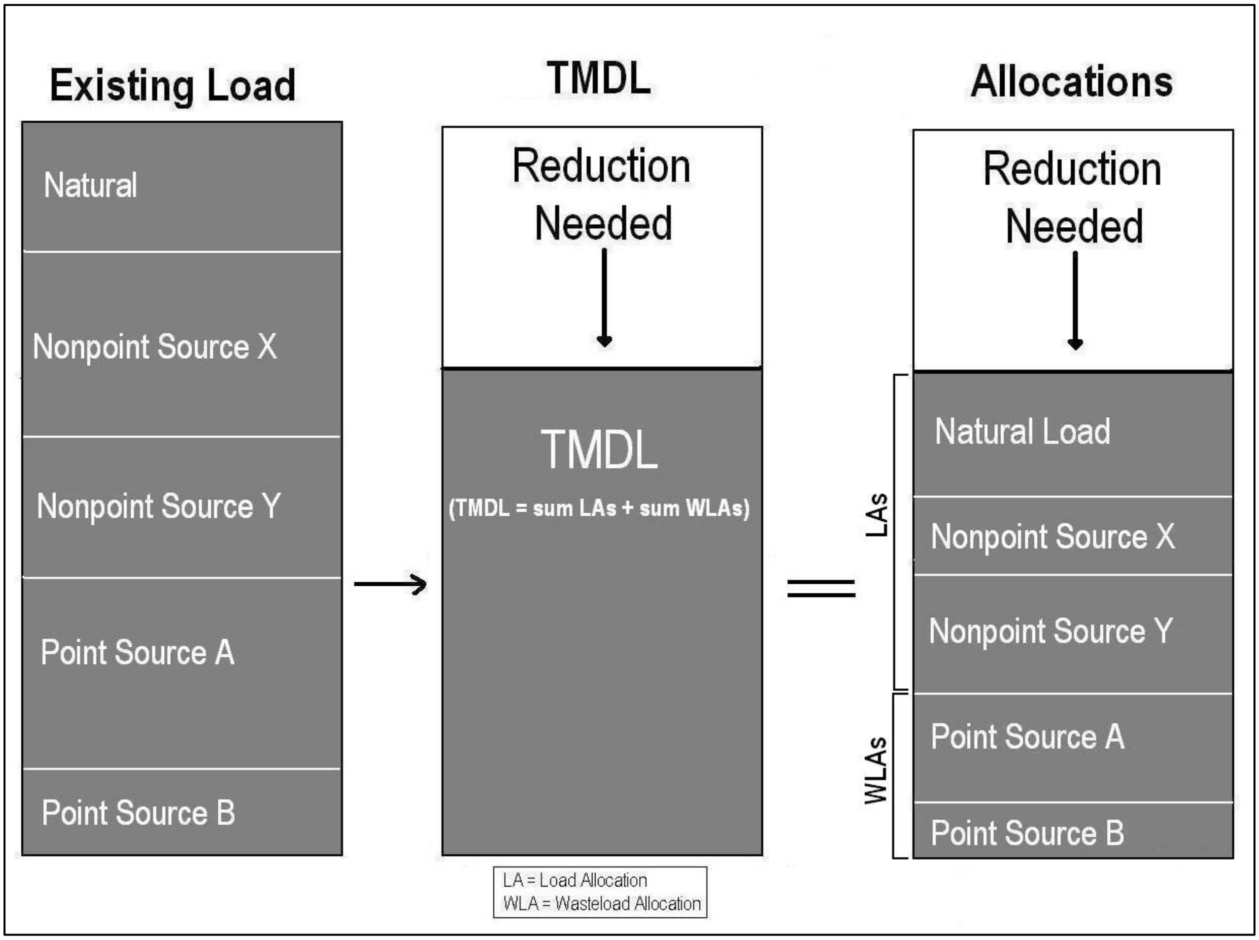

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

Incorporating an MOS is required when developing TMDLs. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999).

5.0 SEDIMENT TMDL DEVELOPMENT

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

5.1 MECHANISM OF EFFECTS OF EXCESS SEDIMENT ON BENEFICIAL USES

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

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

5.2 STREAM SEGMENTS OF CONCERN

A total of 17 waterbody segments in the Beaverhead TPA appeared on the 2012 Montana 303(d) List due to sediment impairments (**Table 5-1**). These include: Beaverhead River (lower), Blacktail Deer Creek, Clark Canyon Creek, Dyce Creek, Farlin Creek, French Creek, Rattlesnake Creek (upper and lower), Reservoir Creek, Scudder Creek, Spring Creek, Steel Creek, Stone Creek (upper and lower), Taylor Creek, West Fork Blacktail Deer Creek, and West Fork Dyce Creek. As shown in **Table 5-1**, many of the waterbodies with sediment impairments are also listed for habitat and flow alterations, which are non-pollutant forms of pollution frequently associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

Grasshopper Creek, (MT41B002_010), a tributary to the Beaverhead River and the upper segment of the Beaverhead River (MT41B001_010), were not on the 303(d) list for sediment, but do have habitat alterations that are potentially linked to sediment and therefore were also evaluated as part of TMDL development.

Table 5-1. Waterbody Segments in the Beaverhead TPA with Sediment Listings and Possible Sediment-related Listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Beaverhead River (upper), Clark Canyon Dam to Grasshopper Creek	MT41B001_010		Alteration in streamside or littoral vegetative covers & low flow alterations
Beaverhead River (lower), Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers, low flow alterations, and physical substrate habitat alterations
Blacktail Deer Creek, headwaters to mouth (Beaverhead River)	MT41B002_030	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & low flow alterations
Clark Canyon Creek, headwaters to mouth (Beaverhead River)	MT41B002_110	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Dyce Creek, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & low flow alterations
Farlin Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_020	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
French Creek, headwaters to mouth (Rattlesnake Creek)	MT41B002_100	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Grasshopper Creek, headwaters to mouth (Beaverhead River)	MT41B002_010		Alteration in streamside or littoral vegetative covers & low flow alterations
Rattlesnake Creek (upper), headwaters to Dillon PWS off-channel well T7S R10W S11	MT41B002_091	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Rattlesnake Creek (lower), from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Sedimentation/ Siltation & Solids (Suspended/ Bedload)	Alteration in streamside or littoral vegetative covers & low flow alterations
Reservoir Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Scudder Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_180	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & low flow alterations
Steel Creek, headwaters to mouth (Driscoll Creek)	MT41B002_160	Sedimentation/ Siltation & Solids (Suspended/ Bedload)	Alteration in streamside or littoral vegetative covers

Table 5-1. Waterbody Segments in the Beaverhead TPA with Sediment Listings and Possible Sediment-related Listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Stone Creek (upper), Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	Sedimentation/ Siltation & Turbidity	Alteration in streamside or littoral vegetative covers & low flow alterations
Stone Creek (lower), confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Taylor Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_170	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
West Fork Dyce Creek, headwaters to mouth (Dyce Creek)	MT41B002_070	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

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

5.3.1 Summary of Information Sources

To characterize sediment conditions for TMDL development purposes, a sediment and habitat assessment was completed during 2010 and 2011. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets (**Figure 5-1**).

- DEQ assessment files and 2004/2005 reference sites
- 2010-2011 DEQ sediment and habitat assessment
- 2010 Beaverhead Deerlodge NF sediment and habitat assessment
- 2009-2011 suspended sediment and turbidity data collected by the USGS for the DEQ
- 2008-2009 turbidity and TSS data from collected by HSI for the DEQ
- 2003 stream morphology data collected by Kirk Environmental for the DEQ
- Relevant Local and Regional Reference Data
- BLM Watershed Assessments
- GIS data layers and publications regarding historical land usage, channel stability, and sediment conditions

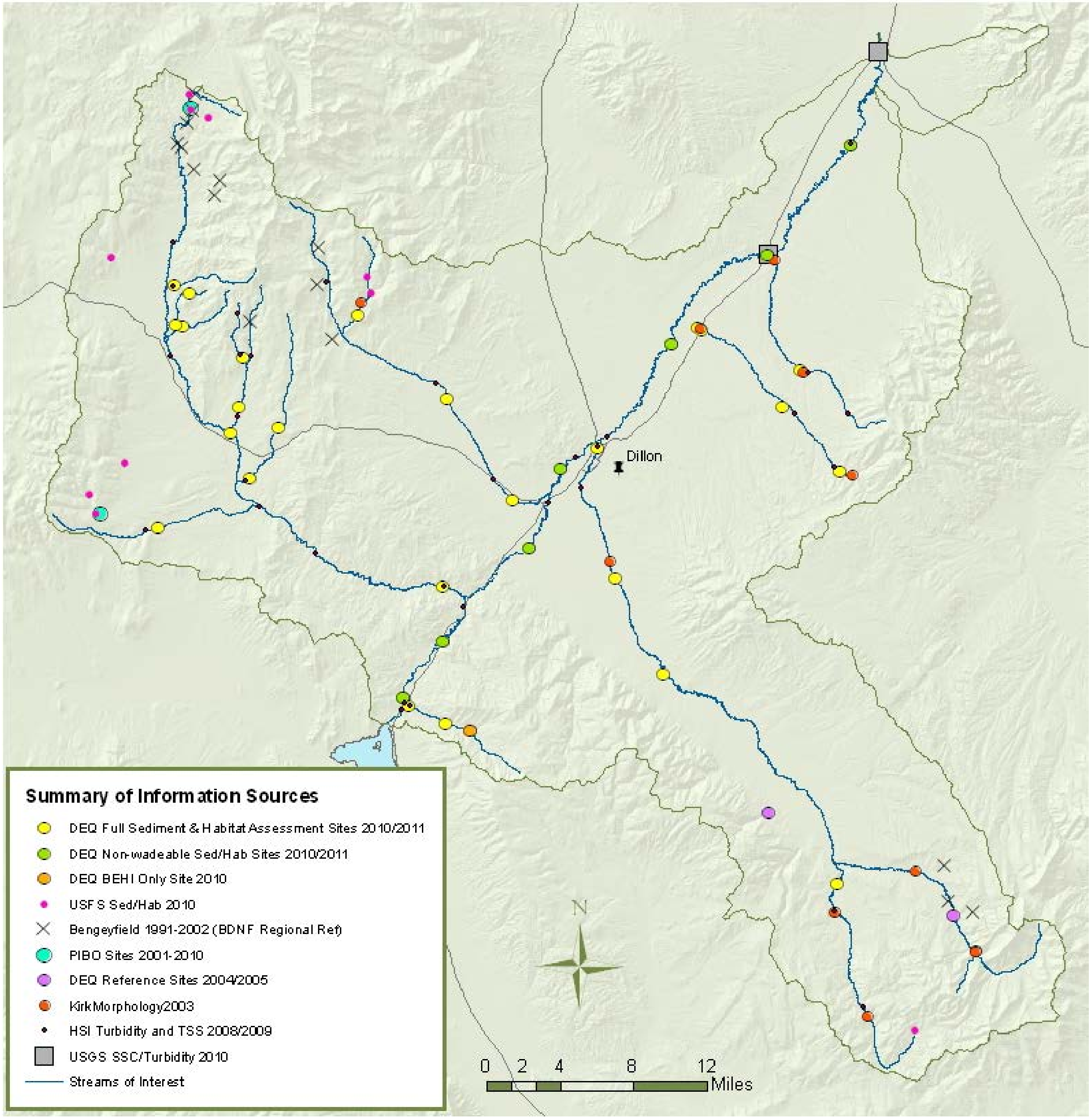

Figure 5-1. Reaches Assessed by DEQ in 2010/2011 and Other Sources of Information

5.3.2 DEQ Assessment Files and Reference Sites

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected by DEQ on most waterbodies between 1992 and 2004 as well as other historical information collected or obtained by DEQ. The most common quantitative data that will be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale. Files are available electronically on DEQ's Clean Water Act Information Center website: http://cwaic.mt.gov/.

In addition to the assessment files, the DEQ collected sediment and habitat data on two reference sites in the Beaverhead TPA in 2004/2005. Photos, TSS, Rosgen level II parameters, NRCS Habitat Assessment, macroinvertebrates, and periphyton were collected at both Cottonwood Creek and East Fork Blacktail Deer Creek (See **Appendix D** for relevant data).

5.3.3 DEQ's 2010-2011 Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters (Montana Department of Environmental Quality, 2010) were collected in September 2010 and April 2011 from 31 reaches on 19 waterbody segments to aid in TMDL development (**Figure 5-1**). Field measurement methods were modified for several reaches on the Beaverhead River where high flows prevented wading during the assessment period **(Appendix C)**. To aid in the characterization of bank erosion in Clark Canyon Creek, an additional reach was assessed for bank erosion severity and source identification. In total, sediment and habitat data were collected from 32 reaches.

Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes not affected by human activity: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influences sediment transport and deposition. The next step in the aerial assessment involved identification of near-stream land uses since land management practices can have a significant influence on stream morphology and sediment characteristics. The resulting product was a stratification of streams into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, provided the basis for selecting the above-referenced monitoring reaches.

Monitoring reaches were chosen with the goal of being representative of various reach characteristics, land use category, and anthropogenic influence. There was a preference toward sampling those reaches where anthropogenic influences would most likely lead to impairment conditions since it is a primary goal of sediment TMDL development to further characterize sediment impairment conditions. Thus, it is not a random sampling design intended to sample stream reaches representing all potential impairment and non-impairment conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reach types while ensuring that reaches within each [sediment] 303(d) listed waterbody with potential impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low gradient, unconfined streams larger than 1st order (i.e., having at least one tributary); therefore, this stream type was the focus of the field effort (**Table 5-2**). Although the TMDL development process necessitates this targeted sampling design, it is acknowledged that this approach results in less certainty regarding conditions in 1st order streams and higher gradient reaches, and that conditions within sampled reaches are not necessarily representative of conditions throughout the entire stream. Additionally, reach selection on the Beaverhead River was limited by access and wadeability.

The field parameters assessed in 2010 and 2011 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, sites were actually sampling reaches ranging from 500 to 2000 feet (depending on the channel bankfull width) that were broken into five individual and equally-sized cells. With the exception of the non-wadeable and BEHI only sites; channel morphology, stream habitat, riparian, and bank erosion measures were performed in all cells, while fine sediment measures were performed in four of the cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data are contained in the 2011 monitoring summary report (**Appendix C**).

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

Reach Type*	Number of Reaches	Sites Monitored	Methods Used
MR_2_1_U	14	SCUD 11-01	All Sed/Hab Methods
MR_4_1_U	48	STEL 05-01	All Sed/Hab Methods
		WFDY 17-01	All Sed/Hab Methods
MR_0_2_U	53	CLKC 32-01	All Sed/Hab Methods
		DYCE 02-02	All Sed/Hab Methods
		SPRG 31-01	All Sed/Hab Methods
		STON 20-02	All Sed/Hab Methods
		STON 22-02	All Sed/Hab Methods
		STON 22-02B	All Sed/Hab Methods
		TAYL 32-01	All Sed/Hab Methods
MR_2_2_C	29	FREN 23-01	All Sed/Hab Methods
MR_2_2_U	51	CLKC 19-02	All Sed/Hab Methods
		FARL 28-01	All Sed/Hab Methods
		RESR 11-01	All Sed/Hab Methods
		STON 05-01	All Sed/Hab Methods
		TAYL 27-01	All Sed/Hab Methods
MR_4_2_U	26	CLKC 18-02	BEHI Only
MR_0_3_U	62	RATT 54-04	All Sed/Hab Methods
		RATT 60-04	All Sed/Hab Methods
		WFBK 08-04	All Sed/Hab Methods
MR_0_4_U	34	GRAS 12-01	All Sed/Hab Methods
		GRAS 20-11	All Sed/Hab Methods
MR_0_5_U	30	BLKD 02-08	All Sed/Hab Methods
		BLKD 02-14	All Sed/Hab Methods
		BLKD 02-30	All Sed/Hab Methods
MR_0_7_U	32	BEAV 04-02	Cross-sections only
		BEAV 04-05	Cross-sections only
		BEAV 09-04	Non-wadeable reach methods
		BEAV 09-06	Non-wadeable reach methods with std. cross-sections
		BEAV 09-11	Non-wadeable reach methods
		BEAV 09-14	Non-wadeable reach methods
		BEAV 09-15	Non-wadeable reach methods

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

5.3.4 Beaverhead Deerlodge NF Sediment and Habitat Assessment 2010

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

5.3.5 USGS Suspended Sediment and Turbidity Data 2010

The U.S. Geological Survey (USGS) monitored suspended sediment and turbidity for the DEQ at two sites on the Beaverhead River in 2010/2011. At site 06018500, monthly suspended sediment concentrations (SSC) and sand fractions were collected from May through October in 2009 and 2010; June 1, 2010 to October 31, 2010; and two low flow samples in December 2010 and February 2011. At site 06023100, bi-monthly SSC and sand fractions were collected from June 1, 2010 to October 31, 2010; with two winter low flow samples in December 2010 and February 2010. Continuous turbidity was collected at both sites from June 2, 2010 to October 31, 2010. Data is available online at http://waterdata.usgs.gov/mt/nwis.

5.3.6 HSI Turbidity and TSS 2008-2009

Instantaneous turbidity and TSS was collected for the DEQ by HSI in 2008 and 2009 on Blacktail Deer Creek (3 sites), the Beaverhead River (8 sites), Clark Canyon Creek, Dyce Creek, East Fork Blacktail Deer Creek , East Fork Dyce Creek, Farlin Creek, French Creek, Grasshopper Creek (5 sites), Rattlesnake Creek (3 sites), Reservoir Creek (2 sites), Scudder Creek (2 sites), Spring Creek (4 sites), Stone Creek (4 sites), Taylor Creek (2 sites), West Fork Blacktail Deer Creek (2 sites), and West Fork Dyce Creek (2 sites).

5.3.7 KirK Environmental Stream Morphology Data 2003

KirK Environmental collected basic cross-section data in 2003 on Blacktail Deer Creek, East Fork Blacktail Deer Creek, French Creek, Indian Creek, Spring Creek, Stone Creek, and West Fork Blacktail Deer Creek. Relevant parameters assessed include bankfull width, W/D ratio, entrenchment ratio, sinuosity, pool count and depth, and an estimated d50 of the substrate. In addition to cross section data, KirK performed a visual habitat assessment on the creeks mentioned above and on the Beaverhead River, Dyce Creek, East Fork Dyce Creek, Farlin Creek, Grasshopper Creek, Rattlesnake Creek, Reservoir Creek, Scudder Creek, Steel Creek, Taylor Creek, and West Fork Dyce Creek.

5.3.8 PIBO Data

The PACFISH/INFISH Biological Opinion Effectiveness (PIBO) monitoring program collects data from reference and managed (i.e., non-reference) stream sites on USFS and BLM land within the Beaverhead watershed. Reference sites are defined as having catchment road densities less than 0.5 km/km^2, riparian road densities less than 0.25 km/km^2, no grazing within 30 years, and no known in-channel mining upstream of the site. Within the Beaverhead TPA, data were collected in 2006, 2008, and 2009 at three non-reference sites on Buffalo, Grasshopper and East Fork Blacktail Deer creeks (**Figure 5-1**). There are 18 reference sites within the Beaverhead Deerlodge National Forest (BDNF) in the Middle Rockies Level IV ecoregion, but because that is a small dataset for target development, and ecoregion is a primary stratification category, all PIBO reference data from the Middle Rockies ecoregion were used for target development. This consists of all sites within the BDNF as well as data from 55 other sites collected between 2001 and 2010. Data was collected following protocols described in *“Effectiveness Monitoring for Streams and Riparian Areas within the Pacific Northwest: Stream Channel Methods for Core Attributes” (U.S. Department of Agriculture, Forest Service, 2006).* Relevant data collected during these assessments include width/depth ratios, residual pool depths, pool frequency, large woody debris frequency, pebble counts, and the percentage of fine sediment in pool tails <6mm via grid toss.

5.3.9 Beaverhead Deerlodge Regional Reference Data

Regional reference data are available from the Beaverhead Deerlodge National Forest (BDNF). BDNF data were collected between 1991 and 2002 from approximately two hundred reference sites: seventy of the sites are located in the Greater Yellowstone Area and the remaining sites are in the BDNF, which is also located in southwestern Montana (Bengeyfield, 2004). Applicable reference data are width/depth ratios, entrenchment ratios, and fine sediment <6mm from pebble counts.

5.3.10 BLM Watershed Assessments

Watershed Assessments are available from the Bureau of Land Management and include Beaverhead West, Blacktail, East Bench, and East Grasshopper assessment areas. Relevant data collected during these assessments includes rangeland, riparian, and biodiversity health.

5.4 Water Quality Targets and Comparison to Existing Conditions

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

In developing targets, natural variation throughout the river continuum must be considered. As discussed in more detail in **Section 3** and **Appendix B**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is utilizing reference site data, but modeling, professional judgment, and literature values may also be used. The DEQ defines “reference” as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody’s greatest potential for water quality given historic and current land use activities. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated beneficial uses because they are based on the reference approach, which strives for the highest achievable condition. Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations due to climate, bedrock, soils, hydrology and other natural physiochemical differences yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity.

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

5.4.1 Water Quality Targets

The sediment water quality targets for the Beaverhead TPA are summarized in **Table 5-3** and described in detail in the sections that follow. Sediment-related targets for the Beaverhead TPA are based on a combination of reference data from the BDNF, from the Middle Rockies portion of the PIBO dataset, and sample data from the DEQ 2010/2011 sampling effort. **Attachment C** provides a summary of the DEQ 2010/2011 sample data and a description of associated field protocols.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999), water quality targets for the Beaverhead TPA are comprised of a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e., fine sediment and biological indices).

Target parameters and values are based on the current best available information, but they will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one or more target values does not necessarily equate to a determination that the information supports impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values.

Table 5-3. Sediment Targets for the Beaverhead TPA

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of fine surface sediment in riffles via pebble count (reach average)	Channel slope ≤ 2% for 6mm ≤ 17% Channel slope > 2% for 6mm ≤ 10% E channels for 6mm ≤ 30% Channel slope ≤ 2% for 2mm ≤ 11% Channel slope > 2% for 2mm ≤ 7% E channels for 2mm ≤ 25%
	Percentage of fine surface sediment < 6mm in pool tails via grid toss (reach average)	B & C channels ≤ 9% E channel: No target value Beaverhead River: No target value

Table 5-3. Sediment Targets for the Beaverhead TPA

Parameter Type	Target Description	Criterion
Channel Form and Stability	Bankfull width/depth ratio (reach average)	B stream type: > 12 and < 16 C stream type: > 12 and < 23 E & A stream types: < 12 Beaverhead River: No target value
	Entrenchment ratio (reach median)	A stream type: > 1.4
		B stream type: > 1.4-2.2
		C and E stream types: > 2.2
Instream Habitat	Residual pool depth (reach average)	< 15' bankfull width : > 0.9 (ft)
		> 15' bankfull width : > 1.4 (ft)
		Beaverhead River: No target value
	Pools/mile	< 15' bankfull width : ≥ 90
		15' - 30' bankfull width: ≥ 52
		> 30' bankfull width : ≥ 15
		Beaverhead River: No target value
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 56% understory shrub cover (where potential exists)
	Percent of streambank with bare ground	< 1% (recent ground disturbance)
Sediment Supply	Riffle stability index	<70 for B stream types >45 and <75 for C stream types
Biological Index	Macroinvertebrate bioassessment threshold	O/E ≥ 0.80

5.4.1.1 Fine Sediment

The percent of surface fines less than 6 mm and 2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard, et al., 1984; Suttle, et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species, and because the particle size defined as "fine" is variable and some assessment methods measure surficial sediment while others measure subsurface fine sediment, literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle, et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10 to 40 percent fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea, et al., 2000). Bryce, et al. (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment < 2mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development, but because increasing concentrations of fine sediment are known to be harmful to aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B**, and consistent with Montana's water quality standard for sediment as described in **Section 3.2**.

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

Surface fine sediment measured in riffles by the modified (Wolman, 1954) pebble count indicates the particle size distribution across the channel width is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2010/2011 were performed in four riffles per sampling reach for a total of at least 400 particles.

BDNF reference data and Middle Rockies PIBO reference data were examined for fine sediment < 6 mm during the development of these targets. The BDNF reference data for pebble count was collected using the "zigzag" method, which includes both riffles and pools. The PIBO pebble count data are also a composite of riffle and pool particles. Both of these methods of collection likely result in a higher percentage of fines than a riffle pebble count, which was the method used for TMDL related data collection in the Beaverhead TPA, and because of this difference in methodology, the median statistic is applied (as discussed in **Section 5.4**) to reflect the desired condition. Targets for fine sediment < 6 mm are set at less than or equal to the median of the BDNF reference dataset **(bold** in **Table 5-4)**. The BDNF dataset is derived from regional sites and best represents target conditions.

In order to derive targets for fine sediment < 2 mm from the BDNF dataset, a ratio was determined through review of the proportionality of the 2010/2011 DEQ data. It is assumed in this watershed that the proportion of < 2 mm particles to < 6 mm particles will be relatively consistent, regardless of sediment volume. Therefore, the DEQ data, despite being taken from predominantly impaired segments, provides a resource to review this proportionality. That ratio (dividing the < 2mm median value by the <6 mm median value for both high and low gradient slopes) was then used with the BDNF reference data to develop targets for percent fines < 2mm **(bold** in **Table 5-5)**.

Values are based on slope, as high gradient reaches are typically "transport" reaches, or those reaches where slope and velocity are conducive to the movement of sediment through a system, rather than low gradient reaches, which tend to deposit sediment on the stream bottom. As a result, it is expected that transport reaches will have less percent surface fines than low gradient reaches. Due to an inherently high percentage of fines typical in Rosgen Type E channels, E channel values were examined separately. Because of the large amount of data available for E channels from the BDNF dataset, E channel targets for percent fines < 6mm are set at ≤ 30 and percent fines < 2mm are set at ≤25 based on the ratio taken from the DEQ dataset. Target values should be compared to the reach average value from pebble counts.

Table 5-4. 2010/2011 DEQ Data Summary and BDNF Reference Dataset Median Percent Fine Sediment < 6 mm. Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
BDNF reference – Channel Slope ≤ 2% (excludes E channels)	30	Median	**17**
BDNF reference - Channel Slope > 2%	49	Median	**10**
BDNF reference (E channels only)	64	Median	**30**
DEQ Sample Data – Channel Slope ≤ 2% (excludes E channels)	21	Median	32
		25th	25
DEQ Sample Data - Channel Slope > 2%	8	Median	39
		25th	29
Sample Data (E channels only)	1	Median and 25th	48

Table 5-5. 2010/2011 DEQ Data Summary and BDNF Reference Dataset Median Percent Fine Sediment < 2 mm. Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
BDNF reference – Channel Slope ≤ 2% (excludes E channels)	Extrapolated from DEQ ratio	Median	**11**
BDNF reference - Channel Slope > 2%	Extrapolated from DEQ ratio	Median	**7**
BDNF reference (E channels only)	Extrapolated from DEQ ratio	Median	**25**
DEQ Sample Data – Channel Slope ≤ 2% (excludes E channels)	21	Median	21
		25th	17
DEQ Sample Data - Channel Slope > 2%	8	Median	28
		25th	22
Sample Data (E channels only)	1	Median and 25th	24

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

Grid toss measurements in pool tails assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer, et al., 1993) was used to estimate the percent surface fine sediment < 6mm in pool tails in the Beaverhead TPA, and three tosses, or 147 points, were performed and then averaged for each assessed pool.

Grid toss reference data for pool tails are available from the PIBO dataset. The 75th percentile of the PIBO reference data for pool tails is 18% and the median is 9% (**Table 5-6**). PIBO performs three grid tosses at every pool encountered, and DEQ performs three grid tosses in each scour pool encountered where appropriate sized spawning gravels have been identified and the potential for spawning exists. Given that the DEQ performs a grid toss only in pools where spawning gravels exist, the resulting fines may be higher in pools found in the PIBO reference dataset, and because of this difference, the median statistic of the PIBO reference data is applied (as discussed in **Section 5.4**) to reflect the desired condition. The pool grid toss target for fine sediment less than 6 mm is set at 9%, using the median of the reference dataset. Due to an inherently high percentage of fines in Rosgen Type E channels, E channels will be evaluated independently.

Table 5-6. PIBO Reference and 2010/2011 DEQ Data Percentiles for Percent Fine Sediment < 6 mm via Grid Toss in Pool Tails. Target values are indicated in bold.

Data Source	Sample Size (n)	Parameter	Summary
PIBO Pool Tail	70	Median	**9**
		75th	18
DEQ 2010/2011 Sample Data Pool Tail	134	Median	19
		25th	11

*Each grid toss was counted as a sample

5.4.1.2 Channel Form and Stability

5.4.1.2.1 Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are dimensionless values representing fundamental aspects of channel morphology. Each provides a measure of channel stability, as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e., riffles, pools, and near bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald, et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in-channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood events versus having energy dissipation on the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Rosgen, 1996; Knighton, 1998; Rowe, et al., 2003). Width/depth and entrenchment ratios were calculated for each 2010/2011 assessment reach based on 5 riffle cross section measurements.

Width/Depth Ratio Target Development

There is reference riffle width/depth ratio data for both the BDNF and PIBO datasets. The 2010/2011 Beaverhead dataset is primarily comprised of B and C channels and on average B channels tend to have a smaller width/depth ratio than C channels (Rosgen, 1996). The target value for width/depth ratio is based on the BDNF reference dataset, which is stratified by Rosgen channel type. The width/depth ratio target for the Beaverhead TPA for B & C channel types is set at greater than 12 and less than or equal to the 75th percentile of the reference value; and for A & E channels is set at less than 12 based on Rosgen stream type classification (**Table 5-7**).

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

Data Source	Category	Sample Size	75th Percentile W/D
BDNF Reference	B channel type	30	**16**
BDNF Reference	C channel type	40	**23**

Entrenchment Ratio Target Development

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

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

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

5.4.1.3 Instream Habitat Measures

For all instream habitat measures (i.e., residual pool depth and pool frequency), there is available reference data from PIBO. All of the instream habitat measures are important indicators of sediment input and movement as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to sediment impacts. The use of instream habitat measures in evaluating or characterizing impairment needs to be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

Residual Pool Depth

Residual pool depth, defined as the difference between the pool maximum depth and the pool tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods (Nielson, et al., 1994; Bonneau and Scarnecchia, 1998; Baigun, 2003). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment (fine or coarse), a reduction in-channel obstructions (such as large woody debris), and changes in-channel form and stability (Bauer and Ralph, 1999). A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also impair fish condition by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems.

The definition of pools for the PIBO protocol is fairly similar to the definition used for the 2010/2011 Beaverhead sample dataset; both define a pool as having its maximum depth greater than or equal to 1.5 times the pool tail crest depth. However, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth because the DEQ protocol records all pools encountered, whereas the PIBO protocol only counts pools greater than half the wetted channel.

Because of the variance between the PIBO and DEQ methods of counting pools, the residual pool depth target is equal to or greater than the PIBO median value (**bold** in **Table 5-9**). Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths may indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis using the data collected in 2010/2011 as a baseline. Future monitoring should document an improving trend (i.e. deeper pools) at sites which fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-9. PIBO Reference and 2010/2011 DEQ Sample Data Percentiles for Residual Pool Depth (ft). Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
< 15 ft bankfull width	9	**0.9**	0.7	18	0.6	0.8
15 - 30 ft bankfull width	40	**1.4**	1.2	5	1.3	1.6
> 30 ft bankfull width	17	**1.4**	1.2	2	0.8	0.9

Pool Frequency

Pool frequency is another indicator of sediment loading that relates to changes in-channel geometry and is an important component of a stream's ability to support the fishery beneficial use for many of the same reasons associated with the residual pool depth discussed above and also because it can be a major driver of fish density (Muhlfeld and Bennett, 2001; Muhlfeld, et al., 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, aggradation of larger particles may exceed the stream's capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e., watershed area) increases.

Again, because of the difference between the PIBO and DEQ pool identification, the median statistic of the PIBO reference data is applied (as discussed in **Section 5.4**) to reflect the desired condition. The pool frequency target is equal to or greater than the PIBO median value (**bold** in **Table 5-10).** Pools per mile should be calculated based on the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-10. PIBO Reference and 2010/2011 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values. Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	N	Median	25th	n	Median	75th
< 15 ft bankfull width	9	**108**	90	18	79	127
15 - 30 ft bankfull width	40	**62**	52	5	48	53
> 30 ft bankfull width	17	**17**	15	2	34	49

5.4.1.4 Riparian Health

Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During DEQ assessments conducted in 2010/2011, ground cover, understory shrub cover and overstory vegetation were cataloged at 10 to 20 foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each monitoring reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs. While shrub cover is important for stream health, not all reaches have the potential for dense shrub cover or they may have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

At the 2010/2011 assessment sites, the 75^{th} percentile of understory shrub cover was 56%. Based on the 75^{th} percentile, a target value of ≥ 56% is established for understory shrub cover in the Beaverhead TPA. This target value should be assessed based on the reach average greenline understory shrub cover value. Because not all reaches have the potential for dense shrub cover, for any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian shrub cover.

Bare ground along Green Line

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance was observed, leaving bare soil exposed. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

At the 2010/2011 assessment sites, the 25^{th} percentile of bare ground throughout all reaches was one percent. Based on the 25^{th} percentile, a target value of $\leq$1% is established for bare ground along the greenline for streams in the Beaverhead TPA.

5.4.1.5 Sediment Supply

Riffle Stability Index

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

5.4.1.6 Biological Indices

Macroinvertebrates

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

The macroinvertebrate assessment tool used by DEQ is the Observed/Expected model (O/E). The rationale and methodology for the index is presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). The O/E model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled and is expressed as a ratio of the Observed/Expected taxa (O/E value). However, scores in excess of 1.2 may not reflect the effects of sediment in the stream if there is an abundance of nutrients or a condition beyond the experience of the model, such as a large river system or a reference site not used to build the model. An O/E score of > 0.80 is established as a sediment target in the Beaverhead TPA, keeping in mind that scores over 1.2 may indicate excess nutrients or a condition beyond the experience of the model.

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

5.4.1.7 Suspended Sediment Concentration (SSC) and Turbidity

Suspended solids consist of organic and inorganic materials that are transported to surface waters by overland flow or introduced into a system from streambank erosion. SSC is often used as an indicator of the amount of fine sediment moving through the system. Suspended sediment monitoring provides a direct measure of sediment transport dynamics, while turbidity (which is highly correlated with suspended sediment levels) provides an indirect, but more easily conducted measure of sediment. Suspended sediment and turbidity are seasonally variable and strongly correlated to stream discharge. Turbidity and suspended sediment concentrations tend to be hysteretic, with higher values on the rising limb of the hydrograph relative to the falling limb. In supply limited, high-energy stream environments, increased concentrations of suspended sediment during peak flows do not necessarily correspond to impairment of biological function.

The inherent seasonal variability of suspended sediment concentrations, and indirect link to biological impacts makes this a challenging variable to use for sediment targets. Additionally, insufficient data for turbidity and SSC exist to determine natural conditions. Therefore, sediment targets will not be expressed in terms of SSC or turbidity. This approach is taken based on the assumption that addressing other indicators of sediment will reduce SSC inputs to levels expected with reasonable land, water, and soil conservation practices in place. However, both SSC and turbidity data collected on the Beaverhead River by the USGS in 2010 will be used to support the TMDL development determination on the lower segment.

5.4.2 Existing Condition and Comparison to Water Quality Targets

This section presents summaries and evaluations of relevant water quality data for Beaverhead TPA waterbodies appearing on the Montana 2012 303(d) list. The weight-of-evidence approach described earlier in **Section 4.1**, using a suite of water quality targets, has been applied to each of the listed water quality impairments. Data presented in the section comes primarily from sediment and habitat assessments performed by DEQ during summer 2010/2011. Results of the 2010/2011 assessment are supported by additional data collected by DEQ in the DEQ Assessment Files, the Bureau of Reclamation, the USGS, KirK Engineering and Natural Resources, Hydro Solutions Inc. (HSI), and by data supplied by the Beaverhead National Forest. However, this section is not intended to provide an exhaustive review of all available data.

5.4.2.1 Beaverhead River (upper) MT41B001_010

The upper segment of the Beaverhead River is not listed for sedimentation/siltation on the 2012 303(d) List; however, it is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. The upper segment of the Beaverhead River flows 11.5 miles from the Clark Canyon Dam to Grasshopper Creek.

Physical Condition and Sediment Sources

In 2011, DEQ performed two cross sections at two monitoring sites on the upper segment of the Beaverhead River. The upstream site (BEAV 04-02) was located on the Clark Canyon Ranch just downstream of the HWY 15 overpass. Stream channel conditions at the reach included landform confinement and subsequent braiding when the channel opened, with several oxbows and back sloughs observed. There was some embedded cobble and few fines. Stream channel measurements at the reach resembled Rosgen type C4. Bank erosion at the reach was minimal, because of heavily vegetated riparian areas. A good portion of the riparian area was fenced-in and included water gaps, with evidence of heavy livestock grazing just outside of the riparian area adjacent to the fencing (**Figure 5-2**). The fencing has allowed the riparian area to develop quality vegetation dominated by sandbar willow, sedge along the water's edge, wetland grasses, rose, and currant.

Figure 5-2. Heavy willow browse outside of fenced riparian area

The downstream site of the upper segment of the Beaverhead River (04-05) was located at the Pipe Organ Fishing Access site just off of HWY 15, downstream of the bridge. Stream channel conditions at this reach included an abundance of sand and silt, with some embedded substrate. The reach was channelized and rip-rapped in areas. Stream channel measurements at the reach resembled Rosgen type C4. Bank erosion at the reach was minimal, with spotty erosion from recreational access to the river. The reach had several depositional bars consisting of fines along the sides of the channel. The reach had good riparian cover with sandbar willow, rose, and prickly currant in the areas that were not rip-rapped.

Comparison to Water Quality Targets
The existing data in comparison to the targets for the upper segment of the Beaverhead River are summarized in **Table 5-11** (See **Figure 5-3** for map). All bolded cells represent conditions where target values are not met.

Table 5-11. Existing Sediment-Related Data for the Upper Beaverhead River Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
BEAV 04-02	2011	98	C4	C3	8	6		40	3.4				
BEAV 04-05	2011	102	C4	C3	**21**	**20**		39	4.2				

Values that do not meet the target are in **bold**. Some parameters were not considered for targets on the Beaverhead River mainstem (parameter and values italicized).

Figure 5-3. Upper Beaverhead River DEQ Assessment Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Site BEAV 04-02 on Clark Canyon Ranch did not show signs of impairment at the time of sampling and the reach itself had abundant native wetland vegetation and the streambanks were in good condition. However, located just above the site, Clark Canyon Creek has been known to deliver large loads of fine sediment into the Beaverhead River during heavy spring precipitation events. The reservoir releases from Clark Canyon Dam have not been timed to correlate with tributary sediment discharges into the Beaverhead River, and in certain years, limited releases in the spring have resulted in large depositions of fine sediment in the upper segment of the Beaverhead River (**See Figure 5-4**). The Montana DEQ funded the Bureau of Reclamation (BOR) to perform a flushing flow analysis to determine the flows that would activate the sediment deposited from Clark Canyon Creek into the Beaverhead River (See **Attachment A** for the complete report). The result of the analysis indicates that a flow of 350 cfs may mobilize the sediment in the upper reach near the dam. The DEQ recommends that the release of 350 cfs be timed in conjunction with spring runoff events to be in accordance with reasonable water impoundment operations (ARM §17.30.636) and to meet the definition of all reasonable land, soil, and water conservation practices. It is noted however, that Montana's water quality law cannot divest, impair, or diminish legally obtained water rights, (MCA §75-5-705) and therefore meeting water rights may override managing reservoir releases to provide flushing flows for sediment mobility.

The site at Pipe Organ (BEAV 04-05) exceeded the riffle pebble count target values for fine sediment. Because of the limited amount of targets for the Beaverhead River mainstem, it is important to focus on the contribution and possible reduction from tributaries to the Beaverhead River. Excess fines in the upper segment of the Beaverhead River are related to the deposition of sediment that makes its way down from the outlet of Clark Canyon Creek. Because of the contribution of fine sediment from Clark Canyon Creek, it is important that dam releases coincide with spring runoff events, as mentioned above. Since a TMDL has been written for Clark Canyon Creek, and Clark Canyon Creek serves as the most significant source of sediment to the upper segment of the Beaverhead River, and the management and control of sediment deposition in the upper segment of the Beaverhead River is directly related to reservoir operations, no TMDL will be developed at this time for the upper segment of the Beaverhead River. It is assumed that if flushing flows are instituted to mobilize sediment in the Beaverhead River and the Clark Canyon Creek TMDL is met, sediment will not be an issue for the upper segment of the Beaverhead River.

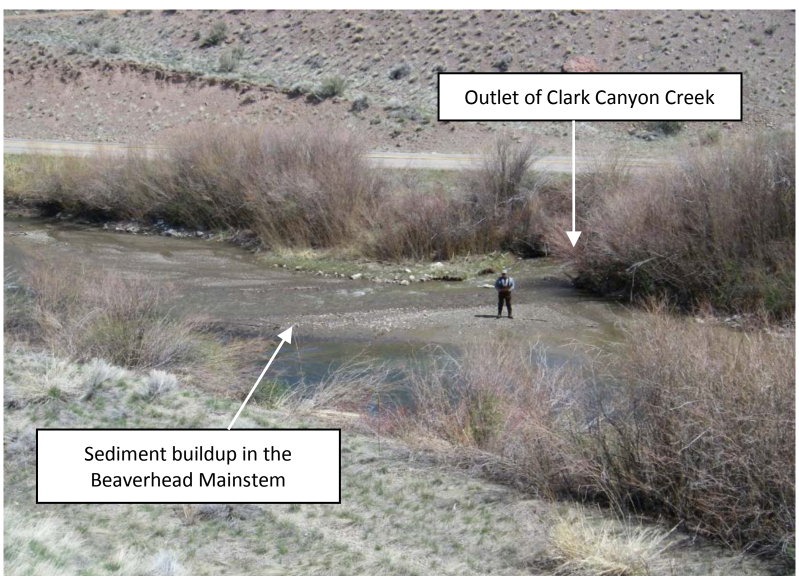

Figure 5-4. Sediment buildup in the Beaverhead River from Clark Canyon Creek (Oswald, FWP, 2009)

5.4.2.2 Beaverhead River (lower) MT41B001_020

The lower segment of the Beaverhead River is listed for sedimentation/siltation on the 2012 303(d) List. In addition, the lower segment of the Beaverhead River is also listed for alterations in streamside or littoral vegetative covers, flow alterations, and physical substrate habitat alterations; which are non-pollutant forms of pollution commonly linked to sediment impairment. The lower segment of the Beaverhead River flows 62.8 miles from Grasshopper Creek to the mouth (Jefferson River).

Physical Condition and Sediment Sources

In 2010, DEQ performed modified sediment and habitat assessments at five monitoring sites on the lower segment of the Beaverhead River. The uppermost site (BEAV 09-04) was located just below the

East Bench Canal Diversion off of Old Stage Rd. Stream channel conditions at the reach included a berm on river right from past channel manipulation and recent deposition of fill at the water's edge, with additional channel and flow manipulation for field irrigation. Stream channel measurements at the reach resembled Rosgen type C4. Within the sample reach, a layer of fines covered the gravel and cobble substrate and the reach had minimal pool habitat. Bank erosion at the site was minimal, where sandbar willow held the banks together. However, the lower quarter of the reach had some localized erosion where there was no fencing to keep grazing out of riparian area. The vegetation on river right, located next to cropland, was composed of mostly reed canary grass. Whereas the vegetation on river left, which had the riparian area fenced off from grazing and included a water gap, had high willow cover, sedge on the water's edge, grass ground cover, and decadent cottonwoods (**Figure 5-5**).

Figure 5-5. Difference in riparian cover on river right and left (BEAV 09-04)

The next site downstream (BEAV 09-06) was located on private property just above Dillon on Wheat Lane. Stream channel conditions at the reach included very thick growth of green algae and aquatic plants, which covered about 90% of the gravel and cobble substrate; with significant fines trapped by the algae and vegetation. Most of the substrate under the algae was embedded with fines and a white mineral crust. Stream channel measurements at the reach resembled Rosgen type C4. There were two types of eroding banks located at the reach; one caused by historical grazing, which was revegetating because of riparian fencing. The other type was a high bank located on outer meander bends, where the river was naturally cutting into the bank. The riparian vegetation was mostly pasture grass (including reed canary) and weeds (thistle and hounds-tongue), with some sedge and bulrush at the water's edge. There was some willow, mostly mature, with signs of historic overgrazing.

The middle site on the lower segment (BEAV 09-11) was located just north of the bridge on Anderson Lane. Stream channel conditions at the reach included a substrate dominated by sand and gravels, covered by aquatic vegetation. Any cobble present was not providing additional habitat as fines had filled in interstitial spaces. Stream channel measurements at the reach resembled Rosgen type E5. The majority of the banks were not eroding as tall grass, sedge, and willow dominated the riparian area. The meandering channel caused some erosion at outside bends. Historic grazing, resulting in a lack of established vegetation in places at outside bends, may have contributed to erosion at these locations.

There was evidence of heavy grazing historically on both river left and right; however, the riparian area was recovering with wetland vegetation cover and willows.

The fourth site on the lower segment (BEAV 09-14) was located at Beaverhead Rock, just upstream of the bridge on MT-41. Stream channel conditions at the reach included deep pools (5' to 6') and some smaller scour pools. The substrate was mostly gravel in riffles with sand interspersed, and heavy fines in slower water. Stream channel measurements at the reach resembled Rosgen type C4. River left was armored with riprap in places and eroding to fence-line in some locations. Bank erosion occurred mostly around the bridge and on river left due to grazing and riparian shrub removal. The reach was dominated by reed canary grass with some sedge, bulrush, and spike sedge at the water's edge.

The most downstream site on the lower segment of the Beaverhead River (BEAV 09-15) was located off of Silver Bow Lane, with the reach boundaries both up and downstream of the bridge. Stream channel conditions included an abundance of fine sediment, ranging from sand to clay, with some gravels and cobble. Pools were shallow throughout the reach. Stream channel measurements at the reach resembled Rosgen type C4/C5. Bank erosion occurred on outside meander bends where the stream naturally cut into the side of the bank; however, historic and current riparian grazing have left the banks with minimal vegetation and minimal deep binding root mass, increasing the vulnerability of banks to erosion. Banks were pugged throughout the reach and livestock browse was suppressing willow regeneration and reducing shrub cover. Sedges and meadow foxtail were found at the water's edge with some skunk bush, rose, snowberry, and birch in higher areas.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the lower segment of the Beaverhead River are summarized in **Table 5-12**. The macroinvertebrate bioassessment data for the lower segment of the Beaverhead River is located in **Table 5-13** (See **Figure 5-6** for map). All bolded cells represent conditions where target values are not met.

Table 5-12. Existing Sediment-Related Data for the Lower Beaverhead Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
BEAV 09-04	2010	73	C4	C4	**52**	**37**		32	3.5			**51**	**2**
BEAV 09-06	2010	90	C4	C4	**43**	**36**		44	2.7			**15**	**5**
BEAV 09-11	2010	74	E5	E4				29	5.1			**39**	**9**
BEAV 09-14	2010	105	C4	C4	**43**	**38**		*46*	**3.1**			**39**	**8**
BEAV 09-15	2010	86	C4/C5	C4				38	3.2			**3**	**3**

Values that do not meet the target are in **bold**. Some parameters were not considered for targets on the Beaverhead River mainstem (parameter and values *italicized*).

Table 5-13. Macroinvertebrate Bioassessment Data for Lower Beaverhead River

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02BVHDR01	45.183383	-112.689983	Low Valley	26-Jul-02	HESS	1.1
M08BEAVR01	45.545278	-112.335556	Low Valley	26-Jul-02	HESS	1.3
M02BVHDR01	45.183383	-112.689983	Low Valley	30-Jul-03	KICK	1.3
M08BEAVR01	45.545278	-112.335556	Low Valley	31-Jul-03	KICK	1.1
M08BEAVR01	45.545278	-112.335556	Low Valley	29-Jul-04	KICK	1.1
M02BVHDR01	45.183383	-112.689983	Low Valley	28-Jul-04	HESS	1.0
M02BVHDR01	45.183383	-112.689983	Low Valley	28-Jul-04	HESS	1.1

Values that do not meet the target are in **bold**.

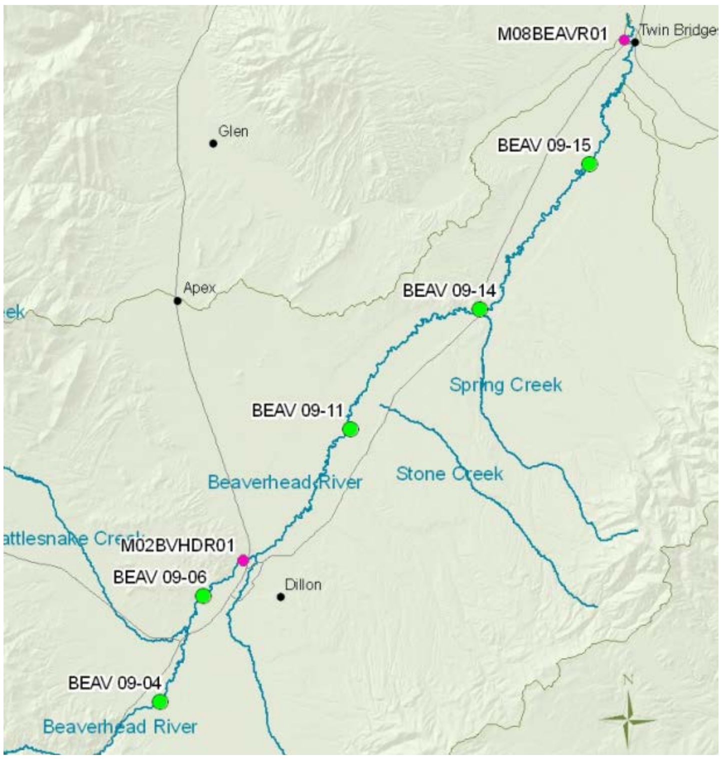

Figure 5-6. Lower Beaverhead River DEQ Assessment Sites and Macro Sites

Assessment methods were revised for some measurement variables to allow sampling in non-wadeable reaches (**see Appendix C**). Categorical data for channel substrate collected on non-wadeable reaches of the Beaverhead River are summarized in **Table 5-14**. These data provide a general picture of the size class of substrate in assessed non-wadeable reaches, but are not directly comparable to percent fine sediment data collected by Wolman pebble count.

Table 5-14. Percent of Substrate by Reach for each Cross-section per Substrate Type

Reach Id	Substrate	% of Substrate			Reach Average
		XS1	XS2	XS3	
BEAV_09_04	Silt / Clay	5	23	1	10
	Sand	60	33	44	45
	Gravel	32	35	31	32
	Cobble	3	9	25	12

Table 5-14. Percent of Substrate by Reach for each Cross-section per Substrate Type

Reach Id	Substrate	% of Substrate			Reach Average
		XS1	XS2	XS3	
BEAV_09_11	Silt / Clay	12	-	-	12
	Sand	60	-	-	60
	Gravel	28	-	-	28
	Cobble	0	-	-	0
BEAV_09_14	Silt / Clay	9	1	20	10
	Sand	42	53	43	46
	Gravel	47	39	29	38
	Cobble	2	7	8	6
BEAV_09_15	Silt / Clay	26	19	15	20
	Sand	45	31	33	36
	Gravel	28	46	46	40
	Cobble	1	4	6	4

Additional data and data summaries for longitudinal profiles and channel cross-sections from non-wadeable reaches are included in **Appendix C**. Few trends are evident from the data, but review of the cross-section plots reveals a high proportion of fine sediment in the downstream Beaverhead River reaches, and in some cross-sections of reaches further upstream.

See **Appendix D** for additional data collected by USGS and HSI.

Summary and TMDL Development Determination

All reaches sampled in 2010/2011 failed to meet fine sediment and riparian health targets. Because of the limited amount of targets for the Beaverhead River mainstem, the focus on sediment reduction will be on the tributaries to the Beaverhead River. Several tributaries including Clark Canyon Creek and Grasshopper Creek have contributed excess fines to the Beaverhead River. As discussed in **Section 5.4.2.1**, the DEQ recommends that the BOR coordinate dam releases that coincide with spring runoff events in order to flush excess sediment, coming in from tributaries, through the Beaverhead River (see **Attachment A**). The dam needs to be operated in a reasonable manner, in accordance with ARM §17.30.636, which states that owners and operators of water impoundments that cause conditions harmful to prescribed beneficial uses of state water shall demonstrate to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects. Flushing flow is considered a reasonable operation under most conditions (an exception being drought conditions) to keep from creating depositional areas harmful to fish and aquatic life. DEQ recognizes that water rights may override managing reservoir releases to provide flushing flows for sediment mobility. The BOR flushing flow analysis should be expanded to the lower portion of the Beaverhead River, beyond the irrigation diversion at Barretts, to determine the spatial distribution of sediment and the types of flows necessary to mobilize and flush sediment throughout the entire Beaverhead River.

The banks of the Beaverhead River consist primarily of reworked gravel and sand from the Neogene Sixmile Creek Formation (Thomas, Dr. R., personal communication 2011). Historic and current grazing in the riparian area and along streambanks downstream of Dillon was liberating sediment contained within the banks. Excess sediment is an issue in the Beaverhead River because of inadequate grazing management practices along the mainstem of the river, a large contribution of sediment from tributaries, and dam operations that are not currently releasing flushing flows that coordinate with spring runoff events. Therefore, a sediment TMDL will be developed for the lower segment of the Beaverhead River.

5.4.2.3 Blacktail Deer Creek MT41B002_030

Blacktail Deer Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Blacktail Deer Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Blacktail Deer Creek flows 39.9 miles from the confluence of the West and East Forks of Blacktail Deer Creek to the mouth (Beaverhead River).

Physical Condition and Sediment Sources

In 2010, DEQ performed sediment and habitat assessments at three monitoring sites on Blacktail Deer Creek. The uppermost site (BLKD 02-08) was located on the Matador Ranch, downstream of the USGS gaging station. Stream channel conditions at the reach included good pool diversity, a gravel-dominated substrate, and many meanders. Fine sediment was found close to banks and under aquatic vegetation, with moderately high fines in pool tail-outs. Stream channel measurements throughout the reach resembled Rosgen type C4 and E4. Bank erosion was mostly from low natural scour under sedges. An occasional cattle or game crossing area contributed some sediment. One high eroding bank was noted as the major source of sediment in the system and was naturally occurring on a high terraced outside meander bend. Riparian vegetation was highly diverse with sedges predominate in the understory and thick growth of willow, river birch and dogwood throughout. Some juniper encroachment was found within the floodprone area. Recent grazing had occurred in this area, but cattle access to the stream was limited, and the area seemed to be recovering from heavy historic grazing.

The middle site on Blacktail Deer Creek (BLKD 02-14) was located downstream of Buster Brown Road, east of Blacktail Road. Stream channel conditions at the reach included a few good deep pools, generally under cottonwood trees and good gravels. The channel appeared to have been straightened, with minimal overhanging vegetation and large woody debris. Stream channel measurements throughout the reach resembled Rosgen type C4/F. The reach had many eroding banks mainly due to grazing. Riparian vegetation included a narrow band of decadent cottonwoods with few, heavily browsed willow and cottonwood seedlings. Wetland graminoids were found near the water’s edge, but the understory was otherwise covered in grasses, with houndstongue and Canada thistle prevalent throughout. This reach showed signs of overgrazing.

The downstream site (BLKD 02-30) was located in Dillon at the Blacktail Meadows Fishing Access Site on Blacktail Deer Creek. Stream channel conditions at the site included many deep pools with high fines in slower water. Gravels were highly embedded with a fine layer of silt on top and a mineral crust found on rocks and other objects in the stream. Stream channel measurements throughout the reach resembled Rosgen type C4. Streambanks were mostly low naturally scoured banks, found under willows, with some banks trampled due to recreational foot traffic. One high actively eroding bank was found at a pumping site along the stream. Streambanks had moderate willow cover, with areas of reed canary grass, meadow foxtail, and wetland graminoids near the water’s edge. This reach is heavily used for recreation and had a lot of garbage, cement rubble, and rusty metal parts found in the channel.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Blacktail Deer Creek are summarized in **Table 5-15**. The macroinvertebrate bioassessment data for Blacktail Deer Creek is located in **Table 5-16** (See **Figure 5-7** for map). All bolded cells represent conditions where target values are not met.

Table 5-15. Existing Sediment-Related Data for Blacktail Deer Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		Sediment supply
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline% Bare Ground	RSI
BLKD 02-08	*2010*	*30*	*C4/E4*	*C4/E4*	**28**	**20**	**19**	*17*	*8.9*	*1.6*	**48**	**42**	**22**	
BLKD 02-14	2010	24	C4/F	C4	**22**	**17**	3	17	**1.3**	**1.3**	**42**	**38**	**6**	68
BLKD 02-30	2010	24	C4	C4	**22**	**16**	**18**	22	7.1	**1.3**	69	68	0	

Values that do not meet the target are in **bold**.

Table 5-16. Macroinvertebrate Bioassessment Data for Blacktail Deer Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
REFBDC	45.005278	-112.445	Mountains	30-Aug-03	WEMAP-RW	1.2
REFBDC	45.005278	-112.445	Mountains	30-Aug-03	WEMAP-TR	1.2
REFBDC	45.005278	-112.445	Mountains	06-Oct-03	WEMAP-RW	1.4
REFBDC	45.005278	-112.445	Mountains	06-Oct-03	WEMAP-TR	1.2
REFBDC	45.005278	-112.445	Mountains	13-Aug-04	HESS	0.9
REFBDC	45.005278	-112.445	Mountains	13-Aug-04	KICK	0.9
REFBDC	45.005278	-112.445	Mountains	13-Aug-04	WEMAP-RW	1.4
REFBDC	45.005278	-112.445	Mountains	13-Aug-04	WEMAP-TR	1.4

Values that do not meet the target are in **bold**.

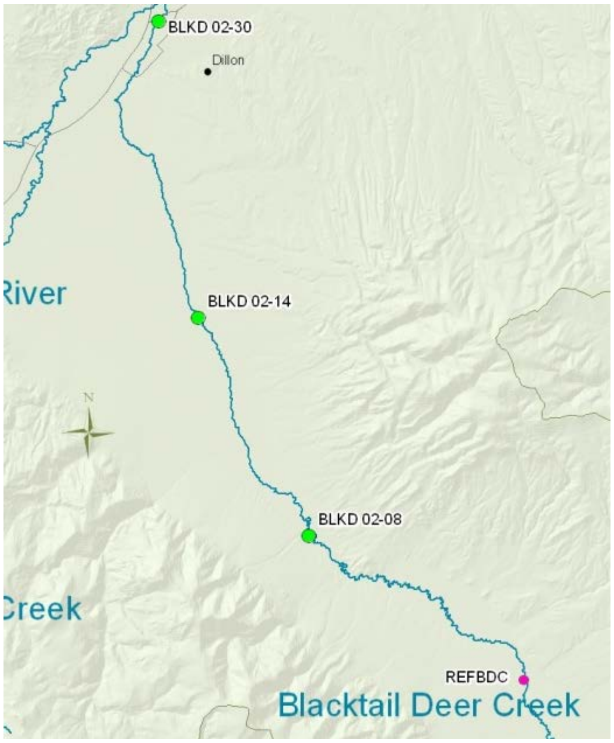

Figure 5-7. Blacktail Deer Creek DEQ Assessment Sites and Macro Sites

See **Appendix D** for additional data collected by KirK and HSI.

Summary and TMDL Development Determination

All reaches exceeded fine sediment targets in riffles and two reaches exceeded fines targets for pool tails. Both the upstream and middle reaches failed to meet pool frequency and riparian health targets. The lower and middle reach failed to meet the residual pool depth targets. Although current grazing management practices at the upper reach seemed to be allowing the riparian area to recover, shrub cover was limited by historic overgrazing within the riparian zone. Although recreational activity was liberating some bank sediment at the downstream site, throughout the majority of the stream impairment of the riparian habitat caused by historical and current grazing activities was linked to excess fine sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Therefore, a sediment TMDL will be prepared for Blacktail Deer Creek.

5.4.2.4 Clark Canyon Creek MT41B002_110

Clark Canyon Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Clark Canyon Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Clark Canyon Creek flows 8.4 miles from its headwaters to the mouth (Beaverhead River).

Physical Condition and Sediment Sources

In 2010, DEQ performed sediment and habitat assessments at two monitoring sites and a bank erosion only assessment on one site on Clark Canyon Creek. The uppermost site (CLCK 18-02), a bank erosion only site, was located on Clark Canyon Ranch property, upstream of the North Fork stream crossing. The stream channel was entrenched. Bank erosion was mostly natural with some evidence of grazing impacts. Most of the slowly eroding banks ranged from 3 to 6 feet, had a 20 degree slope, and minimal surface protection. The bank composition was made up of fines with some cobble interspersed. The actively eroding banks were lower and had evidence of hoof shear. Banks had minimal vegetated cover, mostly grasses and invasive weeds. Clark Canyon Creek had significant natural upland sediment sources (**Figure 5-8)**.

Figure 5-8. Natural upland sediment sources in Clark Canyon Creek

The middle site (CLCK 19-02) was located on Clark Canyon Ranch property. Stream channel was incised throughout the reach. Substrate was gravel and cobble with many fines in riffles and pool tail outs. Stream channel measurements throughout the reach resembled Rosgen type B4. Streambanks were scoured throughout the reach from natural high water events, and other banks were trampled from both historic and current grazing. Riparian vegetation included decadent cottonwoods, encroaching junipers, and limited shrub cover. Entrenched stream seemed to limit water access to the riparian vegetation.

The most downstream site (CLCK 32-01) was located on Clark Canyon Ranch property, just above the culvert leading under the train track and frontage road. The stream channel was entrenched in places and aggraded and braided in others, with overland flow from side channels common. There were large areas of exposed bare cobble/large gravel, including depositional areas on the floodplain. Stream channel measurements throughout the reach resembled Rosgen type B4. Streambank conditions included many actively eroding banks due to past riparian grazing, with signs of hoof shear and a lack of stabilizing riparian vegetation. Riparian vegetation seemed to be lacking due to years of overgrazing and trampling. Willows were regenerating throughout the riparian area. Cattle appeared to have been fenced out of the riparian area in recent years.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Clark Canyon Creek are summarized in **Table 5-17**. The macroinvertebrate bioassessment data for Clark Canyon Creek is located in **Table 5-18** (See **Figure 5-9** for map). All bolded cells represent conditions where target values are not met.

Table 5-17. Existing Sediment-Related Data for Clark Canyon Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		Sediment supply
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	RSI
CLKC 19-02	2010	10	B4	B3	**19**	**15**	**14**	**11**	1.7	0.9	**21**	**44**	**40**	**113**
CLKC 32-01	2010	11	B4	B3	**17**	**13**	**11**	12	1.8	0.9	**84**	**35**	**24**	**106**

Values that do not meet the target are in **bold**.

Table 5-18. Macroinvertebrate Bioassessment Data for Clark Canyon Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02CLKCC01	45.0006	-112.7822	Mountains	02-Sep-05	KICK	0.6
M02CLKCC02	45.0153	-112.8357	Low Valley	02-Sep-05	KICK	0.7
M02CLKCC03	45.0158	-112.8368	Low Valley	21-Jul-05	KICK	0.6

Values that do not meet the target are in bold.

Figure 5-9. Clark Canyon Creek DEQ Assessment Sites and Macro Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Clark Canyon Creek failed to meet fine sediment targets in pools and riffles, pool frequency targets, RSI targets, and riparian health targets. Additionally, the macroinvertebrate samples, collected during two time frames in 2005 failed to meet the Montana O/E targets. Clark Canyon Creek has a geological source of fine-grained sediment in highly erodible upland areas (concentrated in the North Fork) that are subject to mass failure and erosion. However, poor historical land management has also contributed to liberating sediments from exposed banks and removal of riparian habitat. Streambanks are composed of both cobble and fine sediment. Coarse material from streambanks has been exposed and deposited where fine sediments have washed out. Coarse sediment is mobilized during high precipitation and rain on snow events, leading to aggradation in some areas of the stream channel. Clark Canyon Creek has issues with both fine and coarse sediment and although much of the fine sediment is contributed from natural upland sources, historically poor grazing management practices have led to a sediment issue in Clark Canyon Creek and therefore a TMDL will be written. A memorandum to the FWP from Karin Boyd at Applied Geomorphology Inc. (AGI) presents several BMP recommendations for sediment reduction (see **Attachment B**)

5.4.2.5 Dyce Creek MT41B002_140

Dyce Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Dyce Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Dyce Creek flows 4.1 miles from the confluence of the East and West Forks of Dyce to Grasshopper Creek.

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on Dyce Creek. The site (DYCE 02-02), was located half a mile up Rd 1878 (off of Taylor Creek Rd). Stream channel conditions included an overwidened channel, substrate of coarse gravel and few pools of low quality. Stream channel measurements throughout the reach resembled Rosgen type C4. Bank erosion was widespread, primarily due to bank trampling and pugging from riparian grazing. Riparian vegetation included browsed sedges on lower banks and willows. This reach showed signs of historic and current overgrazing. Additionally, the Dillon Field Office of the BLM notes that historic placer mining has altered the stream dimension, pattern, profile, and likely the bed materials. Sediment from ongoing recreational placer mining continues to impact the stream and the Westslope Cutthroat Trout population.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Dyce Creek are summarized in **Table 5-19**. The macroinvertebrate bioassessment data for Dyce Creek is located in **Table 5-20** (See **Figure 5-10** for map). All bolded cells represent conditions where target values are not met.

Table 5-19. Existing Sediment-Related Data for Dyce Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
DYCE 02-02	2010	9	C4	C3	**42**	**30**	**36**	17	20.3	**0.5**	**42**	**29**	0

Values that do not meet the target are in **bold**.

Table 5-20. Macroinvertebrate Bioassessment Data for Dyce Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02DYCEC01	45.275	-113.03333	Mountains	07-Jul-04	KICK	0.98
M02DYCEC02	45.238	-113.04111	Mountains	07-Jul-04	KICK	**0.50**

Values that do not meet the target are in **bold**.

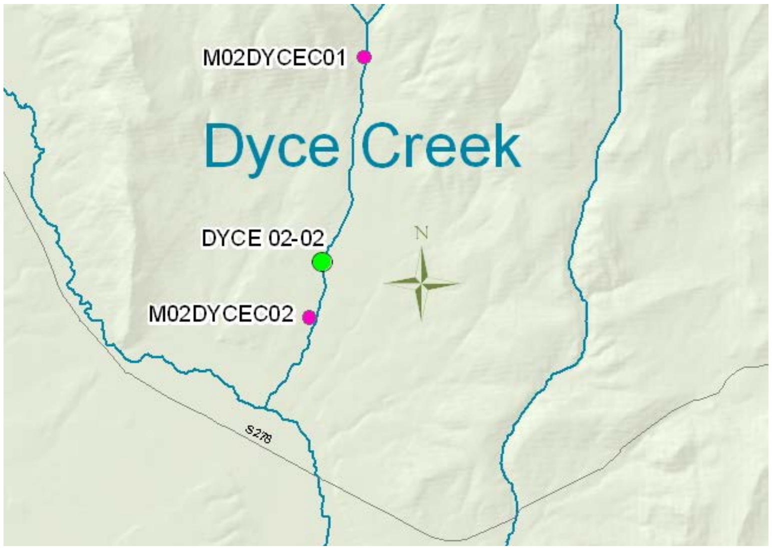

Figure 5-10. Dyce Creek DEQ Assessment Site and Macro Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination
Fine sediment targets were well exceeded in both riffles and pools at the reach in Dyce Creek. Pool frequency and residual pool depth failed to meet target values. Riparian health throughout the reach was compromised because of recent browse. The lower macroinvertebrate site failed to meet its target in 2004. Current and historic grazing practices contribute to high fine sediment percentages within the stream, which is likely limiting its ability to support fish and aquatic life. Because fine sediment targets were more than double the target values in both riffles and pools; and pool habitat targets were not met, a sediment TMDL will be written for Dyce Creek.

5.4.2.6 Farlin Creek MT41B002_020
Farlin Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Farlin Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Farlin Creek flows 6 miles from its headwaters to the mouth (Grasshopper Creek).

Physical Condition and Sediment Sources
In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on Farlin Creek. The site (FARL 28-01), was located off of HWY 278, just before Polaris, upstream from the schoolhouse. Stream channel conditions included an incised and overwidened channel with few gravels, high loads of fine sediment, and pools of generally low quality. Stream channel measurements throughout the reach resembled Rosgen type C4. Bank erosion was widespread due to hoof shear, trampling, and removal of riparian vegetation from overgrazing. Riparian vegetation includes decadent shrubs and pasture grasses, with limited shrub regeneration because of livestock grazing.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Farlin Creek are summarized in **Table 5-21**. The macroinvertebrate bioassessment data for Farlin Creek is located in **Table 5-22** (See **Figure 5-11** for map). All bolded cells represent conditions where target values are not met.

Table 5-21. Existing Sediment-Related Data for Farlin Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Streamside Habitat	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Shrub Cover
FARL 28-01	2010	7	C4	C3	**42**	**25**	**80**	**10**	2.7	**0.7**	148	**46**	1

Values that do not meet the target are in **bold**.

Table 5-22. Macroinvertebrate Bioassessment Data for Farlin Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02FRLNC01	45.338889	-113.12	Mountains	07-Jul-04	KICK	0.9

Values that do not meet the target are in **bold**.

Figure 5-11. Farlin Creek DEQ Assessment Site and Macro Site

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Fine sediment in the reach was more than double the target value in riffles and more than eight times the target value in pools. Residual pool depth failed to meet the target value. Riparian health throughout the reach was limited from recent livestock grazing. Bank trampling, erosion, and removal of riparian vegetation from current grazing contribute to high fine sediment percentages within the stream, which is likely limiting its ability to support fish and aquatic life. Because fine sediment targets were more than double the target values in riffles and far exceeded target values in pools; and residual pool depth and shrub cover targets were not met, a sediment TMDL will be written for Farlin Creek.

5.4.2.7 French Creek MT41B002_100

French Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, French Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. French Creek flows 6.5 miles from its headwaters to the mouth (Rattlesnake Creek).

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on French Creek. The site (FREN 23-01), was located off of Argenta Rd on USFS land. Stream channel has been altered from historic placer mining, with many fines and small gravel moving through the system. Stream channel measurements throughout the reach resembled Rosgen type B4. Bank erosion was limited to slowly eroding banks located on both sides of the reach. Riparian vegetation included good cover of willows and aspen, with riparian forbs and shrubs in the understory. The reach showed signs of impact from historic grazing and upstream mining. The road that parallels the stream may be an additional source of sediment.

Comparison to Water Quality Targets

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

Table 5-23. Existing Sediment-Related Data for French Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
FREN 23-01	2010	7	B4	B3	**33**	**27**	**10**	**11**	2.0	**0.6**	127	70	**6**

Values that do not meet the target are in **bold**.

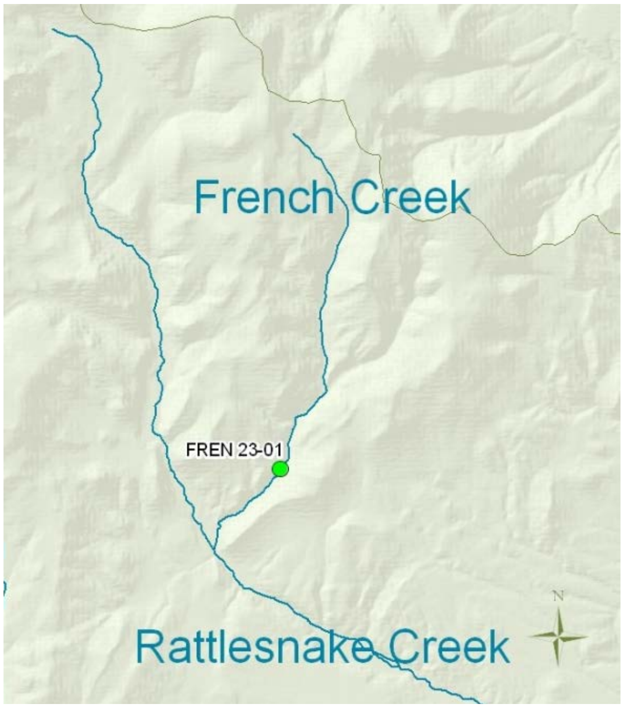

Figure 5-12. French Creek DEQ Assessment Site

See **Appendix D** for additional data collected by USFS, KirK, and HSI.

Summary and TMDL Development Determination
Fine sediment in the reach exceeded the target values in both riffles and pools. Both the width to depth ratio and residual pool depth failed to meet target values. Historic mining and grazing impacts and parallel road segments contribute sediment to the stream, which is likely limiting its ability to support fish and aquatic life. Because fine sediment targets were exceeded in both riffles and pools, and width to depth ratio, residual pool depth, and bare ground targets were not met, a sediment TMDL will be written for French Creek.

5.4.2.8 Grasshopper Creek MT41B002_010
Grasshopper Creek is not listed for sedimentation/siltation on the 2012 303(d) List; however, it is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Grasshopper Creek flows 47.5 miles from its headwaters to the mouth (Beaverhead River).

Physical Condition and Sediment Sources
In 2010, DEQ performed sediment and habitat assessments at two monitoring sites on Grasshopper Creek. The first site (GRAS 12-01), was located off of HWY 278, approximately 1.5 miles east of the W. Taylor Creek Rd. Stream channel was overwidened, with an embedded gravel substrate. Stream channel measurements throughout the reach resembled Rosgen type C4. The majority of streambanks were naturally scoured below the roots, with significant erosion at animal crossings and at banks with hoof shear. Riparian vegetation was dominated by sedge and rush; with some pasture grass, riparian forbs, thistle, and browsed willows. Possible impacts from human sources include historic and current grazing and flow manipulation from irrigation use.

The downstream site (GRAS 20-11) was located off of I-15 south of Dillon, following the dirt road that parallels Grasshopper Creek to the USGS gaging station. The stream channel was entrenched and very sinuous, with deep and frequent pools. The substrate had some embedded gravels, and silt to coarse sand in depositional areas. Stream channel measurements throughout the reach resembled Rosgen type C4. Bank erosion conditions included natural scour at low and medium bank heights, with some high unstable and actively eroding banks where the stream had cut into high terraces with pasture grasses. The majority of the riparian area was severely degraded, with minimal willow regeneration. Herbaceous wetland vegetation was observed on low terraces, but was usually grazed. Human impacts include intense current grazing pressure.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Grasshopper Creek are summarized in **Table 5-24**. The macroinvertebrate bioassessment data for Grasshopper Creek is located in **Table 5-25** (See **Figure 5-13** for map). All bolded cells represent conditions where target values are not met.

Table 5-24. Existing Sediment-Related Data for Grasshopper Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health		Sediment Supply
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground	RSI
GRAS 12-01	2010	33	C4	C4	**25**	**13**	6	**27**	10.4	**1.0**	63	**30**	**18**	**86**
GRAS 20-11	2010	29	C4	C4	**29**	**21**	**31**	**24**	**1.5**	2.3	**42**	**55**	**14**	

Values that do not meet the target are in **bold**.

Table 5-25. Macroinvertebrate Bioassessment Data for Grasshopper Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
PIBO_2649			Mountains	20-Aug-08	Surber	**0.6**
M02GHPRC01	45.474444	-113.12	Mountains	15-Sep-04	KICK	0.8
M02GHPRC01	45.474444	-113.12	Mountains	15-Sep-04	WEMAP-RW	**0.7**
M02GHPRC01	45.474444	-113.12	Mountains	15-Sep-04	WEMAP-TR	**0.7**

Values that do not meet the target are in **bold**.

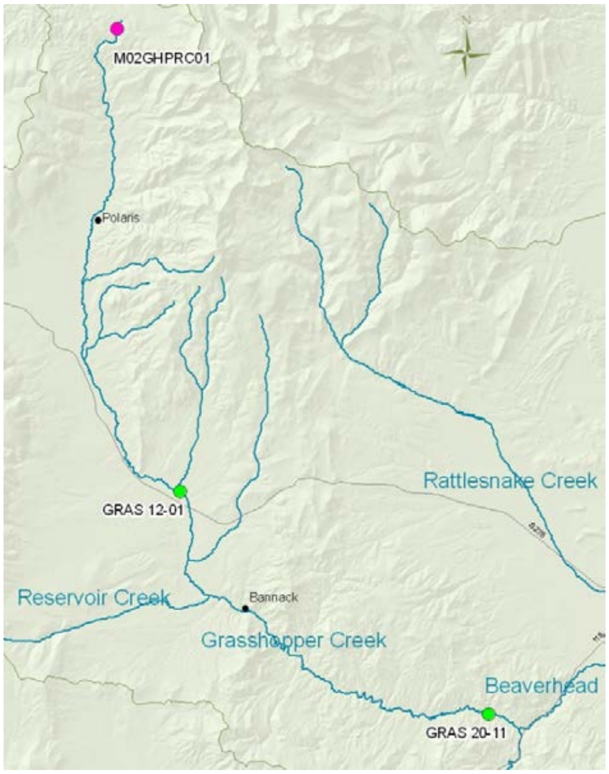

Figure 5-13. Grasshopper Creek DEQ Assessment Sites and Macro Site

See **Appendix D** for additional data collected by the USFS and HSI.

Summary and TMDL Development Determination

There were several exceedances of sediment targets in Grasshopper Creek. The upper site met its targets only in pool frequency and the pool grid toss. The lower site failed to meet every target except for residual pool depth. The macroinvertebrate samples, collected at both PIBO and DEQ sites, failed to meet the Montana O/E target in both 2004 and 2008 (with the exception of the sample collected using the kick method). Collectively, the field measurements and observations indicate that fine sediment liberated from exposed banks due to current grazing, impairment of the riparian habitat caused by historical activities and current overgrazing, and placer mining operations downstream from Bannack are all linked to excess sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Stakeholders have also expressed concern regarding the sediment contribution to the Beaverhead River from Grasshopper Creek. Therefore, a sediment TMDL will be prepared for Grasshopper Creek.

5.4.2.9 Rattlesnake Creek (upper) MT41B002_091

Upper Rattlesnake Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, upper Rattlesnake Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Upper Rattlesnake Creek flows 18.3 miles from the headwaters to Dillon PWS off-channel well (T7S R10W S11).

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on upper Rattlesnake Creek. The site (RATT 54-04), was located off of Argenta Rd on private land. Stream channel was split throughout the reach, with poorly formed pools, embedded sediment, and many fines throughout the reach. Stream channel measurements throughout the reach resembled Rosgen type C3. Bank erosion occurred mostly because of extensive grazing in the area. Riparian vegetation included large willows, alder, birch, red osier dogwood. Grazing was having a major impact on the reach, causing extensive bank erosion and fines contribution at animal crossings.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the upper segment of Rattlesnake Creek are summarized in **Table 5-26**. The macroinvertebrate bioassessment data for the upper segment of Rattlesnake Creek is located in **Table 5-27** (See **Figure 5-14** for map). All bolded cells represent conditions where target values are not met.

Table 5-26. Existing Sediment-Related Data for Upper Rattlesnake Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
RATT 54-04	2010	18	C3	C3	**23**	**19**	**12**	15	5.0	**1.3**	53	86	**18**

Values that do not meet the target are in **bold**.

Table 5-27. Macroinvertebrate Bioassessment Data for Upper Rattlesnake Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02RATSC01	45.29611	-112.90528	Mountains	20-Jul-04	KICK	0.9

Values that do not meet the target are in **bold**.

Figure 5-14. Upper Rattlesnake Creek DEQ Assessment Site and Macro Site

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination
Fine sediment targets were exceeded in both riffles and pools at the reach in the upper segment of Rattlesnake Creek. Residual pool depth in the reach was just below the target value. The reach failed to meet one of the riparian health targets because of extensive bare ground at animal crossings. The upper segment of Rattlesnake Creek was heavily grazed, and eroding banks and animal crossings were contributing sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for the upper segment of Rattlesnake Creek.

5.4.2.10 Rattlesnake Creek (lower) MT41B002_090
Lower Rattlesnake Creek is listed for sedimentation/siltation and solids on the 2012 303(d) List. In addition, lower Rattlesnake Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Lower Rattlesnake Creek flows 8.8 miles from the Dillon PWS off-channel well (T7S R10W S11) to the mouth (Van Camp Sough).

Physical Condition and Sediment Sources
In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on lower Rattlesnake Creek. The site (RATT 60-04), was located off of HWY 287 on private land. Stream channel was dewatered, and has been channelized, with very with few pools (of low quality) and little habitat diversity. Stream channel measurements throughout the reach resembled Rosgen type C4/E. Bank erosion was minimal throughout the reach because banks are held together with sedge and other grasses, and stream energy is low. There were signs of seasonal grazing, but flow manipulation seemed to be the major influence on this reach.

Comparison to Water Quality Targets
The existing data in comparison to the targets for the lower segment of Rattlesnake Creek are summarized in **Table 5-28**. The macroinvertebrate bioassessment data for the lower segment of Rattlesnake Creek is located in **Table 5-29** (See **Figure 5-15** for map). All bolded cells represent conditions where target values are not met.

Table 5-28. Existing Sediment-Related Data for Lower Rattlesnake Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
RATT 60-04	2010	5	F	C4/E	**33**	**21**	**25**	16	3.2	**0.5**	**21**	**0**	0

Values that do not meet the target are in **bold**.

Table 5-29. Macroinvertebrate Bioassessment Data for Lower Rattlesnake Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02RATSC02	45.2069444	-112.758611	Low Valley	20-Jul-04	KICK	0.9

Values that do not meet the target are in **bold**.

Figure 5-15. Lower Rattlesnake Creek DEQ Assessment Site and Macro Site

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools at the reach in the lower segment of Rattlesnake Creek. Both instream pool habitat targets were not met. The reach failed to meet the target value for shrub cover and was entirely comprised of grasses and sedges as it was located in the middle of an agricultural field. Flow just upstream of the reach across HWY 278 appeared to be at least double of that at the reach. The lower segment of Rattlesnake Creek is located in primarily agricultural land, and flow is diverted for irrigation purposes. Fines from upstream sources were accumulating in this reach as stream energy was very low. Because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for the lower segment of Rattlesnake Creek. The lower segment of Rattlesnake Creek is also listed for solids (suspended bedload), which is a pollutant that falls within the sediment pollutant category. In developing the sediment TMDL, it is assumed that solids are also addressed since satisfying the sediment TMDL targets and sediment allocations addressing both fine and coarse sediment, will result in conditions consistent with reference or naturally occurring conditions.

5.4.2.11 Reservoir Creek MT41B002_120

Reservoir Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Reservoir Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Reservoir Creek flows 12.2 miles from its headwaters to the mouth (Grasshopper Creek).

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on Reservoir Creek. The site (RESR 11-01), was located off of Reservoir Creek Rd on state land. The stream channel was overwidened, with low quality pools and excess fines. Stream channel measurements throughout the reach resembled Rosgen type C4. Bank erosion included both naturally scoured banks and banks eroding due to past and current grazing. Riparian vegetation included decadent willows, sedge, rush, a variety of grasses, milk thistle and Canada thistle. Historic and current grazing have increased sediment and reduced habitat on this reach; however, the reach had not been recently grazed and appeared to be recovering with good riparian vegetation cover.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Reservoir Creek are summarized in **Table 5-30**. The macroinvertebrate bioassessment data for Reservoir Creek is located in **Table 5-31** (See **Figure 5-16** for map). All bolded cells represent conditions where target values are not met.

Table 5-30. Existing Sediment-Related Data for Reservoir Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
RESR 11-01	2010	6	C4	C4	**28**	**17**	**16**	12	3.0	**0.7**	127	57	**6**

Values that do not meet the target are in **bold**.

Table 5-31. Macroinvertebrate Bioassessment Data for Reservoir Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02RESVC01	45.14306	-113.198	Mountains	14-Jul-04	KICK	0.9
M02RESVC02	45.14778	-113.123	Mountains	19-Jul-04	KICK	**0.6**

Values that do not meet the target are in **bold**.

Figure 5-16. Reservoir Creek DEQ Assessment Site and Macro Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools at the reach in Reservoir Creek. Residual pool depth and the bare ground riparian health measurements in the reach failed to meet target values. In 2004, the lower macroinvertebrate site failed to meet the O/E target value. Historic and recent grazing practices have contributed sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Because fines were high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for Reservoir Creek.

5.4.2.12 Scudder Creek MT41B002_180

Scudder Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Scudder Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Scudder Creek flows 4.7 miles from its headwaters to the mouth (Grasshopper Creek).

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on Scudder Creek. The site (SCUD 11-01), was located off of Scudder Creek Rd. (accessed from the Pioneer Mountains Scenic Byway) on private land. The stream channel was overwidened in areas and incised in others, with shallow and short pools filled with fine sediment. Stream channel measurements throughout the reach resembled Rosgen type B5. Bank erosion occurred mostly due to bank trampling, with some low banks having natural scour. Riparian vegetation included decadent willows, sedge, rush, pasture grass, and Canada thistle. The main influence on the reach was current grazing which was causing bank shear and channel widening.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Reservoir Creek are summarized in **Table 5-32**. The macroinvertebrate bioassessment data for Reservoir Creek is located in **Table 5-33** (See **Figure 5-17** for map). All bolded cells represent conditions where target values are not met.

Table 5-32. Existing Sediment-Related Data for Scudder Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
SCUD 11-01	2010	4	B5	B4	**68**	**31**	**87**	**9**	**3.3**	**0.4**	127	68	0

Values that do not meet the target are in **bold**.

Table 5-33. Macroinvertebrate Bioassessment Data for Scudder Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02SCDRC01	45.306944	-113.095278	Mountains	19-Jul-04	JAB	**0.5**

Values that do not meet the target are in **bold**.

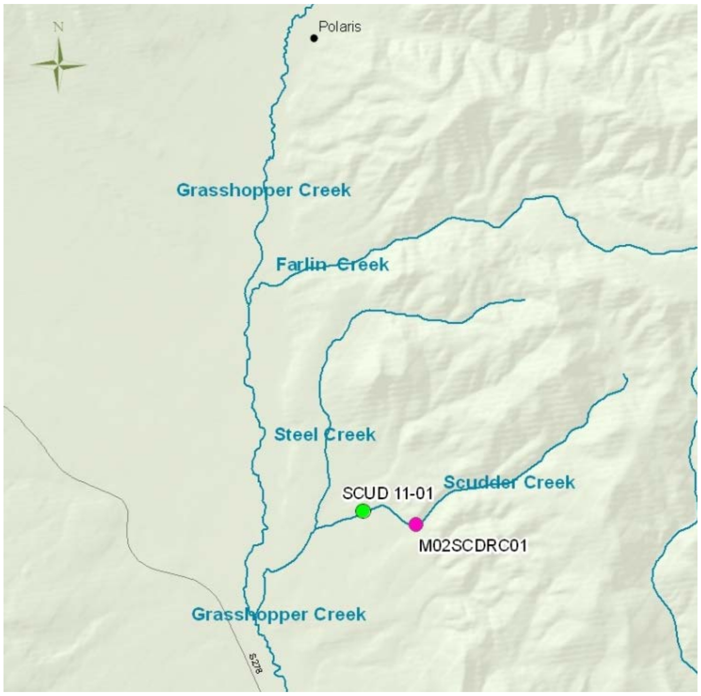

Figure 5-17. Scudder Creek DEQ Assessment Site and Macro Site

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Measurements taken within the reach failed to meet fine sediment targets in both riffles and pools, channel form targets, and residual pool depth and macroinvertebrate target values. Fines sediment in the stream is of particular concern, as target values were well exceeded in riffles and fines in pools were almost ten times the target value. Current grazing has affected the stream and trampled banks were loading sediment to the stream that is likely limiting its ability to support fish and aquatic life. Fish were observed throughout the reach. Because fines were notably high in field observations and field measurements showed that fine sediment targets were well exceeded, a sediment TMDL will be written for Scudder Creek.

5.4.2.13 Spring Creek MT41B002_080

Spring Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Spring Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Spring Creek flows 14.9 miles from its headwaters to the mouth (Beaverhead River).

Physical Condition and Sediment Sources

In 2010, DEQ performed a sediment and habitat assessment at one monitoring site on Spring Creek. The site (SPRG 30-01), was located off of Spring Creek Rd on private land. The stream channel was incised with many fines moving through the system, and few pools. Groundwater was seeping in at mid-bank. Stream channel measurements throughout the reach resembled Rosgen type G4. Bank erosion was severe and widespread from channel downcutting and trampled banks. Riparian vegetation was minimal with mostly raw banks or banks covered in Canada thistle and pasture grass. Some wetland vegetation was starting to form on new low terrace. Historic and current grazing pressure was contributing to deteriorating channel conditions in the reach.

Comparison to Water Quality Targets
The existing data in comparison to the targets for Spring Creek are summarized in **Table 5-34** (See **Figure 5-18** for map). All bolded cells represent conditions where target values are not met.

Table 5-34. Existing Sediment-Related Data for Spring Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
SPRG 30-01	2011	5	G4	C4	**28**	**12**	**29**	**7**	**1.7**	**0.6**	**74**	**9**	**26**

Values that do not meet the target are in **bold**.

Figure 5-18. Spring Creek DEQ Assessment Site

See **Appendix D** for additional data collected by KirK and HSI.

Summary and TMDL Development Determination
All parameters measured at the reach in Spring Creek failed to meet target values. Grazing, both historical and current, has had an effect on the upper portion of the stream. The lower portion of Spring Creek was in agricultural land, to which DEQ was denied access. The stream channel was incised at the reach and bank erosion was severe and widespread, with little to no vegetative cover, contributing sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Because fines were notably high in field observations and field measurements showed that all targets were not being met, a sediment TMDL will be written for Spring Creek.

5.4.2.14 Steel Creek MT41B002_160
Steel Creek is listed for sedimentation/siltation and solids on the 2012 303(d) List. In addition, Steel Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Steel Creek flows 3.8 miles from its headwaters to the mouth (Driscol Creek).

Physical Condition and Sediment Sources
In 2010, DEQ performed a full sediment and habitat assessment at one monitoring site and one visual assessment on Steel Creek. The fully assessed site (STEL 05-01), was located off of a USFS road from Scudder Rd on BLM land. The stream channel was steeper at the top of the reach and alternated between riffle and run sections and had very few and shallow pools. Stream channel measurements throughout the reach resembled Rosgen type A5. Banks were generally low, well vegetated, and pugged throughout the reach, creating small islands where browsed willows were holding the sediment together. Riparian overstory was dominated by aspen and alder with some willow, prickly currant, and rose on the ground. Regeneration of willows was limited by heavy browse and understory was predominately pasture grasses with some sedge cover. This reach was heavily grazed.

The downstream reach (STEL 10-01) that was visually assessed was located just off of Scudder Rd. The stream channel was dry at the reach in both the fall of 2010 and the spring of 2011. The lower end of the reach had a dry defined channel with long eroding banks (**Figure 5-19**). Moving up the reach, the stream channel remained dry and was difficult to define. The substrate was a mix of fines and gravel, with a few cobble noted in mid-reach. Stream appears to sink at slope change where the alluvial fan begins. The reach had long banks at the bottom of the reach that were approximately three feet high and composed of fines. Vegetation at the downstream end of the reach to the lower end of the wetted channel was composed of sagebrush with a few grasses. Human impacts include historic and current grazing throughout the reach.

Figure 5-19. Steel Creek – Dry channel

Comparison to Water Quality Targets

The existing data in comparison to the targets for Steel Creek are summarized in **Table 5-35** (See **Figure 5-20** for map). All bolded cells represent conditions where target values are not met.

Table 5-35. Existing Sediment-Related Data for Steel Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
STEL 05-01	2011	3	A5	A4	**69**	**54**		8	3.1	**0.5**	**53**	60	0

Values that do not meet the target are in **bold**.

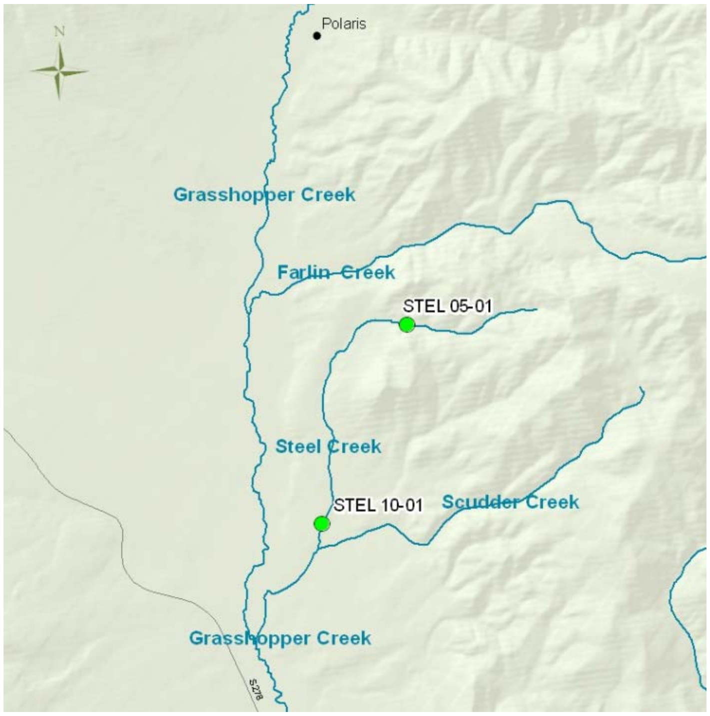

Figure 5-20. Steel Creek DEQ Assessment Sites

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools at the upper reach in Steel Creek. Both instream pool habitat targets were not met. Fine sediment measurements in riffles were seven times the target values. The stream banks were trampled from cattle, contributing fine sediment to the stream that is likely limiting its ability to support fish and aquatic life. Because of the grazing practices throughout the stream and fine sediment targets were well exceeded, a sediment TMDL will be written for Steel Creek. Steel Creek is also listed for solids (suspended bedload), which is a pollutant that falls within the sediment pollutant category. In developing the sediment TMDL, it is assumed that solids are also addressed since satisfying the sediment TMDL targets and sediment allocations addressing both fine and coarse sediment, will result in conditions consistent with reference or naturally occurring conditions.

5.4.2.15 Stone Creek (upper) MT41B002_132

Upper Stone Creek is listed for sedimentation/siltation and turbidity on the 2012 303(d) List. In addition, upper Stone Creek is listed for alterations in streamside or littoral vegetative covers and low flow; which are non-pollutant forms of pollution commonly linked to sediment impairment. Upper Stone Creek flows 10 miles from the confluence of the Left and Middle forks to the confluence of an unnamed tributary (T6S R7W S34).

Physical Condition and Sediment Sources

In 2010, DEQ performed full sediment and habitat assessments at two monitoring sites on upper Stone Creek. The upstream site (STON 05-01), was located off of Stone Creek Rd on private land. The stream channel was incised throughout most of the channel and overwidened at animal crossings. Armoring set along the channel to stabilize banks was cutting off the stream from the floodplain and increasing stream energy. The channel substrate was fairly embedded with excess fines moving through the system. Stream channel measurements throughout the reach resembled Rosgen type B/G. Bank erosion throughout the reach was caused by livestock hoof shear. Banks have been armored in some areas, with large cobble and boulders held together by rebar. Riparian vegetation includes several shrub species, pasture grasses, thistle, houndstongue, and encroaching juniper. Historic and current grazing pressure was affecting the reach with sheared and trampled banks and browsed vegetation.

The downstream site on upper Stone Creek (STON 20-02) was located off of Stone Creek Rd. on private land. The channel was incised, with few pools of poor quality, no large woody debris, and an abundance of fines. The channel has been manipulated and resembles and irrigation ditch. Stream channel measurements throughout the reach resembled Rosgen type F. Banks were low-slowly eroding with very low shear stress all throughout the reach. Riparian vegetation was dominated by upland pasture grass with Canada thistle, cocklebur, and houndstongue. Very few herbaceous riparian species were found. Human influences on the stream include agriculture and some previous grazing.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the upper segment of Stone Creek are summarized in **Table 5-36** (See **Figure 5-21** for map). All bolded cells represent conditions where target values are not met.

Table 5-36. Existing Sediment-Related Data for Upper Stone Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
STON 05-01	2010	7	B4/G	B4	**36**	**31**	**11**	**11**	2.1	**0.6**	127	**41**	**12**
STON 20-02	2010	6	F4	C4	**56**	**54**	**42**	**7**	**2.0**	**0.6**	**21**	**0**	**12**

Values that do not meet the target are in **bold**.

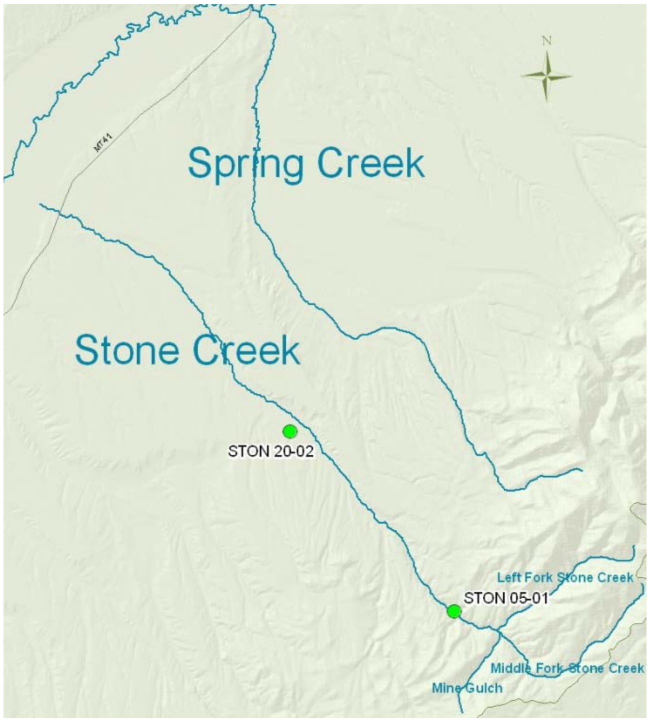

Figure 5-21. Upper Stone Creek DEQ Assessment Sites

See **Appendix D** for additional data collected by KirK and HSI.

Summary and TMDL Development Determination
Fine sediment targets were exceeded in both riffles and pools at both reaches in the upper segment of Stone Creek. Both channel form targets were exceeded in the lower reach and width to depth ratio did not meet the target value in the upper reach. Both instream pool habitat targets were not met in the lower reach and residual pool depth failed to meet the target value in the upper reach. Both reaches failed to meet target values for shrub cover and bare ground. Historic and current grazing were impacting the upper segment of Stone Creek, and eroding banks and animal crossings were contributing sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Because fines were high in field observations and field measurements showed that most of the sediment targets were not being met, a sediment TMDL will be written for the upper segment of Stone Creek. The upper segment of Stone Creek is also listed for turbidity, which is a pollutant that falls within the sediment pollutant category. In developing the sediment TMDL, it is assumed that turbidity is also addressed since satisfying the sediment TMDL targets and sediment allocations addressing both fine and coarse sediment, will result in conditions consistent with reference or naturally occurring conditions.

5.4.2.16 Stone Creek (lower) MT41B002_131
Lower Stone Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, lower Stone Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Lower Stone Creek flows 3.4 miles from the confluence of an unnamed tributary (T6S R7W S34) to an unnamed ditch.

Physical Condition and Sediment Sources
In 2010, DEQ performed full sediment and habitat assessments at two adjacent monitoring sites on lower Stone Creek. The sites were split by a large irrigation return. The upstream site (STON 22-02B),

was located approximately 1000 feet upstream from HWY 41. The stream channel was incised and resembled a spring creek, as groundwater and irrigation returns appeared to be the primary water sources. Pool quality was low yet runs and glides provided some spawning gravels. Stream channel measurements throughout the reach resembled Rosgen type F. Streambank erosion was minimal, as the banks were lined with large grasses and the flow was low energy. One large cut bank was found at an outside meander and irrigation returns were slowly cutting away at banks. Riparian vegetation was dominated by pasture grasses (meadow foxtail, smooth brome, timothy, Canada thistle, slow thistle) and thick macrophyte aquatic vegetation. The reach is impacted by adjacent cropland and changes in flow from irrigation.

The downstream site (STON 22-02), was split by HWY 41 with 600 feet located upstream of the bridge and 400 feet downstream of the bridge. Stream channel was mostly run dominated with an abundance of fines above the bridge and had significantly faster moving water and fewer fines below the bridge. Stream channel measurements throughout the reach resembled Rosgen type F. Bank erosion was minimal throughout the reach as banks were stabilized with vegetation. Riparian vegetation was mostly smooth brome, pasture grasses, and Canada thistle; with an abundance of watercress above the bridge and some sandbar willow below the bridge. The reach is impacted by flow manipulation, with one large irrigation return entering the channel at the top of the reach and significantly increasing flow.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the lower segment of Stone Creek are summarized in **Table 5-37** (See **Figure 5-22** for map). All bolded cells represent conditions where target values are not met.

Table 5-37. Existing Sediment-Related Data for Lower Stone Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
STON 22-02	2010	14	F5	C4	**71**	**68**	**37**	12	2.5	**0.8**	**16**	**6**	0
STON 22-02B	2010	11	F5	C4	**58**	**40**	**11**	13	**1.6**	**0.5**	**32**	**0**	**2**

Values that do not meet the target are in **bold**.

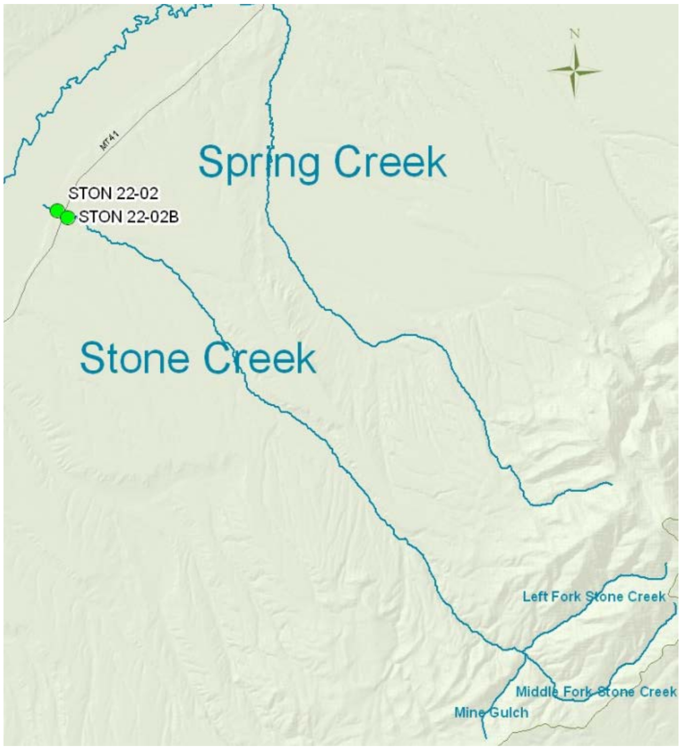

Figure 5-22. Lower Stone Creek DEQ Assessment Sites

See **Appendix D** for additional data collected by KirK

Summary and TMDL Development Determination
Fine sediment targets were exceeded in both riffles and pools at the both reaches in the lower segment of Stone Creek. At each reach, both instream pool habitat targets were not met. The reaches failed to meet the target for shrub cover and the upper reach (STON 22-02B) was mostly comprised of pasture grasses. The two reaches were separated by an irrigation return flow. Reach STON 22-02 was split by highway MT-41 with slower water and higher fine sediment deposits upstream of the bridge and faster water and less fines downstream from the bridge. The lower segment of Stone Creek is located in primarily agricultural land, and flow is manipulated for irrigation purposes. Because fines were notably high in field observations and field measurements showed that fine sediment well exceeded target values, along with pool habitat and other parameters not meeting target values, a sediment TMDL will be written for the lower segment of Stone Creek.

5.4.2.17 Taylor Creek MT41B002_170
Taylor Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Taylor Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. Taylor Creek flows 11.4 miles from its headwaters to the mouth (Grasshopper Creek).

Physical Condition and Sediment Sources
In 2010, DEQ performed full sediment and habitat assessments at two monitoring sites on lower Taylor Creek. The upstream site (TAYL 27-01), was located off of Taylor Creek Rd. The stream channel had many pools, but few were deep. The channel substrate was gravel, with high amounts of fine sediment in pool tails and riffles. Stream channel measurements throughout the reach resembled Rosgen type C5.

Bank erosion was minimal and mostly due to natural scour; with some erosion occurring at animal crossings. Riparian vegetation included sedges and rushes, with some bulrush on the lower terraces. Grass and riparian forbs were found from bankfull to the floodprone area, with spotty willow cover and few seedling willows due to browse. Canada thistle was common at the upper bank level. This area appeared to be recovering from heavy historic grazing.

The downstream site (TAYL 32-01), was located off of Bannack Rd. approximately 1.5 miles from HWY 278. The stream channel was dominated by runs, with some cobble at the downstream end of the reach and predominately fines at the upstream end of the reach. There were few pools with many fines in pool tail-outs. Channel was narrow, deep, and very sinuous. Stream channel measurements throughout the reach resembled Rosgen type E5. Streambank erosion was minimal with natural scour on low vegetated and stable banks. Riparian vegetation included sedges, rushes, pasture grass, and Canada thistle. Willows were primarily of mature size with some regeneration occurring. The area seems to have been grazed in the past, and may have had beaver complex removal.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Taylor Creek are summarized in **Table 5-38**. The macroinvertebrate bioassessment data for Taylor Creek is located in **Table 5-39** (See **Figure 5-23** for map). All bolded cells represent conditions where target values are not met.

Table 5-38. Existing Sediment-Related Data for Taylor Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
TAYL 27-01	2010	7	C5	C4	**55**	**41**	**22**	**11**	14.1	**0.6**	148	**22**	1
TAYL 32-01	2010	3	E5	E4	**48**	**24**	*28**	3	25.3	1.1	**74**	**38**	**11**

Values that do not meet the target are in **bold**.
*No target value for pool grid toss on E channel

Table 5-39. Macroinvertebrate Bioassessment Data for Taylor Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02TALRC01	45.295	-112.983611	Mountains	08-Jul-04	KICK	**0.62**
M02TALRC03	45.1886	-113.025833	Mountains	12-Jul-04	KICK	**0.31**

Values that do not meet the target are in **bold**.

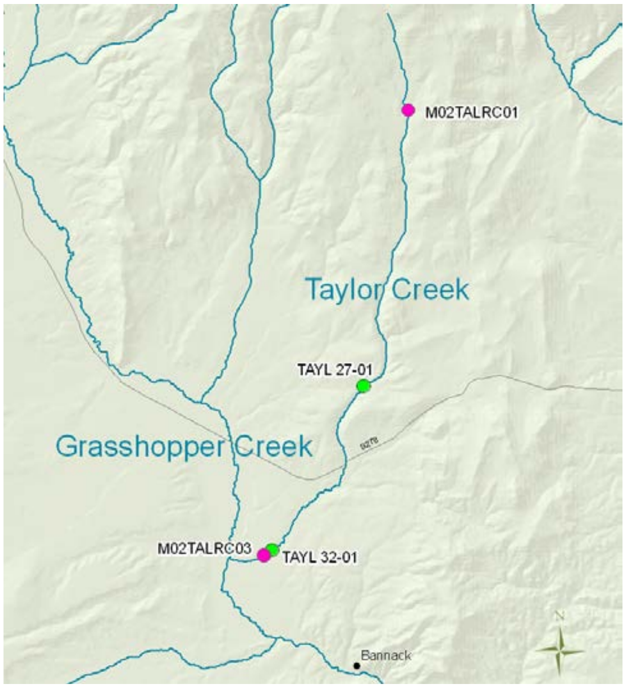

Figure 5-23. Taylor Creek DEQ Assessment Sites and Macro Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination
Fine sediment targets were exceeded in both reaches in Taylor Creek. The upper reach had high fines in pools and did not meet its residual pool depth target. Both reaches failed to meet the target for shrub cover. Observed over expected macroinvertebrate targets were not met. The downstream reach is an E channel and therefore expected to have higher fine sediment; however, the reach still exceeded E channel targets for fine sediment. Both reaches show signs of heavy historic grazing, however vegetation and eroding banks seemed to be recovering. Nonetheless, because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for Taylor Creek.

5.4.2.18 West Fork Blacktail Deer Creek MT41B002_060
West Fork Blacktail Deer Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Taylor Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. West Fork Blacktail Deer Creek flows 15.9 miles from its headwaters to the mouth (Blacktail Deer Creek).

Physical Condition and Sediment Sources
In 2010, DEQ performed a full sediment and habitat assessment at one monitoring site on West Fork Blacktail Deer Creek. The site (WFBK 08-04), was located up Blacktail Road past the East Fork turnoff where the West Fork Road crosses with the stream. The stream channel had a lot of fine sediments, most likely due to beaver activity; as the reach was between beaver pond complexes. Gravels were common; generally well-embedded with varying amounts of fine sediment in the lower half. Many of the pools were deep and there was a variety of fish habitat. Stream channel measurements throughout the reach resembled Rosgen type C4/E4. Banks were trampled throughout the reach, but were also covered in wetland vegetation. Riparian vegetation included a variety of wetland vegetation and

moderate willow cover. Grazing suppressed willow and shrub regeneration and caused the channel to overwiden in places.

Comparison to Water Quality Targets

The existing data in comparison to the targets for West Fork Blacktail Deer Creek are summarized in **Table 5-40** (See **Figure 5-24** for map). All bolded cells represent conditions where target values are not met.

Table 5-40. Existing Sediment-Related Data for West Fork Blacktail Deer Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
WFBK 08-04	2010	13	C4/E4	C4	**32**	**43**	**19**	14.2	2.6	1.5	**84**	**41**	1

Values that do not meet the target are in **bold**.

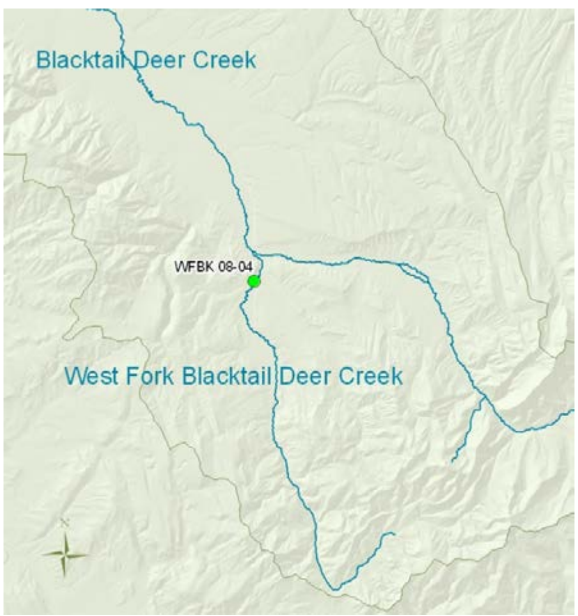

Figure 5-24. West Fork Blacktail Creek DEQ Assessment Sites and Macro Sites

See **Appendix D** for additional data collected by KirK and HSI.

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools at the reach in West Fork Blacktail Deer Creek. Pool frequency targets were not met. The reach failed to meet the target for shrub cover and shrub regeneration was limited by current grazing. Throughout the stream, some areas of bank trampling from riparian grazing was contributing sediment. The road was also contributing sediment where it parallels close to the stream. Because fines were notably high in field observations and field measurements showed that fine sediment targets were not being met, a sediment TMDL will be written for West Fork Blacktail Deer Creek.

5.4.2.19 West Fork Dyce Creek MT41B002_070

West Fork Dyce Creek is listed for sedimentation/siltation on the 2012 303(d) List. In addition, West Fork Dyce Creek is listed for alterations in streamside or littoral vegetative covers; which is a non-pollutant form of pollution commonly linked to sediment impairment. West Fork Dyce Creek flows 4.6 miles from its headwaters to the mouth (Dyce Creek).

Physical Condition and Sediment Sources

In 2010, DEQ performed a full sediment and habitat assessment at one monitoring site on West Fork Dyce Creek. The site (WFDY 17-01), was located off of the western fork of Dyce Creek Rd. The stream was overwidened, except in areas of dense willows. The channel had few pools that were generally shallow due to excess fine sediment. Stream channel measurements throughout the reach resembled Rosgen type G5. Banks were trampled throughout the reach and composed of silt that was highly susceptible to erosion. Some tall actively eroding banks were present at cattle crossings. Riparian vegetation was heavily browsed. Most willows were mature and decadent. The understory was dominated by pasture grasses with some sedge at the water's edge. Past and current grazing were the primary impacts to the reach, with the road as a secondary source. As with the mainstem of Dyce Creek, the Dillon Field Office of the BLM notes that historic and ongoing placer mining have altered the stream dimension, pattern, profile, and likely the bed materials.

Comparison to Water Quality Targets

The existing data in comparison to the targets for West Fork Dyce Creek are summarized in **Table 5-41**. The macroinvertebrate bioassessment data for West Fork Dyce Creek is located in **Table 5-42** (See **Figure 5-25** for map). All bolded cells represent conditions where target values are not met.

Table 5-41. Existing Sediment-Related Data for West Fork Dyce Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count		Grid Toss	Channel Form		Instream Habitat		Riparian Health	
					% < 6mm (mean)	% < 2mm (mean)	Pool % < 6mm (mean)	W/D Ratio (mean)	Entrenchment Ratio (median)	Residual Pool Depth (ft)	Pools / Mile	Greenline % Shrub Cover	Greenline % Bare Ground
WFDY 17-01	2010	4	G5	B4	**49**	**29**	**35**	**7.5**	2.6	**0.6**	95	62	0

Values that do not meet the target are in **bold**.

Table 5-42. Macroinvertebrate Bioassessment Data for West Fork Dyce Creek

Station ID	Location		Site Class	Collection Date	Collection Method	O/E
M02DYWFC02	45.31583	-113.04611	Mountains	23-Jun-04	KICK	0.9
M02DYWFC03	45.28167	-113.03556	Mountains	23-Jun-04	KICK	0.9

Values that do not meet the target are in **bold**.

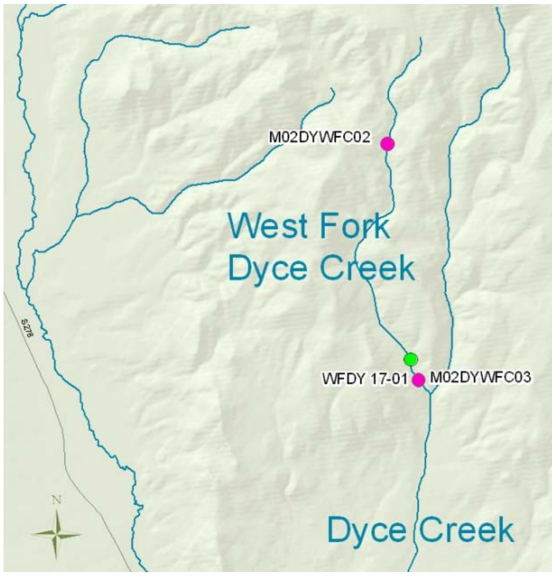

Figure 5-25. West Fork Blacktail Creek DEQ Assessment Sites and Macro Sites

See **Appendix D** for additional data collected by HSI.

Summary and TMDL Development Determination

Fine sediment targets were exceeded in both riffles and pools at the reach in West Fork Dyce Creek. Pool frequency targets were not met. The reach failed to meet the target for shrub cover and shrub regeneration was limited by current grazing. Grazing impacts and parallel road segments were contributing sediment into the stream. Because fine sediment targets were exceeded in both riffles and pools, and pool frequency and shrub cover targets were not met, a sediment TMDL will be written for West Fork Dyce Creek.

5.5 TMDL Development Summary

Based on the comparison of existing conditions to water quality targets, 17 sediment TMDLs will be developed in the Beaverhead TPA. **Table 5-43** summarizes the sediment TMDL development determinations and corresponds to **Table 1-1**, which contains the TMDL development status for listed waterbody segments in the Beaverhead TPA on the 2012 303(d) List.

Table 5-43. Summary of TMDL Development Determinations

Stream Segment	Waterbody ID	TMDL Development Determination (Y/N)
Beaverhead River (upper)*, Clark Canyon Dam to Grasshopper Creek	MT41B001_010	N
Beaverhead River (lower), Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Y
Blacktail Deer Creek, headwaters to mouth (Beaverhead River)	MT41B002_030	Y
Clark Canyon Creek, headwaters to mouth (Beaverhead River)	MT41B002_110	Y
Dyce Creek, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Y
Farlin Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_020	Y
French Creek, headwaters to mouth (Rattlesnake Creek)	MT41B002_100	Y
Grasshopper Creek*, headwaters to mouth (Beaverhead River)	MT41B002_010	Y

Table 5-43. Summary of TMDL Development Determinations

Stream Segment	Waterbody ID	TMDL Development Determination (Y/N)
Rattlesnake Creek (upper), headwaters to Dillon PWS off-channel well T7S R10W S11	MT41B002_091	Y
Rattlesnake Creek (lower), from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Y
Reservoir Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Y
Scudder Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_180	Y
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Y
Steel Creek, headwaters to mouth (Driscol Creek)	MT41B002_160	Y
Stone Creek (upper), Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	Y
Stone Creek (lower), confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	Y
Taylor Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_170	Y
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Y
West Fork Dyce Creek, headwaters to mouth (Dyce Creek)	MT41B002_070	Y

* Upper Beaverhead River and Grasshopper Creek were not on Montana's 2012 303(d) List for sediment

5.6 Source Assessment

This section summarizes the assessment approach, current sediment load estimates, and rationale for load reductions within the Beaverhead TPA. Focus is on the below list of four potentially significant sediment source categories and associated controllable human loading associated with each of these sediment source categories.

- streambank erosion
- upland erosion
- roads
- permitted point sources

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

For each impaired waterbody segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). The results include a mix of sediment sizes, particularly for bank erosion that involves both fine and coarse sediment loading to the receiving water, whereas loads from roads, upland erosion, and permitted point source discharges are predominately fine sediment.

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

5.6.1 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2010/2011 at 29 assessment reaches discussed in **Section 5.3** to help obtain a representative dataset of existing loading conditions, causes, and the potential for loading reductions associated with improvements in land management practices. Sediment loading from eroding streambanks was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen, 2006) along monitoring reaches in 2010/2011. BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- irrigation-shifts instream energy
- natural sources
- other (typically refers to disturbance from past human activity that is not easily discernible due to elapsed time)

Based on the aerial assessment process (described in **Section 5.3**) in which each assessed stream segment is divided into different reaches, streambank erosion data from each 2010/2011 monitoring site was used to extrapolate data and provide load estimates to the stream reach, stream segment and sub-watershed scales. Sediment load reductions were calculated by estimating the load that would result if reasonable Best Management Practices (BMPs) were in place; therefore achieving the naturally occurring condition.

For bank erosion, some sources are the result of historical land management activities that are not easily mitigated through changes in current management, and they may be costly to restore and have been irreversibly altered. Therefore, although the sediment load associated with bank erosion is presented in separate source categories (e.g., transportation, grazing, cropland), the allocation is presented as a percent reduction expected collectively from human sources. A more detailed description of this assessment can be found in *Streambank Erosion Source Assessment,* which is included as **Appendix E**.

Assessment Summary

Based on the source assessment, streambank erosion contributes an estimated 68,525 tons of sediment per to the Beaverhead TPA. It is estimated that this sediment load can be reduced to 21,122 tons per year, which is a 69% reduction in sediment load from streambank erosion. Sediment loads due to streambank erosion range from 396 tons/year in West Fork Dyce Creek to 27,505 tons per year in the lower Beaverhead River. For the whole watershed, 18% of the sediment load from streambank erosion is attributed to natural sources (no human impacts), while 82% is attributable to human sources. Current riparian grazing and historic uses (including historic clearing, mining, and grazing) are the greatest anthropogenic contributors of sediment loads due to streambank erosion for most assessed sites in the Beaverhead TPA. Irrigation and hay production in Stone Creek and hay production in Blacktail Dear Creek are the major sources contributing to bank erosion in those creeks, but are not primary sources throughout the TPA. **Appendix E** contains additional information about sediment loads from eroding streambanks in the Beaverhead TPA by subwatershed, including all that were assessed. **Table 5-44** provides a summary of the bank erosion loads by each watershed where TMDLs are being developed in this document. **Table 5-44** also includes sediment load reduction information based on the application of best management practices. The load reduction approach and associated assumptions are described in **Appendix E**.

Table 5-44. Bank Erosion Results; Estimated Load Reduction Potential and Resulting Modeled Loads after Application of Best Management Practices

Watershed	Total Bank Erosion Load (tons/yr)	Avg. % Reduction	Modeled Load After Application of Best Management Practices (tons/yr)
Beaverhead River Lower (Beaverhead River Upper Total and Beaverhead River Lower Total)	68,525	69%	21,122
Beaverhead River Upper (Clark Canyon Ck and Beaverhead River Upper)	6,134	67%	2,052
Blacktail Deer Creek (W.F. Blacktail Deer Ck and Blacktail Deer Ck)	8,572	61%	3,376
Clark Canyon Creek	1,083	62%	409
Dyce Creek (West Fork Dyce Ck and Dyce Ck)	1,499	61%	582
Farlin Creek	731	56%	319
French Creek	853	67%	283
Grasshopper Creek (Farlin Ck, Steel Ck, Scudder Ck, W.F. Dyce Ck, Dyce Ck, Taylor Ck, Reservoir Ck, and Grasshopper Ck)	13,459	62%	5,135
Rattlesnake Creek - Lower (Rattlesnake Ck Upper Total and Rattlesnake Ck Lower)	4,513	57%	1,937
Rattlesnake Creek - Upper (French Ck and Rattlesnake Ck Upper)	3,580	54%	1,661
Reservoir Creek	2,612	64%	952
Scudder Creek (Steel Ck and Scudder Ck)	1,190	59%	488
Spring Creek	4,038	72%	1,144
Steel Creek	414	62%	157
Stone Creek Lower (Stone Ck Upper and Stone Ck Lower)	4,306	75%	1,089
Stone Creek Upper	2,938	75%	745
Taylor Creek	2,298	58%	974
West Fork Blacktail Deer Creek	1,730	55%	784
West Fork Dyce Creek	396	63%	148

5.6.2 Upland Erosion and Riparian Buffering Capacity

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE). Sediment delivery to the stream was predicted using a sediment delivery ratio, taking into account riparian buffering. The USLE results are useful for source assessment as well as for determining allocations to human-caused upland erosion. This model provided an estimate of existing sediment loading from upland sources and an estimate of potential sediment loading reductions that could be achieved by applying best management practices (BMPs) in the uplands and in the near stream riparian area.

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

Assessment Summary

Based on the source assessment, upland erosion contributes approximately 17,952 tons per year to the Beaverhead TPA. The assessment indicates that rangeland grazing and hay production within the near stream riparian buffer are the most significant contributors to accelerated upland erosion. Sediment loads due to upland erosion range from 61 tons/year in the Steel Creek sub-watershed to 3,846 tons/year in the lower Beaverhead River sub-watershed. Since this assessment was conducted at the sub-watershed scale, it is expected that larger watersheds will have greater sediment loads. A significant portion of the sediment load due to upland erosion is contributed by natural sources. **Appendix F** contains additional information about sediment loads from upland erosion in the Beaverhead TPA by subwatershed, including all 6th code HUCs in the TPA. In order to facilitate reporting of the upland sediment loading information following the allocation strategy specific to this source category the data from each sub-watershed located in the appendix was further manipulated by:

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

Table 5-45 below reports the total potential load reductions and resulting loads after applying the BMP reductions**.** This information can be used as a basis for setting TMDL load allocations. (See **Appendix F** for more detailed information**).**

Table 5-45. Existing Upland Sediment Loads and Estimated Load Reduction Potential after Application of Upland and Riparian BMPs

Watershed	Estimated Existing Upland Sediment Load (tons/year)	Estimated Load Reduction Potential (% reduction)	Modeled Load After Application of Best Management Practices
Beaverhead River Lower (Beaverhead River Upper Total and Beaverhead River Lower Total)	17952	69%	5541
Beaverhead River Upper (Clark Canyon Ck and Beaverhead River Upper)	596	59%	245
Blacktail Deer Creek (W.F. Blacktail Deer Ck, E.F. Blacktail Deer Ck, and Blacktail Deer Ck)	6473	69%	2013
Clark Canyon Creek	146	38%	91
Dyce Creek (West Fork Dyce Ck and Dyce Ck)	250	69%	77
Farlin Creek	94	62%	36
French Creek	220	58%	92
Grasshopper Creek (Farlin Ck, Steel Ck, Scudder Ck, W.F. Dyce Ck, Dyce Ck, Taylor Ck, Reservoir Ck, and Grasshopper Ck)	3859	68%	1236
Rattlesnake Creek - Lower (Rattlesnake Ck Upper Total and Rattlesnake Ck Lower)	1486	65%	513
Rattlesnake Creek - Upper (French Ck and Rattlesnake Ck Upper)	713	59%	292
Reservoir Creek	116	70%	35
Scudder Creek (Steel Ck and Scudder Ck)	164	71%	48
Spring Creek	763	68%	242
Steel Creek	103	74%	27
Stone Creek Lower (Stone Ck Upper and Stone Ck Lower)	929	74%	242
Stone Creek Upper	716	75%	182
Taylor Creek	344	75%	87
West Fork Blacktail Deer Creek	1212	75%	304
West Fork Dyce Creek	88	71%	25

5.6.3 Road Sediment Assessment

5.6.3.1 Erosion from Unpaved Roads

Sediment loading from unpaved roads was assessed using GIS, field data collection, and sediment modeling. Each identified unpaved road crossing and near-stream road segment was assigned attributes for road name, surface type, road ownership, stream name, subwatershed, and landscape type (i.e., mountain, foothill, or valley). Twenty-six crossings and seven near-stream parallel segments representing the range of conditions within the watershed were field assessed in 2010, and sediment loading was estimated using the Water Erosion Prediction Project Methodology (WEPP:Road). The average sediment contribution from unpaved road crossings and near-stream road segments were extrapolated to all unpaved roads in the watershed based on Level IV Ecoregion. To address sediment from unpaved roads in the TMDLs and allocations that follow in **Section 5.7**, the WEPP:Roads analysis was also run using BMPs, reducing contributing road segment lengths to 100 feet. The 100-foot BMP scenario is used in this document as a general approximation of achievable modeled loading reduction to help develop the road crossing allocations. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. Other potential BMPs include the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting. A more detailed description of this assessment can be found in **Appendix G**.

Assessment Summary

Based on the source assessment, unpaved roads are contributing 66 tons of sediment per year to the Beaverhead TPA. This includes 45 tons from unpaved road crossings and 21 tons per year from parallel unpaved road segments for the Beaverhead TPA. Sediment loads range from < 1 ton/year in the Clark Canyon Creek watershed to 66 tons/year in the lower Beaverhead watershed. Factors influencing sediment loads from unpaved roads at the watershed scale include the overall road density within the watershed, watershed size, and the configuration of the road network, along with factors related to road construction and maintenance. **Table 5-46** contains annual sediment loads from unpaved roads (crossings & parallel segments) from the watersheds where TMDLs are developed within this document. **Table 5-46** also includes the percent load reduction by watershed based on the contributing road length BMP scenario which is further defined within **Appendix G**.

Table 5-46. Annual Sediment Load (tons/year) from Unpaved Roads (Crossings + Parallel Segments) within the Beaverhead TPA.

Watershed	Total Estimated Existing Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
Beaverhead River Lower (Beaverhead River Upper Total and Beaverhead River Lower Total)	66.4	70%	19.6
Beaverhead River Upper (Clark Canyon Ck and Beaverhead River Upper)	1.5	69%	0.5
Blacktail Deer Creek (W.F. Blacktail Deer Ck, E.F. Blacktail Deer Ck, Middle Blacktail Deer Ck, and Blacktail Deer Ck)	17.5	72%	4.9
Clark Canyon Creek	0.3	67%	0.1
Dyce Creek (West Fork Dyce Ck and Dyce Ck)	1.9	74%	0.5
Farlin Creek	0.4	75%	0.1
French Creek	1.7	73%	0.5
Grasshopper Creek (Farlin Ck, Steel Ck, Scudder Ck, W.F. Dyce Ck, Dyce Ck, Taylor Ck, Reservoir Ck, and Grasshopper Ck)	16.5	72%	4.6
Rattlesnake Creek - Lower (Rattlesnake Ck Upper Total, Ermont Gulch, and Rattlesnake Ck Lower)	7.3	70%	2.2
Rattlesnake Creek - Upper (French Ck and Rattlesnake Ck Upper)	3.7	73%	1.0
Reservoir Creek	0.5	67%	0.2
Scudder Creek (Steel Ck and Scudder Ck)	1.1	69%	0.3
Spring Creek	2.5	70%	0.7
Steel Creek	0.7	66%	0.2
Stone Creek Lower (Stone Ck Upper and Stone Ck Lower)	2.0	66%	0.7
Stone Creek Upper	1.7	66%	0.6
Taylor Creek	1.1	74%	0.3

Table 5-46. Annual Sediment Load (tons/year) from Unpaved Roads (Crossings + Parallel Segments) within the Beaverhead TPA.

Watershed	Total Estimated Existing Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
West Fork Blacktail Deer Creek	3.1	77%	0.7
West Fork Dyce Creek	0.6	70%	0.2

5.6.3.2 Traction Sand Application

Montana Department of Transportation traction sand application rates based on the three year average (2009-2011) along State Highway 278, State Highway 41, State Highway 91, and Interstate 15 indicate State Highway 278 has the highest rate of application per plowed mile, while Interstate 15 has the lowest rate of application per plowed mile (**Table G-9**, **Appendix G**). An average of 3,447 tons of traction sand are applied to these four travel routes annually, with application rates per plowed mile ranging from 0.11 tons along Interstate 15 to 0.20 tons along State Highway 278. Average annual traction sand application rates range from 149 tons along State Highway 91 to 1,703 tons along Interstate 15. No data was available from the Beaverhead Roads Department for traction sand application rates along the Pioneer Mountains Scenic Byway or Blacktail Road. No estimate of road sand contribution to the annual sediment load was calculated due to insufficient information; however, significant application rate reductions have already been achieved for state roadways by the transition from road sand to road salt.

5.6.3.3 Culvert Failure and Fish Passage Analysis

Undersized or improperly installed culverts may be a chronic source of sediment to streams or a large acute source during failure, and they may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for a subset of culverts. The flow capacity culvert analysis was performed on 19 culverts and incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g., 2, 5, 10, 25, 50, and 100 year) and measurements for each culvert to estimate its capacity and amount of fill material.

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

Fish passage assessments were performed on 19 culverts. The assessment was based on the methodology defined in **Appendix G**, which is geared toward assessing passage for juvenile salmonids. Considerations for the assessment include streamflow, the culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e., culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish passage barriers and those that need a more in-depth analysis. Culverts with fish passage concerns may have elevated road failure concerns since fish passage is often linked to undersized culvert design.

Assessment Summary

Within the Beaverhead TPA, all 19 culverts assessed in the field are capable of passing the two-year flood event, while only two of these culverts (11%) pass a 100-year flood event (see **Appendix G** for more details). Assessed culverts passing the Q25 flood event varied by land ownership with 100% of the culverts located on USFS land passing, 60% of the culverts located on BLM land passing, 33% of culverts located on state land passing, and 50% of the culverts located on private land passing.

In the Beaverhead TPA, five of the culverts (26%) allowed fish passage, while 14 culverts (74%) were classified as fish passage barriers (**Appendix G**). No estimated annual load was incorporated into the TMDL due to an uncertainty of failure events and deficient monitoring information.

5.6.4 Point Sources

As of January 19, 2012, there were seventeen Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within the Beaverhead TPA (**Appendix A**, **Map A-14**):

- City of Dillon WWTF (MT0021458),
- Beaverhead Talc Mine (MT0027821)
- Barretts Minerals Inc (MT0029891)
- Two Concentrated Animal Feeding Operations (MTG010165 and MTG010212)
- Three Storm Water Mining Permits (MTR300135, MTR300136, and MTR300160), and
- Nine general permits for construction stormwater

To provide the required wasteload allocation for permitted point sources, a source assessment was performed for these point sources. However, because of the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits. It is assumed that the WLAs will be met by adherence to permit requirements.

5.6.4.1 Dillon Wastewater Treatment Facility (MT0021458)

The Dillon WWTF, which discharges to the Beaverhead River, is a partially-aerated five cell lagoon treatment system with a design capacity of 0.75 million gallons per day (MGD) and Ultra Violet light disinfection. The facility is authorized under an individual permit (MT0021458), which has a 7-day average total suspended solids (TSS) concentration limit of 135 mg/L and a 30-day average TSS concentration limit of 100 mg/L. Like most wastewater discharge, the suspended solids in the effluent are likely predominantly organic matter and not sediment. Based on Discharge Monitoring Reports submitted by the facility, monthly, TSS samples were collected from February 2009 through January 2012 and none exceeded the 30-day average concentration limit of 100 mg/L. The highest concentration was 52 mg/L in September 2010 and May 2009, and the average value of all samples was 22 mg/L. A conservative calculation of the existing load was made by assuming an average daily discharge of 0.6 MGD, which is the maximum measured discharge in the permit file, at a TSS concentration of 22 mg/L. This would result in an annual load of 20.1 tons.

The maximum allowable permit values can be used to evaluate impact to the Beaverhead River by evaluating the potential increase in TSS loading to the Beaverhead River from the Dillon discharge. Based on water quality chemistry and flow data collected by HSI in 2008/2009, the typical low flow for the Beaverhead River was about 35 cfs, and the average TSS value during these low flow events was about 5.5 mg/l. The Dillon facility design capacity discharge of 0.75 MGD is approximately 1.2 cfs. If the Dillon facility was discharging with a TSS concentration of 135 mg/l into the Beaverhead River when the Beaverhead River was flowing at 35 cfs, the result would be an increase in TSS concentration in the Beaverhead River from 5.5 mg/l to 9.8 mg/l. Although this represents close to a doubling of the TSS concentration, 9.8 mg/l represents an acceptably low level that is not expected to cause harm to aquatic life (Newcombe and Jensen, 1996) nor is it expected to result in aesthetic concerns.

5.6.4.2 Beaverhead Talc Mine (MT0027821)

The Beaverhead Talc Mine is a historically active open-pit mining and sorting operation in the Middle Fork Stone Creek drainage that utilized conventional hard rock mining methods to produce cosmetic grade talc. In 1986, the open-pit operations ceased and underground mining operations commenced. Water generated from the underground operations and on-site was pumped or diverted to the Mine Pit prior to the first of four sedimentation ponds. In 1999, Luzenac America, Inc. (LAI) closed the underground mine and upon reissuance of the current MPDES permit, LAI was undergoing post-closure reclamation work for the entire site. Currently water is collected from mine seepage, runoff, and seepage from the reclaimed and partially stabilized waste rock pile and routed to two sedimentation ponds prior to discharge to Outfall 001. Discharge is intermittent to the unnamed tributary to the Middle Fork Stone Creek.

MPDES permit MT0027821 has numeric limits for turbidity and monitoring requirements for TSS. LAI is required to not cause a net increase in turbidity within the unnamed tributary to Middle Fork of Stone Creek in excess of 5 NTU as measured by subtracting the analytical results at sampling sites CRK B from A. Discharge occurs from the sedimentation pond during late spring to early fall and is continuous during this timeframe. Discharge is attributed to runoff generated on-site during periods of snow-melt and precipitation. Because turbidity cannot be expressed as a load, TSS values were developed using a 2:1 relationship of TSS and turbidity established in a study by Bansak et al. (2000), used in Swan TMDL development. Although it is recognized that the TSS to NTU relationships in the Swan Lake Watershed could be inherently different than those in the Beaverhead TPA, the relationship also correlates well with a study done by Water Consulting (2002) for the Boulder River. The Boulder River resides within the Middle Rockies Ecoregion, as does the Beaverhead, and has similar characteristics to the Beaverhead TPA.

The permit states that discharge from Outfall 001 shall not cause a net increase in turbidity within the unnamed tributary to Middle Fork Stone Creek in excess of 5 NTU as measured by subtracting analytical results at the sampling site downstream from the sampling site upstream. The typical flow downstream from the permitted effluent is 75 gpm and typically flows from the late spring to early fall. A conservative calculation of the existing load was made by assuming an average discharge of 75 gpm at the downstream site, at a TSS concentration of 10 mg/L (using the ratio from Bansak). This would result in an annual load of 0.7 tons.

5.6.4.3 Barretts Minerals Inc (MT0029891)

Barretts Minerals Inc.'s Treasure Mine is an open-pit talc mine in the Left Fork Stone Creek drainage. The mine has been operating since the late 1950's utilizing conventional hard rock mining methods. The mine pit has been constructed adjacent to the pre-mining Left Fork Stone Creek (LFSC) drainage and a waste rock pile has been placed in the drainage-way with an engineered rock drain at its base. The Mine's MPDES Private Minor Industrial Discharge Permit allows discharge of mine dewatering wastewater, runoff and mine drainage from disturbed areas, and stormwater runoff from precipitation events in excess of one inch to the LFSC. Two outfalls are permitted: Outfall 001 is located at the toe of the waste rock dump, and constitutes the entire flow of LFSC (discharge is continuous and sources of wastewater include mine drainage from the waste rock pile constructed in the LFSC drainage). Outfall 002 is located inside the mine where water is infiltrated to the rock drain at Site I (discharge is continuous and the source of wastewater is pit dewatering). Water quality monitoring is conducted at Outfalls 001 and 002, as well as upstream influent locations of LFSC and two unnamed drainages.

The quality of effluent discharged by the facility from Outfall 002 has a numerical limitation for Total Suspended Solids of 25 mg/L for the average monthly limit and 45 mg/L as the daily maximum. The load will be calculated using the typical (median) flow at Outfall 002, which is around 200 gpm. A conservative calculation of the existing load was made by assuming a typical discharge of 200 gpm, at a TSS concentration of 25 mg/L. This would result in an annual load of approximately 11 tons.

However, because Outfall 001 receives the discharge from within the mine (through Outfall 002), as well as the runoff from the mine's waste rock dump, a separate analysis was conducted to see if monitoring and compliance should take place at Outfall 001. In order to evaluate if the Mine is causing an increase in turbidity within Left Fork Stone Creek in excess of 5 NTU, turbidity data was analyzed from a 2011 report written by Rithron for Barretts Minerals Inc. The average turbidity in the 2007-2010 period from sampling site D (Left Fork Stone Creek downstream of the Mine site) was subtracted from the average turbidity from that same period at sampling site A (Left Fork Stone Creek upstream of the Mine site). The average increase in turbidity over the four year time period was 1.6 NTU and below the maximum allowable increase above naturally occurring turbidity for B-1 streams, which is 5 NTU. Additionally, a load was calculated using the maximum allowable increase of 5 NTU from Site A to Site D. Using the 2011 Rithron report, the typical (median) flow downstream from the permitted effluent is 507 gpm. A conservative calculation of the existing load was made by assuming an average discharge of 507 gpm at the downstream site, at a TSS concentration of 10 mg/L (using the ratio from Bansak as discussed in permit MT0027821). This would result in an annual load of 11 tons.

The analysis of Outfall 001 provides an estimated load that is equivalent to the estimated load from Outfall 002. Additionally, the analysis of Outfall 001 indicates that the average increase in turbidity is below the maximum allowable increase. Therefore, the TMDL will be met by adherence to all requirements within the permit, specifically to the numeric TSS limitations for Outfall 002.

5.6.4.4 Storm Water – Mining, Oil, & Gas Extraction

5.6.4.4.1 Barretts Minerals Inc – Treasure Mine (MTR300135)

The Barretts Minerals Inc – Treasure Mine facility is also authorized under the General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities (MTR300000) and the facility is located in the Left Fork Stone Creek drainage. The permit (MTR300135) includes a Storm Water Pollution Prevention Plan (SWPPP) and requires biannual reporting of discharge monitoring data. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges. DEQ conducted an inspection of the 960 acre site in June 2010 and concluded the SWPPP was being followed.

According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/l. The SWPPP for the Treasure Mine provides information pertaining to site conditions. The annual average precipitation for this site is approximately 16 inches. Although the permitted area is 960 acres, the majority of this area is drained to the main pit sump located inside of the mine, which allows sediment to settle before discharging at Outfall 002 (Outfall 002 has a TSS limitation under permit MT0029891 - see **Section 5.6.4.3**). However, 13 of the 960 acres are a waste rock pile that does not drain to the main pit sump and has the potential to contribute sediment to Left Fork Stone Creek during storm events. Given the 13 acres of disturbed area, 16 inches of precipitation, and using the condition of the benchmark value (100 mg/l) found in the permit, the area from the waste rock pile has an estimated load of 2.4 tons a year.

In order to estimate the total load due to stormwater runoff the load of 2.4 tons per year from the mine's waste rock pile is added to stormwater runoff that discharges at Outfall 002 (main pit sump location). At Outfall 002 in permit MT0029891 the daily maximum TSS limitation is 45 mg/L and the highest recorded flow since 2009 is 360 gpm. A conservative calculation of the existing load was made by assuming a high flow of 360 gpm, at a TSS concentration of 45 mg/L. This would result in a load of approximately 0.1 tons per event. Using a conservative assumption of 3 major storm events per year, the load at Outfall 002 for storm events would be increased by 0.3 tons per year. Therefore, the maximum estimated annual sediment load from this site due to stormwater runoff would equate to approximately 2.7 tons/year. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR300000), which include a Storm Water Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

5.6.4.4.2 Barretts Minerals Inc – Regal Mine (MTR300136)

The Barretts Minerals Inc – Regal Mine facility is authorized under the General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities (MTR300000) and the facility is located in the Carter Creek drainage. Because no sediment TMDL is being presented for Carter Creek, the WLA for the permit will be part of the TMDL for the lower segment of the Beaverhead River. The permit (MTR300136) includes a Storm Water Pollution Prevention Plan (SWPPP) and requires biannual reporting of discharge monitoring data. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges. DEQ conducted an inspection of the 190 acre site in July 2007 and concluded the SWPPP was being followed.

According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/l. According to PRISM data the annual average precipitation for this site is approximately 18 inches. Given the 190 acres of disturbed area, 18 inches of precipitation, and using the condition of the benchmark value (100 mg/l) found in the permit, the maximum estimated annual sediment load from this site due to stormwater runoff would equate to approximately 39 tons/year. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR300000), which include a Storm Water Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

5.6.4.4.3 Barretts Minerals Inc – Talc Mill (MTR300160)

The Barretts Minerals Inc – Talc Mill facility is authorized under the General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities (MTR300000) and is located in the lower Beaverhead River drainage. The permit (MTR300160) includes a Storm Water Pollution Prevention Plan (SWPPP) and requires biannual reporting of discharge monitoring data. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges. DEQ conducted an inspection of the 72 acre site in June 2010 and concluded the SWPPP was being followed.

According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/l. According to PRISM data the annual average precipitation for this site is approximately 10 inches. Given the 72 acres of disturbed area, 10 inches of precipitation, and using the condition of the benchmark value (100 mg/l) found in the permit, the maximum estimated annual sediment load from this site due to stormwater runoff would equate to approximately 8 tons/year. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR300000), which include a Storm Water Pollution Prevention Plan (SWPPP) with numerous BMPs and site stabilization before a permit can be terminated.

5.6.4.5 Concentrated Animal Feeding Operations

Big West Management LLC (MTG010212) and Matador Cattle Company (MTG010165)

Big West Management Cattle Development Center is located east of Dillon on Sweetwater Road in the Carter Creek drainage. Matador Cattle Company is located southeast of Dillon on Blacktail Road in the Blacktail Deer Creek drainage. Both facilities operate under a Concentrated Animal Feeding Operation General Permit.

In addition to the general permit requirements, the permits for Big West Management LLC and Matador Cattle Company include additional considerations which must be met, two of which are observed here in the development of the sediment TMDLs.

1) The facility must be designed, constructed, and operated to contain all process generated wastewaters, plus the precipitation from the runoff of a 25-year, 24-hour rain event. The weather station to determine the amount of precipitation that occurs at the facility shall be the Dillon Airport. The permittee has the option of maintaining a comparable precipitation gage at the facility.

2) The facility shall prepare an Annual Report Form (AR2) that is site-specific and addresses manure, wastewater handling, storage, land application of manure, actual animal counts and other nutrient sources, site management, record keeping, and other items outlined in the report.

Compliance with the Concentrated Animal Feeding Operation General Permit, and the associated DEQ approved Annual Report Form (AR2) constitute the meeting of all TMDL requirements for sediment for these facilities. Under the conditions of the permits, all pollutants are to be contained on site during any and all storm events less than a 25-year, 24 hour rain event. Therefore the TMDL is 0 for this source, under typical rainfall events (less than 25-year storm event).

5.6.4.6 Construction Storm Water Permits

All construction stormwater permits were authorized under General Permit MTR100000. Since construction activities at a site are relatively temporary and short term in nature, the number of construction sites covered by the general permit at any given time varies. Collectively, these areas of severe ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained. Each construction stormwater permittee is required to develop a SWPPP that identifies the stormwater BMPs that will be in place during construction. Prior to permit termination, disturbed areas are required to have a vegetative density equal to or greater than 70% of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required, and although Montana stormwater regulations provide the authority to require stormwater monitoring, water quality sampling is typically not required (Heckenberger, Brian, personal communication 2009).

To estimate the disturbed acreage associated with construction stormwater permits, the permit files were reviewed for anticipated acres to be disturbed. As of January 17, 2012 there were nine of construction stormwater permits in the Beaverhead TMDL planning area:

- 7 projects in the Beaverhead River watershed – 40 disturbed acres total
- 2 projects in the Blacktail Deer Creek watershed - 23 disturbed acres total

Because TMDLs are allocated to the watershed scale, all permitted construction project loading within the Beaverhead TPA will be evaluated cumulatively to facilitate development of a composite wasteload allocation.

Two approaches were used to estimate sediment loading from permitted construction sites. The first approach provides an estimate of the sediment loads if inadequate BMPs were in place. The second approach then provides an estimate of the sediment loads with BMPs in place, consistent with storm water construction permit expectations. Loads from both approaches were derived using the output from the upland erosion assessment (**Section 5.6.2** and **Appendix F**). Construction sites have the potential to have C-factors ranging from 0.3 to 1 (Toy and Foster, 1998; Pudasaini, et al., 2004; Sinha and Labi, 2007), with variability associated with soil type and slope, stage of construction, and level of BMP implementation. To estimate impacts from a site with inadequate BMPs, the existing annual erosion rate normalized per acre for the Beaverhead TPA for cultivated crops was tripled to represent construction sites with some ground cover but inadequate BMP implementation (i.e., approximate C-factor = 0.6), resulting in an erosion rate of 0.05 tons/acre/year. This value is then multiplied by the disturbed acreage associated with construction stormwater permits, resulting in 2 tons/year (0.05 * 40 acres = 2) for the Beaverhead watershed and about 1.2 tons for the Blacktail Deer Creek watershed (0.05 * 23 acres = 1.15).

To estimate impacts from these same sites with BMPs in place, the loading rate associated with implementation of upland and riparian BMPs from the desired condition of the cultivated crops category used in **Appendix F** was used as an equivalent condition. This loading rate is equal to 0.009 tons/acre/year and equates to a C-factor of 0.1. This loading rate is then multiplied by the disturbed acreage resulting in a load of 0.4 tons/year for the Beaverhead watershed and 0.2 tons/year for the Blacktail Deer Creek watershed. These lower values represent the estimated existing loads from permitted construction sites based on the assumption that appropriate BMPs are in place and being properly maintained.

Assessment Summary

Based on the source assessment, MPDES permits in the Beaverhead TPA have an allowable load of 153 tons of sediment per year (**Table 5-47**). Allowable loads assume the resultant load when all permit required BMPs are in place. Depending on actual implementation and maintenance of BMPs, the existing load may be less than the allowable load; or, if BMPs are currently not in place or insufficient to meet the permit requirements, the existing load may be exceeding the allowable load. For the purpose of the estimated existing loads in **Table 5-47**, permitted entities were assumed to be in compliance with BMP requirements when no site-specific BMP data was available.

Table 5-47. Annual Sediment Load (tons/year) from Point Sources within the Beaverhead TPA.

Watershed	Facility	Permit	Total Estimated Existing Load (tons/year)	Total Allowable Load (tons/year)	Sediment Load Allocation (Percent Reduction)
Beaverhead River Lower (includes WLAs for Carter Creek)	Dillon WWTF	MT0021458	20	91*	0%
	BMI Talc Mill	MTR300160	8	8	0%
	BMI Regal Mine	MTR300136	39	39	0%
	Storm Water Construction	MTR100000 (7 projects)	0.4	0.4	0%
	Big West Management	MTG010212	0	0	0%
Blacktail Deer Creek	Storm Water Construction	MTR100000 (2 projects)	0.2	0.2	0%
	Matador Cattle Company	MTG010165	0	0	0%
Stone Creek Upper	Beaverhead Talc Mine	MT0027821	0.7	0.7	0%
	BMI Treasure Mine	MT0029891	11	11	0%
	BMI Treasure Mine	MTR300135	2.7	2.7	0%

*Permit allows for loading above current levels

5.6.5 Source Assessment Summary

The estimated annual sediment load from all identified sources throughout the Beaverhead TPA is 86,564 tons. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, due to the uncalibrated nature of the source assessment work and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate source impacts within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus waters quality restoration activities in the Beaverhead TMDL planning area by indicating the relative contribution of different subwatersheds or landcover types for that source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendices E**, **F**, and **G**).

5.7 Sediment TMDLs and Allocations

This section is organized by the following topics:

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

5.7.1 Application of Percent Reduction and Yearly Load Approaches

The sediment TMDLs for the Beaverhead TPA will be based on a percent reduction approach discussed in **Section 4.** This approach will apply to the loading allocated among sources as well as each individual waterbody TMDLs. An implicit margin of safety will be applied as further discussed in **Section 5.8**. (Cover, et al., 2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools; it is assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attainment of the sediment related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate th**e** allowable load and because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL), particularly when comparing different load categories such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement best practices (i.e., BMPs), versus focusing on uncertain loading values.

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

5.7.2 Development of Sediment Allocations by Source Categories

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

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

Progress towards TMDL and individual allocation achievement can be gaged by adherence to point source permits, BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

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

5.7.2.1 Streambank Erosion
Sediment loads associated with bank erosion were identified by separate source categories (e.g., transportation, grazing, natural) in Appendix E. Because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding impacts from historical land management activity, all human caused sources of bank erosion were combined for the purpose of expressing the TMDL and allocations. Streambank stability and erosion rates are very closely linked to the health of the riparian zone; reductions in sediment loading from bank erosion are expected to be achieved by applying BMPs within the riparian zone.

5.7.2.2 Upland Erosion
No reductions were allocated to natural sources, which are a significant portion of all upland land use categories. The allocation to upland sources includes application of BMPs to present land use activities as well as recovery from past land use influences such as riparian harvest. For all upland sources, the largest percent reduction will be achieved via riparian improvements.

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

5.7.2.4 Permitted Point Sources
Due to the limited number of subwatersheds with permitted point sources, WLAs are only presented in the TMDLs for the Beaverhead River, Blacktail Deer Creek, and Stone Creek. WLAs are expected to be met by adherence to permit conditions.

5.7.3 Allocations and TMDLs for Each Stream
The following subsections present of the existing quantified sediment loads, allocations and TMDL for each waterbody.

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

Sediment loading values and the resulting TMDLs and allocations are acknowledged to be coarse estimates. Progress towards TMDL achievement will be gauged by permit adherence for WLAs, BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

The sediment TMDLs for all streams and stream segments presented below are expressed as a yearly load, and a percent reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in the associated tables (**Tables 5-48** through **5-65).** Each impaired segment's TMDL consists of any upstream allocations.

5.7.3.1 Beaverhead River, lower segment (MT41B001_020)

Table 5-48. Sediment Source Assessment, Allocations and TMDL for the Lower Beaverhead River

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		66	20	70%
Eroding Banks	Human Influenced	55,924	21,122	69%
	Natural	12,600		
Upland Erosion	All Land Uses	17,952	5,541	69%
Point Source	Dillon WWTF	20	*91	0%
	BMI Talc Mill	8	8	0%
	BMI Regal Mine	39	39	0%
	Storm Water Construction	0.4	0.4	0%
	Big West Management	0	0	0%
	Upstream Point Sources**	14.6	14.6	0%
Total Sediment Load		86,624	26,836	69%

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
*Permit allows for loading above current levels
**Allocations for upstream point sources can be found in the Upper Stone Creek and Blacktail Deer Creek TMDLs

Additional Condition: BOR Flushing Flow Release
Sediment from Clark Canyon Creek, Grasshopper Creek, and other tributaries is known to create depositional areas in the Beaverhead River during the spring because of limited flow releases from the Clark Canyon Dam. The dam needs to be operated in a reasonable manner, in accordance with ARM §17.30.636, which states that owners and operators of water impoundments that cause conditions harmful to prescribed beneficial uses of state water shall demonstrate to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects. Flushing flow is considered a reasonable operation under most conditions (an exception being drought conditions) to keep from creating depositional areas harmful to fish and aquatic life. This is particularly applicable for the occasional early season high flow events within Clark Canyon Creek that lead to high levels of sediment deposition in the Beaverhead River. DEQ recognizes that water rights may override managing reservoir releases to provide flushing flows for sediment mobility.

5.7.3.2 Blacktail Deer Creek (MT41B002_030)

Table 5-49. Sediment Source Assessment, Allocations and TMDL for Blacktail Deer Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		18	5	72%
Eroding Banks	Human Influenced	6,266	3,376	61%
	Natural	2,305		
Upland Erosion	All Land Uses	6,473	2,013	69%
Point Source	Storm Water Construction	0.2	0.2	0%
	Matador Cattle Company	0	0	0%
Total Sediment Load		15,062	5,394	64%

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

5.7.3.3 Clark Canyon Creek (MT41B002_110)

Table 5-50. Sediment Source Assessment, Allocations and TMDL for Clark Canyon Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		0.3	0.1	67%
Eroding Banks	Anthropogenically Influenced	807	409	62%
	Natural	277		
Upland Erosion	All Land Uses	146	91	38%
Total Sediment Load		1,230	500	59%

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

5.7.3.4 Dyce Creek (MT41B002_140)

Table 5-51. Sediment Source Assessment, Allocations and TMDL for Dyce Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		1.9	0.5	74%
Eroding Banks	Anthropogenically Influenced	1,104	582	61%
	Natural	395		
Upland Erosion	All Land Uses	250	77	69%
Total Sediment Load		1,751	660	62%

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

5.7.3.5 Farlin Creek (MT41B002_020)

Table 5-52. Sediment Source Assessment, Allocations and TMDL for Farlin Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		0.4	0.1	75%
Eroding Banks	Anthropogenically Influenced	500	319	56%
	Natural	231		
Upland Erosion	All Land Uses	94	36	62%
Total Sediment Load		825	355	57%

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

5.7.3.6 French Creek (MT41B002_100)

Table 5-53. Sediment Source Assessment, Allocations and TMDL for French Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		1.7	0.5	73%
Eroding Banks	Anthropogenically Influenced	677	283	67%
	Natural	177		
Upland Erosion	All Land Uses	220	92	58%
Total Sediment Load		1,076	376	65%

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

5.7.3.7 Grasshopper Creek (MT41B002_010)

Table 5-54. Sediment Source Assessment, Allocations and TMDL for Grasshopper Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		16.5	4.6	72%
Eroding Banks	Anthropogenically Influenced	9,992	5,135	62%
	Natural	3,467		
Upland Erosion	All Land Uses	3,859	1,236	68%
Total Sediment Load		17,335	6,376	63%

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

5.7.3.8 Rattlesnake Creek, upper segment (MT41B002_091)

Table 5-55. Sediment Source Assessment, Allocations and TMDL for the Upper Rattlesnake Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		3.7	1	73%
Eroding Banks	Anthropogenically Influenced	2,341	1,661	54%
	Natural	1,240		
Upland Erosion	All Land Uses	713	292	59%
Total Sediment Load		4,298	1,954	55%

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

5.7.3.9 Rattlesnake Creek, lower segment (MT41B002_090)

Table 5-56. Sediment Source Assessment, Allocations and TMDL for Lower Rattlesnake Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		7.3	2.2	70%
Eroding Banks	Anthropogenically Influenced	3,114	1,937	57%
	Natural	1,399		
Upland Erosion	All Land Uses	1,486	513	65%
Total Sediment Load		6,006	2,452	59%

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

5.7.3.10 Reservoir Creek (MT41B002_120)

Table 5-57. Sediment Source Assessment, Allocations and TMDL for Reservoir Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		0.5	0.2	67%
Eroding Banks	Anthropogenically Influenced	1,982	952	64%
	Natural	630		
Upland Erosion	All Land Uses	116	35	70%
Total Sediment Load		2,729	987	64%

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

5.7.3.11 Scudder Creek (MT41B002_180)

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

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		1.1	0.3	69%
Eroding Banks	Anthropogenically Influenced	846	488	59%
	Natural	344		
Upland Erosion	All Land Uses	164	48	71%
Total Sediment Load		1,355	536	60%

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

5.7.3.12 Spring Creek (MT41B002_080)

Table 5-59. Sediment Source Assessment, Allocations and TMDL for Spring Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		2.5	0.7	70%
Eroding Banks	Anthropogenically Influenced	3,399	1,144	72%
	Natural	639		
Upland Erosion	All Land Uses	763	242	68%
Total Sediment Load		4,804	1,387	71%

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

5.7.3.13 Steel Creek (MT41B002_160)

Table 5-60. Sediment Source Assessment, Allocations and TMDL for Steel Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		0.7	0.2	66%
Eroding Banks	Anthropogenically Influenced	307	157	62%
	Natural	107		
Upland Erosion	All Land Uses	103	27	74%
Total Sediment Load		518	184	64%

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

5.7.3.14 Stone Creek, upper segment (MT41B002_132)

Table 5-61. Sediment Source Assessment, Allocations and TMDL for Upper Stone Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		1.7	0.6	66%
Eroding Banks	Anthropogenically Influenced	2,560	745	75%
	Natural	378		
Upland Erosion	All Land Uses	716	182	75%
Point Source	Beaverhead Talc Mine	0.7	0.7	0%
	BMI Treasure Mine	11	11	0%
	BMI Treasure Mine (stormwater)	2.7	2.7	0%
Total Sediment Load		3,670	942	74%

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

5.7.3.15 Stone Creek, lower segment (MT41B002_131)

Table 5-62. Sediment Source Assessment, Allocations and TMDL for Lower Stone Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		2	0.7	66%
Eroding Banks	Anthropogenically Influenced	3,755	1,089	75%
	Natural	551		
Upland Erosion	All Land Uses	929	242	74%
Point Source	Upstream Point Sources*	14.4	14.4	0%
Total Sediment Load		5,251	1,346	74%

Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
*Allocations for upstream point sources can be found in the Upper Stone Creek TMDL

5.7.3.16 Taylor Creek (MT41B002_170)

Table 5-63. Sediment Source Assessment, Allocations and TMDL for Taylor Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		1.1	0.3	74%
Eroding Banks	Anthropogenically Influenced	1,611	974	58%
	Natural	687		
Upland Erosion	All Land Uses	344	87	75%
Total Sediment Load		2,643	1,061	60%

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

5.7.3.17 West Fork Blacktail Deer Creek (MT41B002_060)

Table 5-64. Sediment Source Assessment, Allocations and TMDL for West Fork Blacktail Deer Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		3.1	0.7	77%
Eroding Banks	Anthropogenically Influenced	1,161	784	55%
	Natural	569		
Upland Erosion	All Land Uses	1,212	304	75%
Total Sediment Load		2,945	1,089	63%

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

5.7.3.18 West Fork Dyce Creek (MT41B002_070)

Table 5-65. Sediment Source Assessment, Allocations and TMDL for West Fork Dyce Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction)
Roads		0.6	0.2	70%
Eroding Banks	Anthropogenically Influenced	298	148	63%
	Natural	98		
Upland Erosion	All Land Uses	88	25	71%
Total Sediment Load		485	173	64%

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

5.7.4 Meeting the Intent of TMDL Allocations

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

It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased sediment loading. For example, a landowner or land manager that negatively impacts an existing healthy riparian area might increase sediment loading in a manner that is not consistent with the bank erosion and/or upland sediment load allocations that apply throughout the watershed.

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

5.8 SEASONALITY AND MARGIN OF SAFETY

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

5.8.1 Seasonality

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

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

5.8.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a margin of safety is required as a component of each TMDL. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets.
- TMDL development was pursued for all listed streams evaluated, even though some streams were close to meeting all target values. This approach addresses some of the uncertainty

associated with sampling variability and site representativeness, and recognizes that sediment source reduction capabilities exist throughout the watershed.

- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below in **Section 5.9** and in **Sections 6** and **7**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- TMDLs are developed at the watershed scale addressing all potentially significant human related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.9 TMDL Development Uncertainties and Adaptive Management

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

As noted in **Section 5.8.2**, adaptive management represents an important component of the implicit margin of safety. This document provides a framework to satisfy the MOS by including a section focused on TMDL implementation, monitoring and adaptive management (**Section 6**). Furthermore, state law (ARM 75-5-703), requires monitoring to gage progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

Perhaps the most significant uncertainties within this document involve the accuracy and representativeness of 1) field data and target development and 2) the accuracy and representativeness of the source assessments and associated load reductions. These uncertainties and approaches used to reduce uncertainty are discussed in following subsections.

5.9.1 Sediment and Habitat Data Collection and Target Development

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

Data Collection

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

Even with the applied quality controls, a level of uncertainty regarding overall accuracy of collected data will exist. There is uncertainty regarding whether or not the appropriate sites were assessed and whether or not an adequate number of sites were evaluated for each stream. Also, there is the uncertainty of the representativeness of collecting data from one sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access problems.

Target Development

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

The established targets are meant to apply under median conditions of natural background and natural disturbance. It is recognized that under some natural conditions such as a large fire or flood event, it may be impossible to satisfy one or more of the targets until the stream and/or watershed recovers from the natural event. The goal, under these conditions, is to ensure that management activities are undertaken in a way that the achievement of targets is not significantly delayed in comparison to the natural recovery time. Also, human activity should not significantly increase the extent of water quality impacts from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be significantly increased from a large number of road crossing or culvert failures.

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

5.9.2 Source Assessments and Load Reduction Analyses

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

Bank Erosion

The load quantification approach for bank erosion is based on a standard methodology (BEHI) as defined within **Appendix C**. Field data collection was by trained environmental professionals per a standard DEQ procedure (Montana Department of Environmental Quality, 2010). Prior to any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP, and was based on a stratification process described in **Appendix C**. The results were then extrapolated across the Beaverhead watersheds as defined in **Appendix E** to provide an estimate of the relative bank erosion loading from various streams and associated stream reaches.

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

There is additional uncertainty regarding the amount of bank erosion linked to human activities and the specific human sources, as well as the ability to reduce the human related bank erosion levels. This is further complicated by historic human disturbances in the watershed, which could still be influencing proper channel shape, pattern and profile and thus contributing to increased bank erosion loading that may appear natural. Even if difficult to quantify, the linkages between human activity such as riparian clearing and bank erosion, are well established and these linkages clearly exist at different locations throughout the Beaverhead watershed. Evaluating bank erosion levels, particularly where best management practices have been applied along streams, is an important part of adaptive management that can help define the level of human-caused bank erosion as well as the relative impact that bank erosion has on water quality throughout the Beaverhead watershed.

Upland Erosion

A professional modeler determined upland erosion loads applying a standard erosion model as defined in **Appendix F**. As with any model, there will be uncertainty in the model input parameters including uncertainties regarding land use, land cover and assumptions regarding existing levels of BMP application. For example, the model only allows one vegetative condition per land cover type (i.e., cannot reflect land management practices that change vegetative cover from one season to another), so an average condition is used for each scenario in the model. To minimize uncertainty regarding existing conditions and management practices, model inputs were reviewed by stakeholders familiar with the watershed.

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

Roads

As described in **Appendix G**, the road crossings sediment load was estimated via a standardized simple yearly model developed by the U.S. Forest Service. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 26 sites were randomly selected for evaluation, representing about 3% of the total population of roads. A total of 7 parallel road segments were selected for evaluation in the field. The results from these sites were extrapolated to the whole population of roads stratified by Level IV Ecoregion. The potential to reduce sediment loads from unpaved roads through the application of Best Management Practices (BMPs) was assessed by reducing contributing road segment lengths to 100 feet. This approach introduces uncertainty based on how well the sites and associated BMPs represent the whole population. Although the exact percent reduction will vary by road, the analysis clearly shows a high potential for sediment loading reduction by applying standard road BMPs in places where they are lacking or can be improved.

Application of Source Assessment Results

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

6.0 Other Identified Issues or Concerns

6.1 Non-Pollutant Listings

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) list. In other cases, streams in the Beaverhead TPA may appear on the 303(d) list but may not always require TMDL development for a pollutant, but do have non-pollutant listings such as “alteration in streamside or littoral vegetation covers” that could be linked to a pollutant. These habitat related non-pollutant causes are often associated with sediment issues, may be associated with nutrient or temperature issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Beaverhead watershed as a whole. In some cases, pollutant and *non-pollutant* causes are listed for a waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the non-pollutant listings. **Table 6-1** presents the *non-pollutant* listings in the Beaverhead TPA, and notes those streams listed that either do not have any associated sediment pollutant listings or a TMDL in this document.

Table 6-1. Waterbody segments with non-pollutant listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
*Beaverhead River (upper), Clark Canyon Dam to Grasshopper Creek	MT41B001_010	Alteration in streamside or littoral vegetative covers & low flow alterations
Beaverhead River (lower), Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Alteration in streamside or littoral vegetative covers, low flow alterations, and physical substrate habitat alterations
Blacktail Deer Creek, headwaters to mouth (Beaverhead River)	MT41B002_030	Alteration in streamside or littoral vegetative covers & low flow alterations
Clark Canyon Creek, headwaters to mouth (Beaverhead River)	MT41B002_110	Alteration in streamside or littoral vegetative covers
Dyce Creek, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Alteration in streamside or littoral vegetative covers & low flow alterations
*East Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_040	Alteration in streamside or littoral vegetative covers
Farlin Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_020	Alteration in streamside or littoral vegetative covers
French Creek, headwaters to mouth (Rattlesnake Creek)	MT41B002_100	Alteration in streamside or littoral vegetative covers
Grasshopper Creek, headwaters to mouth (Beaverhead River)	MT41B002_010	Alteration in streamside or littoral vegetative covers & low flow alterations
Rattlesnake Creek (upper), headwaters to Dillon PWS off-channel well T7S R10W S11	MT41B002_091	Alteration in streamside or littoral vegetative covers
Rattlesnake Creek (lower), from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Alteration in streamside or littoral vegetative covers & low flow alterations

Table 6-1. Waterbody segments with non-pollutant listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Reservoir Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Alteration in streamside or littoral vegetative covers
Scudder Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_180	Alteration in streamside or littoral vegetative covers
Spring Creek, headwaters to mouth (Beaverhead River)	MT41B002_080	Alteration in streamside or littoral vegetative covers & low flow alterations
Steel Creek, headwaters to mouth (Driscoll Creek)	MT41B002_160	Alteration in streamside or littoral vegetative covers
Stone Creek (upper), Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	Alteration in streamside or littoral vegetative covers & low flow alterations
Stone Creek (lower), confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	Alteration in streamside or littoral vegetative covers
Taylor Creek, headwaters to mouth (Grasshopper Creek)	MT41B002_170	Alteration in streamside or littoral vegetative covers
West Fork Blacktail Deer Creek, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Alteration in streamside or littoral vegetative covers
West Fork Dyce Creek, headwaters to mouth (Dyce Creek)	MT41B002_070	Alteration in streamside or littoral vegetative covers

* Streams listed for *non-pollutant* with no corresponding sediment pollutant listing and no sediment TMDL in this document.

6.2 Non-Pollutant Causes of Impairment Descriptions

Non-pollutant listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant, however non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and non-pollutant categories are linked and appear together in the cause listings, however a non-pollutant category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of the identified non-pollutant causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteration in Streamside or Littoral Vegetation Covers
This is a form of habitat alteration impairment that refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the streamside vegetation, destabilized banks from loss of vegetative root mass could lead to overwidened stream channel conditions and elevated sediment loads.

Physical Substrate Habitat Alterations
This is a form of habitat alteration impairment that generally describes cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of

habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Low Flow Alterations
Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life.

It should be noted that while Montana law states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate any state or federal regulations or guidance related to stream assessment and beneficial use determination. Subsequent to the identification of this as a probable cause of impairment, it is up to local users, agencies, and entities to improve flows through water and land management.

6.3 Monitoring and BMPs for Non-Pollutant Affected Streams

Two forms of habitat alteration (alteration in streamside or littoral vegetation covers and physical substrate habitat alterations) can be linked to the sediment TMDL development, where there is overlap between the two (**Table 6-1**). It is likely that meeting the sediment TMDL targets will also equate to addressing the habitat impairment conditions in each of these streams. For the two streams with no sediment TMDL (East Fork Blacktail Deer Creek and upper segment of the Beaverhead River), meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

Streams listed for *non-pollutants* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data is minimal and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses are not well defined. Watershed management planning should also include strategies to help increase stream flows, particularly during summer low flow periods for those streams with low flow alteration impairment causes. Increasing flow during the winter and spring to address low flow problems in the upper segment of the Beaverhead River should also be part of the watershed management strategy. The monitoring and restoration strategies that follow in **Sections 7.0** and **8.0** are presented to address both pollutant and non-pollutant issues for streams in the Beaverhead TPA with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant categories.

7.0 Restoration Objectives and Implementation Strategy

While certain land uses and human activities are identified as sources and causes of water quality impairment during TMDL development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain water quality standards in Beaverhead TPA streams. The strategy includes general measures for reducing loading from each significant identified pollutant source.

7.1 Water Quality Restoration Objectives

The following are general water quality goals provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Beaverhead TPA by improving sediment water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,
    - pollutant source assessments, and
    - a restoration and TMDL implementation strategy.

A watershed restoration plan (WRP) can provide a framework strategy for water quality restoration and monitoring in the Beaverhead TPA, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. Watershed restoration plans identify considerations that should be addressed during TMDL implementation and should assist stakeholders in developing a more detailed adaptive plan in the future. A locally developed WRP will likely provide more detailed information about restoration goals and spatial considerations but may also encompass more broad goals than this framework includes. A WRP would serve as a locally organized "road map" for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. The WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities. The following are key elements suggested for the WRP:

- Support for implementing restoration projects to protect water conditions so that all streams and aquatic resources in the watershed maintain good water quality, with an emphasis on waters with TMDLs completed.
- Detailed cost/benefit analysis and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installment and efficiency results tracking.
- Provide information and education components to assist with stakeholder outreach about restoration approaches, benefits, and funding assistance.
- Other various watershed health goals, such as weed control initiatives and wetland restoration.
- Other local watershed based issues.

7.2 Agency and Stakeholder Coordination

Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders. The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help fund water quality improvement and pollution prevention projects, and can help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts include the Beaverhead Watershed Committee, USFS, NRCS, DNRC, FWP, BOR, BLM, NRDP, EPA and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Center, University of Montana Watershed Health Clinic, Montana Aquatic Resources Services (MARS), and MSU Extension Water Quality Program.

7.3 Sediment Restoration Strategy

The goal of the sediment restoration strategy is to prevent the availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport.

Riparian and wetland vegetation restoration and long term riparian area management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Native riparian and wetland vegetation provides root mass which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian vegetation filters pollutants from upland runoff. Therefore, improving riparian and wetland vegetation will decrease bank erosion by improving streambank stability and will also reduce pollutant delivery from upland sources. Sediment is also deposited more heavily in healthy riparian and wetland zones during flooding because water velocities slow in these areas enough for excess sediment to settle out.

Riparian and wetland disturbance has occurred throughout the Beaverhead TPA as a result of many influencing factors. The conversion of forest and valley bottoms for agriculture, livestock production, and residential development have all had varying degrees of impact, depending on the drainage. Restoration recommendations involve the promotion of riparian and wetland recovery through improved land management, floodplain and streambank stabilization, and revegetation efforts where necessary. In general, natural recovery of disturbed systems is preferred however it is acknowledged that existing conditions may not readily allow for unassisted recovery in some areas where disturbance has occurred. Active vegetation planting and bank or stream channel reshaping may increase costs, but may be a reasonable and relatively cost effective restoration approach, depending on the site. When stream channel restoration work is needed because of altered stream channels, cost increases and projects should be assessed on a case by case basis. The restoration of wetlands that have been historically ditched or drained in conjunction with agricultural BMPs and riparian buffers can also be an effective means of reducing sediment inputs. The implementation of BMPs should aim to prevent the availability, transport, and delivery of a pollutant through the most natural or natural-like means possible. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g. WRP).

Improved grazing management is another major component of the sediment restoration approach. This may include adjusting the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas. Additionally, grazing management, combined with some additional fencing in many riparian areas, would promote natural recovery. In general, these are sustainable agricultural practices that promote attainment of conservation objectives while meeting agricultural production goals. The appropriate BMPs will differ by landowner and are recommended to be part of a comprehensive farm/ranch plan.

Although roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams should be to divert water off of roads and ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. Sediment loads from culvert failure and culvert caused scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

All of these best management practices are considered reasonable restoration approaches due to their benefit and generally low costs. Riparian restoration and road erosion control are standard best management practices identified by NRCS. Although the appropriate BMP will vary by waterbody and site, controllable sources and BMP types can be prioritized by watershed to reduce sediment loads in individual streams.

7.4 Restoration Approaches by Source Category

For each major source of human-caused pollutant loads in the Beaverhead TPA, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Beaverhead TPA should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. The source assessment results provided within **Appendices E - G** and summarized in **Section 5.6** provide information that should be used to help determine priorities for each major source type in the watershed and for each of the general management recommendations discussed.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current non-pollutant-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 8.0**.

7.4.1 Riparian Areas, Wetlands, and Floodplains

Riparian areas, wetlands, and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. The performance of the above named functions is dependent on the connectivity of riparian areas, wetlands and floodplains to both the stream channel and upland areas. Anthropogenic activities affecting the quality of these transitional habitats or their connectivity can alter their performance and greatly affect the transport of water, sediments, and contaminants (e.g. channelization, increased stream power, bank erosion, and habitat loss or degradation). Therefore, restoring, maintaining, and protecting riparian areas, wetlands, and floodplains within the watershed should be a priority of TMDL implementation in the Beaverhead TPA.

Initiatives to protect riparian areas, wetlands, and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian and wetland vegetation communities and limited their functionality, a tiered approach for restoring stream channels and adjacent riparian and wetland vegetation should be considered. Restoration should prioritize areas based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover and local native riparian and wetland vegetation on streambanks. Passive riparian and wetland restoration is preferable, but in areas where stream channels are unnaturally stable or streambanks are eroding excessively, active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be needed. Factors influencing appropriate riparian and wetland restoration would include the severity of degradation, site-potential for various species, and the availability of local and native sources as transplant materials. In general, riparian and wetland plantings would promote the establishment of functioning stands of native riparian species. Weed management should also be a dynamic component of managing riparian and wetland areas.

The use of riprap or other “hard” approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although they may be absolutely necessary in some instances, these “hard” approaches generally redirect channel energy and exacerbate erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat.

7.4.2 Grazing

Development of riparian and wetland area grazing management plans should be a goal for landowners in the watershed who are not currently using a plan. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. The goal of riparian grazing management is not to eliminate all grazing in these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure. Grazing should be managed to provide filtering capacity via adequate groundcover and streambank stability via mature riparian vegetation communities.

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Beaverhead TPA are providing off-site watering sources, limiting livestock access to streams, providing "water gaps" where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank revegetation are preferred BMPs, in some instances, bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and non-pollutant can be obtained in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2007).

7.4.3 Small Acreages

Small acreages are growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007) or the MSU extension website at: http://www.msuextension.org/ruralliving/Index.html.

7.4.4 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality. To minimize water quality effects from AFOs, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal. An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and in addition may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as, regulatory components. If voluntary efforts can eliminate discharges to state waters, in some cases no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce wasteloads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90 percent (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Opportunities for financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance are available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at:
http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp

Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:
- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ Permitting Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

7.4.5 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendations for the Beaverhead TPA are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for filter strips and 50 percent for buffers (Montana Department of Environmental Quality, 2007). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2007).

7.4.6 Flow and Irrigation

Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to stream flow can have a profound effect on the ability of a stream to mobilize sediment, allow sediment to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis, 1995; Schmidt and Potyondy, 2004). See **Attachment A** for Flushing Flow Recommendations for the Beaverhead River. Local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

7.4.7 Unpaved Roads

The road sediment reductions in this document represent an estimation of the sediment load that would remain once appropriate road BMPs were applied at all locations. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.
- Limit new road stream crossings and the length of near-stream parallel segments to the extent practicable.

7.4.7.1 Culverts and Fish Passage

Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis found that approximately 58% of the culverts pass the discharge of a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 19 culverts in the watershed, which is a small percentage of the total culverts, and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. In a coarse assessment of fish passage, 74% of assessed culverts were determined to pose a significant passage risk to juvenile fish at all flows; this suggests that a large percentage of culverts in the watershed are barriers to fish passage. Each fish barrier should be assessed individually to determine if it functions as an invasive species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana FWP can aid in determining if a fish passage barrier should be mitigated, and, if so, can aid in culvert design.

7.4.7.2 Traction Sand
Severe winter weather and mountainous roads in the Beaverhead TPA will require the continued use of relatively large quantities of traction sand. Nevertheless, closer evaluation of and adjustments to existing practices should be done to reduce traction sand loading to streams to the extent practicable. The necessary BMPs may vary throughout the watershed and particularly between state and private roads but may include the following:

- Utilize a snow blower to directionally place snow and traction sand on cutslopes/fillslopes away from sensitive environments.
- Increase the use of chemical deicers and decrease the use of road sand, as long as doing so does not create a safety hazard or cause undue degradation to vegetation and water quality.
- Improve maintenance records to better estimate the use of road sand and chemicals, as well as to estimate the amount of sand recovered in sensitive areas.
- Continue to fund MDT research projects that will identify the best designs and procedures for minimizing road sand impacts to adjacent bodies of water and incorporate those findings into additional BMPs.
- Street sweeping and sand reclamation.
- Identify areas where the buffer could be improved or structural control measures may be needed.
- Improved maintenance of existing BMPs.
- Increase availability of traction sand BMP training to both permanent and seasonal MDT employees as well as private contractors.

7.4.8 Forestry and Timber Harvest
Timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (i.e., timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners. .

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. USFS INFISH Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana’s SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995).

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Water yield and peak flow increases should be modeled in areas of continued timber harvest and potential effects should be evaluated. Furthermore, noxious weed control should be actively pursued in all harvest areas and along all forest roads.

7.4.9 Beaver Populations and Sediment Yields

Historic trapping of beavers has likely had an effect on sediment yields in the watershed. Before the removal of beavers, many streams had a series of catchments that moderated flow, with smaller unincised multiple channels and frequent flooding. Now some stream segments have incised channels and are no longer connected to the floodplain. This results in more bank erosion because high flows scour streambanks to a greater extent instead of flowing onto the floodplain. Beaver ponds also capture and store sediment and there can be large reductions in total suspended solids (TSS) concentrations below a beaver impoundment in comparison to TSS concentrations above the beaver impoundment (Bason, 2004).

Management of headwaters areas should include consideration of beaver habitat. Long-term management could include maintenance of beaver habitat in headwaters protection areas and even allowing for increased beaver populations in areas currently lacking the beaver complexes that can trap sediment, reduce peak flows, and increase summer low flows. Allowing for existing and even increased beaver habitat is considered consistent with the sediment TMDL water quality goals.

7.4.10 Storm Water Construction Permitting and BMPs

Construction activities disturb the soil, and if not managed properly, they can be substantial sources of sediment. Construction activity disturbing one acre or greater is required to obtain permit coverage through DEQ under the Storm Water General Permit for Construction Activities. A Storm Water Pollution Prevention Plan (SWPPP) must be developed and submitted to obtain a permit. A SWPPP identifies pollutants of concern, which is most commonly sediment, construction related sources of those pollutants, any nearby waterbodies that could be affected by construction activities, and BMPs that will be implemented to minimize erosion and discharge of pollutants to waterbodies. The SWPPP must be implemented for the duration of the project, including final stabilization of disturbed areas, which is a vegetative cover of at least 70% of the pre-disturbance level or an equivalent permanent stabilization measure. Development and implementation of a thorough SWPPP should ensure WLAs within this document are met.

Land disturbance activities that are smaller than an acre (and exempt from permitting requirements) also have the potential to be substantial pollutant sources, and BMPs should be used to prevent and control erosion consistent with the upland erosion allocations. Potential BMPs for all construction activities include construction sequencing, permanent seeding with the aid of mulches or geotextiles, check dams, retaining walls, drain inlet protection, rock outlet protection, drainage swales, sediment basin/traps, earth dikes, erosion control structures, grassed waterways, infiltration basins, terraced slopes, tree/shrub planting, and vegetative buffer strips. An EPA support document for the construction permits has extensive information about construction related BMPs, including limitations, costs, and effectiveness (EPA 2009).

7.4.11 Urban Area Stormwater BMPs

Even though Dillon and Twin Bridges do not have a large enough population to require a municipal stormwater permit, activities to reduce pollutant loading from new development or redevelopment should be pursued consistent with the upland erosion allocations and efforts to avoid future water quality problems. Any BMPs which promote onsite or after collection infiltration, evaporation, transpiration or reuse of the initial flush stormwater should be implemented as practicable on all new or redevelopment projects. EPA provides more comprehensive information about stormwater best

management practices on their website at:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

7.4.12 Nonpoint Source Pollution Education

Because most nonpoint source pollution (NPS) is generated by individuals, a key factor in reducing NPS is increasing public awareness through education. The Beaverhead Watershed Committee provides educational opportunities to both students and adults through local water quality workshops and informational meetings. Continued education is key to ongoing understanding of water quality issues in the Beaverhead TPA, and to the support for implementation and restorative activities.

7.5 Potential Funding Sources

Funding and prioritization of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources to assist with TMDL implementation.

7.5.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 40 percent match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

7.5.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed annually in December and June. Projects that may be applicable to the Beaverhead watershed include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats.

7.5.3 Watershed Planning and Assistance Grants

The MT DNRC administers Watershed Planning and Assistance Grants to watershed groups that are sponsored by a Conservation District. Funding is capped at $10,000 per project and the application cycle is quarterly. The grant focuses on locally developed watershed planning activities; eligible activities include developing a watershed plan, group coordination costs, data collection, and educational activities.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana’s Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

7.5.4 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years. Each county receives an annual EQIP allocation and applications are accepted continually during the year; payments may not exceed $300,000 within a six-year period.

7.5.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDG) is an annual program administered by MT DNRC that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the AML priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment. RIT/RDG projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

8.0 MONITORING FOR EFFECTIVENESS

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The margin of safety is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring framework presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

The objectives for future monitoring in the Beaverhead TPA include: 1) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, 2) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality and 3) refining the source assessments. Each of these objectives is discussed below.

8.1 ADAPTIVE MANAGEMENT AND UNCERTAINTY

An adaptive management approach is used to manage resource commitments as well as achieve success in meeting the water quality standards and supporting all beneficial uses. This approach works in cooperation with the monitoring strategy and allows for adjustments to the restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary. These adjustments would take into account new information as it arises.

The adaptive management approach is outlined below:

- <u>TMDLs and Allocations</u>: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices.
- <u>Water Quality Status</u>: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified.

8.2 Tracking and Monitoring Restoration Activities and Effectiveness

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the effects, or lack of effects, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutant that is targeted for each project. Information about specific locations, spatial extent, designs, contact information, and any effectiveness evaluation should be compiled about each project. Information about all restoration projects along with tracking overall extent of BMP implementation should be compiled into one location for the entire watershed.

For sediment, which has no numeric standard, loading reductions and BMP effectiveness may be estimated using the approaches used within this document. However, tracking BMP implementation and project-related measurements will likely be most practical for sediment. For instance, for road improvements, it is not anticipated that post-project sediment loads will be measured. Instead, documentation of the BMP, reduced contributing length, and before/after photos documenting the presence and effectiveness of the BMP will be most appropriate. For installation of riparian fencing, before/after photo documentation of riparian vegetation and streambank and a measurement such as greenline that documents the percentage of bare ground and shrub cover may be most appropriate. Evaluating instream parameters used for sediment targets will be one of the tools used to gage the success of implementation when DEQ conducts a formal assessment but may not be practical for most projects since the sediment effects within a stream represent cumulative effects from many watershed scale activities and because there is typically a lag time between project implementation and instream improvements (Meals, et al., 2010).

If sufficient implementation progress is made within a watershed, DEQ will conduct a TMDL Implementation Evaluation (TIE). During this process, recent data are compiled, monitoring is conducted (if necessary), data are compared to water quality targets (typically a subset for sediment), BMP implementation since TMDL development is summarized, and data are evaluated to determine if the TMDL is being achieved or if conditions are trending one way or another. If conditions indicate the TMDL is being achieved, the waterbody will be recommended for reassessment and may be delisted. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9)), the evaluation must determine if:

- The implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary,
- Water quality is improving, but more time is needed for compliance with water quality standards, or
- Revisions to the TMDL are necessary to achieve applicable water quality standards and full support of beneficial uses.

8.3 Baseline and Impairment Status Monitoring

In addition to effectiveness monitoring, watershed scale monitoring should be conducted to expand knowledge of existing conditions and to provide data that can be used during the TIE. Although DEQ is the lead agency for conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

Each of the sediment streams of interest was stratified into unique reaches based on physical characteristics and anthropogenic influence. The assessed sites represent only a percentage of the total number of stratified reaches. Sampling additional monitoring locations could provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole.

It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to achieve those objectives. However, when possible, it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle pebble count (using Wolman Pebble Count methodology and/or 49-point grid tosses)
- Residual pool depth and pool frequency measurements
- Greenline assessment

Additional information will undoubtedly be useful and assist impairment status evaluations in the future and may include total suspended solids, identifying percentage of eroding banks, human sediment sources, areas with a high background sediment load, macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts.

An important part of impairment determination and adaptive management is determining when a stream has fully recovered from past management practices where recovery is still occurring from historical improvements in management but recent BMPs were not applied. Particularly within the Beaverhead Deerlodge National Forest, ongoing PIBO monitoring can provide critical insight into the extent of recovery from past practices via comparisons between reference and managed sites.

8.4 Source Assessment Refinement

In many cases, the level of detail provided by the source assessments only provides broad source categories or areas that need to reduce pollutant loads and additional source inventory and load estimate work may be desirable. Strategies for strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described by pollutant in this section. Although additional suspended sediment and nutrient data at the USGS gage near Garrison may refine the SWAT model, most of the impairments are in tributaries, and thus resources could be used more efficiently by focusing on identifying the most significant source areas within each impaired stream’s watershed to determine where implementation will be most effective. Recommendations for source assessment refinement are described below by pollutant.

Sediment-related information that could help strengthen the source assessments is as follows:

- a bank erosion retreat rate for Beaverhead TPA streams,
- a better understanding of bank erosion impacts from historical land management activities,
- more complex and detailed modeling for upland erosion and sediment delivery to the stream,
- improved modeling for concentrated flow through riparian areas,
- evaluation of seasonal loading aspects for the major sources and potential implications regarding TMDL target parameters,
- a review of land management practices specific to subwatersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories,

- additional sampling in streams with less data to get a better idea of the reductions needed and to identify source areas
- evaluation of “hot spots” that the model may not have adequately addressed, such as a confined animal operation adjacent to a stream, and
- additional field surveys of culverts, roads, and road crossings to help prioritize the road segments/crossings of most concern.

9.0 STAKEHOLDER AND PUBLIC PARTICIPATION

Stakeholder and public involvement is a component of TMDL planning supported by EPA guidelines and required by Montana state law (MCA 75-5-703, 75-5-704) which directs DEQ to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process in the Beaverhead TPA.

9.1 PARTICIPANTS AND ROLES

Throughout completion of the Beaverhead TPA TMDLs, DEQ worked with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Beaverhead TPA and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of theses TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval. Project management was primarily provided by the EPA Regional Office in Helena, MT.

Conservation Districts
The majority of the Beaverhead TPA falls within Beaverhead County. DEQ provided the Beaverhead Conservation District with consultation opportunity during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Beaverhead TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Beaverhead TPA, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members was typically conducted through email and draft documents were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

Area Landowners

Since 46 percent of the planning area is in private ownership, local landowner cooperation in the TMDL process has been critical. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and streamflow characteristics. The DEQ sincerely thanks the planning area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

9.2 Response to Public Comments

Upon completion of the draft TMDL document, and prior to submittal to EPA, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft TMDL document is made available for general public comment, and DEQ addresses and responds to all formal public comments.

This public review period was initiated on April 10th, 2012 and ended on May 9th, 2012. At a public meeting on April 17th in Dillon, MT, DEQ provided an overview of the TMDLs for sediment in the Beaverhead TMDL Planning Area, made copies of the document available to the public, and solicited public input and comment on the plan. The announcement for that meeting was distributed among the Watershed Advisory Group, and advertised in the following newspapers: The Montana Standard in Butte and The Dillon Tribune in Dillon. This section includes DEQ's response to all public comments received during the public comment period.

One letter from Montana Fish, Wildlife, and Parks was submitted to the DEQ during the public comment period. Excerpts from the comment letter are provided below. Responses prepared by DEQ follow each of the individual comments. The original comment letter is held on file at the DEQ and may be viewed upon request.

Montana Fish, Wildlife, and Parks

Comment #1

Riparian Health reference criteria. Because riparian health is a primary factor that directly and indirectly influences stream health, including sediment input, and is dramatically affected by proper implementation of Best Management Practices it is important that particular attention is placed on these parameters. We encourage you to carefully consider whether the sites surveyed in the 2010/2011 assessment are suitable for determining reference criteria. Specifically, it is unclear whether these sites had all reasonable Best Management Practices implemented and are therefore appropriate for consideration as reference conditions. If these sites are not representative of conditions under implementation of Best Management Practices then we strongly encourage you to revisit the reference data used for this portion of the TMDL and augment them with either 1) additional sampling and/or 2) data from literature review and select values that are adequately protective and reflective of riparian conditions associated with Best Management Practices.

Response to #1

The DEQ agrees that riparian health is a primary factor that directly and indirectly influences sediment input to a stream. We believe the use of the 2010/2011 DEQ data to determine the desired or reference condition is reasonable for the statistical analysis used to determine those target values. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development; they include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if high values are desired (as are for % understory cover) and there is a high degree of confidence in the reference data, the 25th percentile of the reference dataset is used; or if reference data are not available and the sampled streams are by and large degraded, the 75th percentile of the sample dataset may be used. Several of the reaches sampled in the Beaverhead TPA in 2010/2011, including reaches on Reservoir, French, and Rattlesnake creeks, are within the range of appropriate riparian conditions. The target value is therefore based on the 75th percentile of the sample dataset (56 %). This approach was taken because regional reference data for percent understory shrub cover are not available for the Beaverhead TPA.

2010/2011 DEQ Data	n	25th	Median	75th
Greenline % understory shrub	29	22	39	**56**

In applying the above statistical approach to the sampled streams which are impaired, it is necessary to note a greater level of uncertainty and perhaps a greater level of future monitoring is warranted as part of the adaptive management approach. However, when comparing the Beaverhead TPA greenline percent understory shrub target value to target values in other recently completed sediment TMDL documents from Montana, ≥56% falls within the mid range of those target values (2012 Little Blackfoot: ≥40%; 2011 Tobacco: ≥57%; 2010 West Fork Gallatin ≥53%; Lower Clark Fork: ≥70%). The ≥56% understory shrub target value in conjunction with the ≤1% disturbed ground target value represents the desired condition based on available data, which the DEQ believes is both protective and feasible. However, as new regional reference data is collected, targets may be modified to reflect the potential of the riparian area.

Comment #2

Beaverhead Reference Conditions. No Sediment Targets were provided for several parameters for the Beaverhead River. Because we will be collectively focusing on reducing sediment loads and ultimately delisting all TMDL listed streams, including the Beaverhead River, over the coming years it is necessary that sediment targets be established as a restoration endpoint for all listed streams. We recognize that establishing these values for the Beaverhead River presents unique challenges related to difficulty of sampling and paucity of comparable reference information but still feel that inclusion of sediment targets for this stream is necessary.

Response to #2

The goal of the target section is to identify values for indicators that represent achievement of water quality standards and are linked to the causes of impairment described in the waterbody listing. Indicators may vary depending on any number of relevant factors. As you acknowledge, the size and flows of the Beaverhead River made sampling common sediment and habitat parameters difficult; that compounded with the paucity of comparable reference information made target setting challenging in the Beaverhead River.

Assessment of sediment sources and habitat conditions on tributaries of the Beaverhead River followed Standard Operating Procedures (SOPs) described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010). Some methods in these SOPs, which are for wadeable streams, were not feasible in many areas of the Beaverhead River. In some reaches, deep water prevented collection of pebble counts, grid toss fine sediment counts, precise cross-sectional measurements, and detailed habitat longitudinal profile. Grid toss measurements in pool tail-outs were not collected at any point on the Beaverhead River, due to the depth of the pools. Precise pool depth and frequency measurements were difficult to obtain in the longitudinal profiles with the methods and equipment available to us. Despite these issues, we believe that a sufficient amount of data was collected to develop targets, and although more limited than tributary targets, they represent the achievement of water quality standards for the Beaverhead River.

Although no sediment targets were provided for pool tail fines via grid toss, residual pool depth, and pools per mile; target values are provided for riffle pebble counts for percent fines less than 6mm and 2mm, percent streambank with understory shrub cover, percent streambank with disturbed bare ground, and macroinvertebrates. Although DEQ was able to measure cross sections in the Beaverhead River, bankfull width to depth ratio targets were not provided because there is a lack of regional reference data for that parameter for larger rivers. Again, as more data is collected by the DEQ or by stakeholders throughout Montana on larger rivers, width to depth ratio and other target values may be added.

Excess sediment is an issue in the Beaverhead River because of inadequate grazing management practices along the mainstem of the river, a large contribution of sediment from tributaries, and dam operations that are not currently releasing flushing flows that coordinate with spring runoff events. When BMPs are put in to place to address eroding banks and diminished riparian areas along the Beaverhead River, tributary contribution of sediment decreases because of BMP implementation, and flow management in the Beaverhead River is improved; then the sediment issues should improve within the mainstem and the established targets should reflect those improvements.

TMDL implementation is an adaptive management process. As methods of data collection improve and more data is collected, targets may be revisited and possibly revised to reflect the potential of the Beaverhead River. For example, if a cost-effective approach is developed to accurately and safely measure pool frequency and residual pool depth in the Beaverhead River, targets may be reviewed and adopted either from regionally relevant data or literature values.

Comment #3

Existing sediment targets. We appreciate the level of thought and effort that went into development of the Sediment Targets for the Beaverhead Sediment TMDL. Aside from the aforementioned exceptions we are pleased with and support the approach, criteria, and values that were proposed in this draft document. However, we are not supportive of modification of any of the Sediment Targets to less protective values in the final document. If any of the Sediment Targets are being considered for modification to less protective values we would appreciate to opportunity to comment on changes prior to finalization.

Response to #3

Thank you for taking the time to review and discuss the sediment target approaches in the Beaverhead TPA. Sediment target values will not be modified for the final document and will be submitted to the EPA as they were proposed in the draft public comment document.

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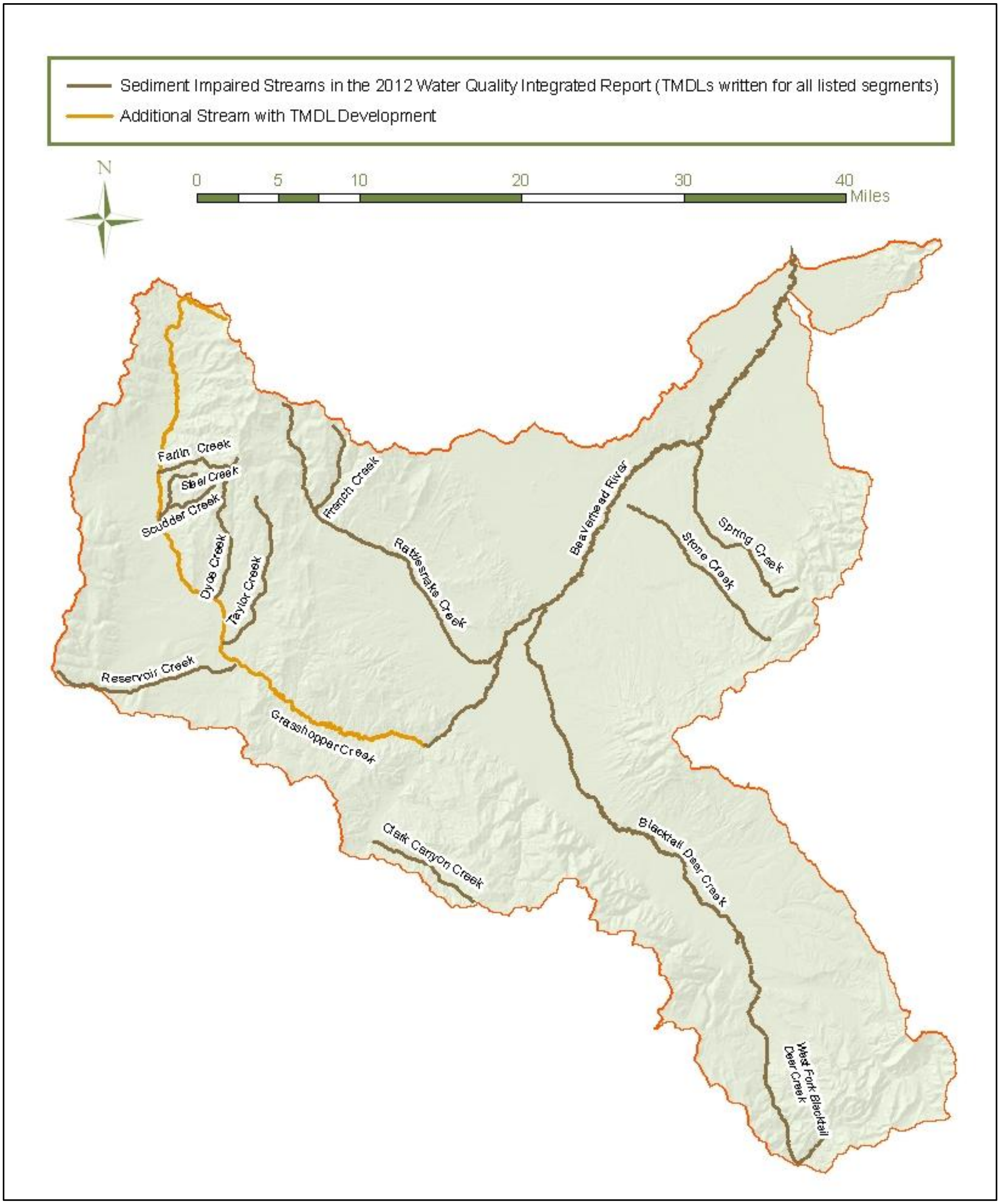
APPENDIX A - MAPS AND TABLES

LIST OF MAPS

LIST OF TABLES



Map A-1. Sediment impaired waterbodies within the Beaverhead TMDL planning area

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
BEAVERHEAD RIVER, Clark Canyon Dam to Grasshopper Creek	MT41B001_010	Lead	Metals	Aquatic Life & Drinking Water	To be completed in a future project
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Partially addressed
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed via restoration plan in this doc; not linked to a TMDL
BEAVERHEAD RIVER, Grasshopper Creek to mouth (Jefferson River)	MT41B001_020	Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Temperature, water	Temperature	Aquatic Life	To be completed in a future project
		Physical substrate habitat alterations	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Partially addressed
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
BLACKTAIL DEER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_030	Temperature, water	Temperature	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
CLARK CANYON CREEK, headwaters to mouth (Beaverhead River), T9S R10W S28	MT41B002_110	Phosphorus (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
DYCE CREEK, confluence of East and West Forks to Grasshopper Creek	MT41B002_140	Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
EAST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_040	Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed via restoration plan in this doc; not linked to a TMDL
FARLIN CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S7	MT41B002_020	Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
FRENCH CREEK, headwaters to mouth (Rattlesnake Creek)	MT41B002_100	Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
GRASSHOPPER CREEK, headwaters to mouth (Beaverhead River)	MT41B002_010	Zinc	Metals	Aquatic Life	To be completed in a future project
		Copper	Metals	Aquatic Life	To be completed in a future project
		Cadmium	Metals	Aquatic Life	To be completed in a future project
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
RATTLESNAKE CREEK, from the Dillon PWS off-channel well T7S R10W S11 to the mouth (Van Camp Slough)	MT41B002_090	Solids (Suspended/Bedload)	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Phosphorus (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Lead	Metals	Aquatic Life & Drinking Water	To be completed in a future project
		Copper	Metals	Aquatic Life	To be completed in a future project
		Cadmium	Metals	Aquatic Life	To be completed in a future project
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
RATTLESNAKE CREEK, headwaters to Dillon PWS off-channel well, T7S R10W S11	MT41B002_091	Copper	Metals	Aquatic Life	To be completed in a future project
		Cadmium	Metals	Aquatic Life	To be completed in a future project
		Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Lead	Metals	Aquatic Life & Drinking Water	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Phosphorus (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

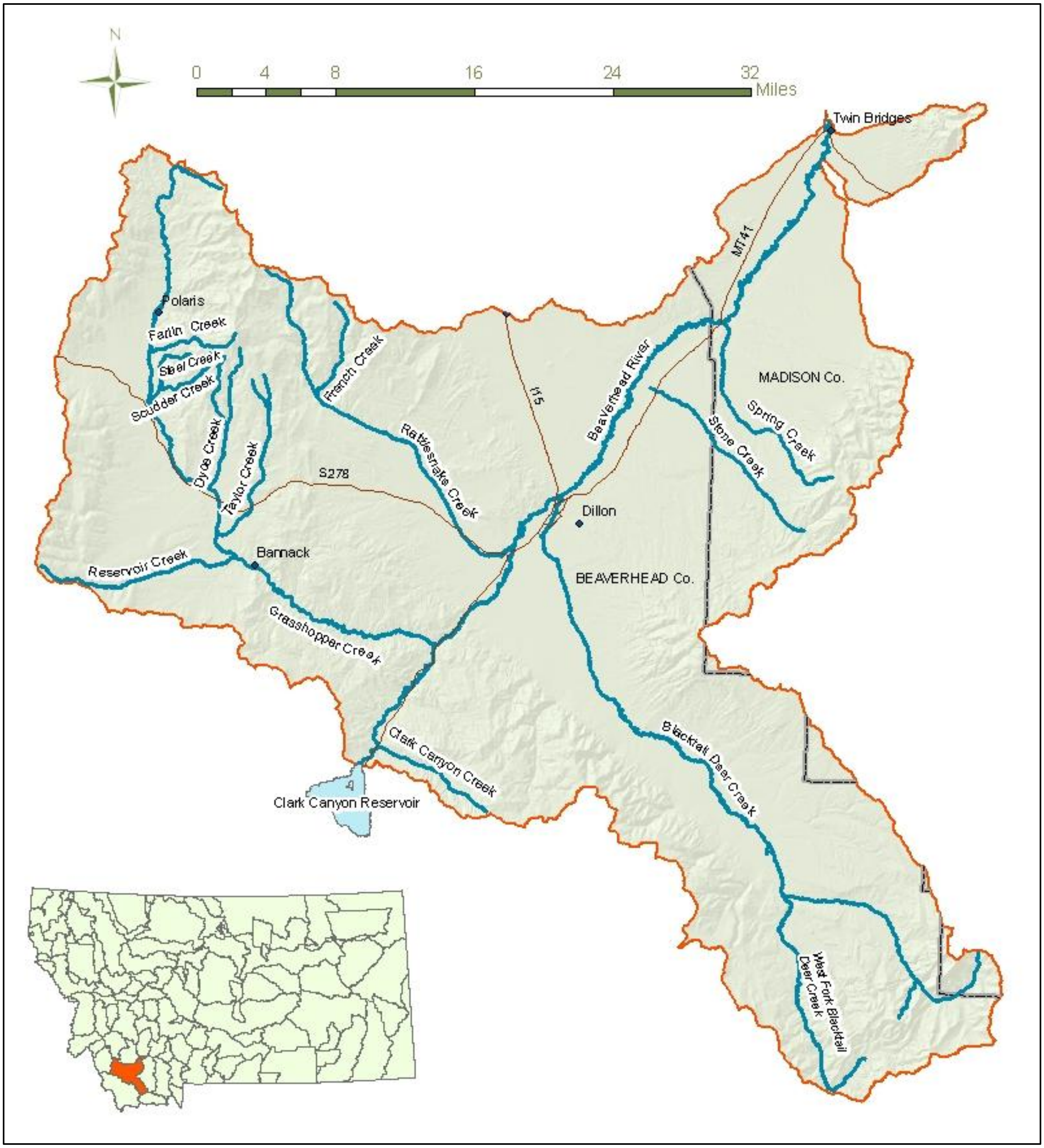
Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
RESERVOIR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_120	Phosphorus (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
SCUDDER CREEK, headwaters to mouth (Grasshopper Creek), T6S R12W S19	MT41B002_180	Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
SPRING CREEK, headwaters to mouth (Beaverhead River)	MT41B002_080	Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Arsenic	Metals	Agricultural & Drinking Water	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

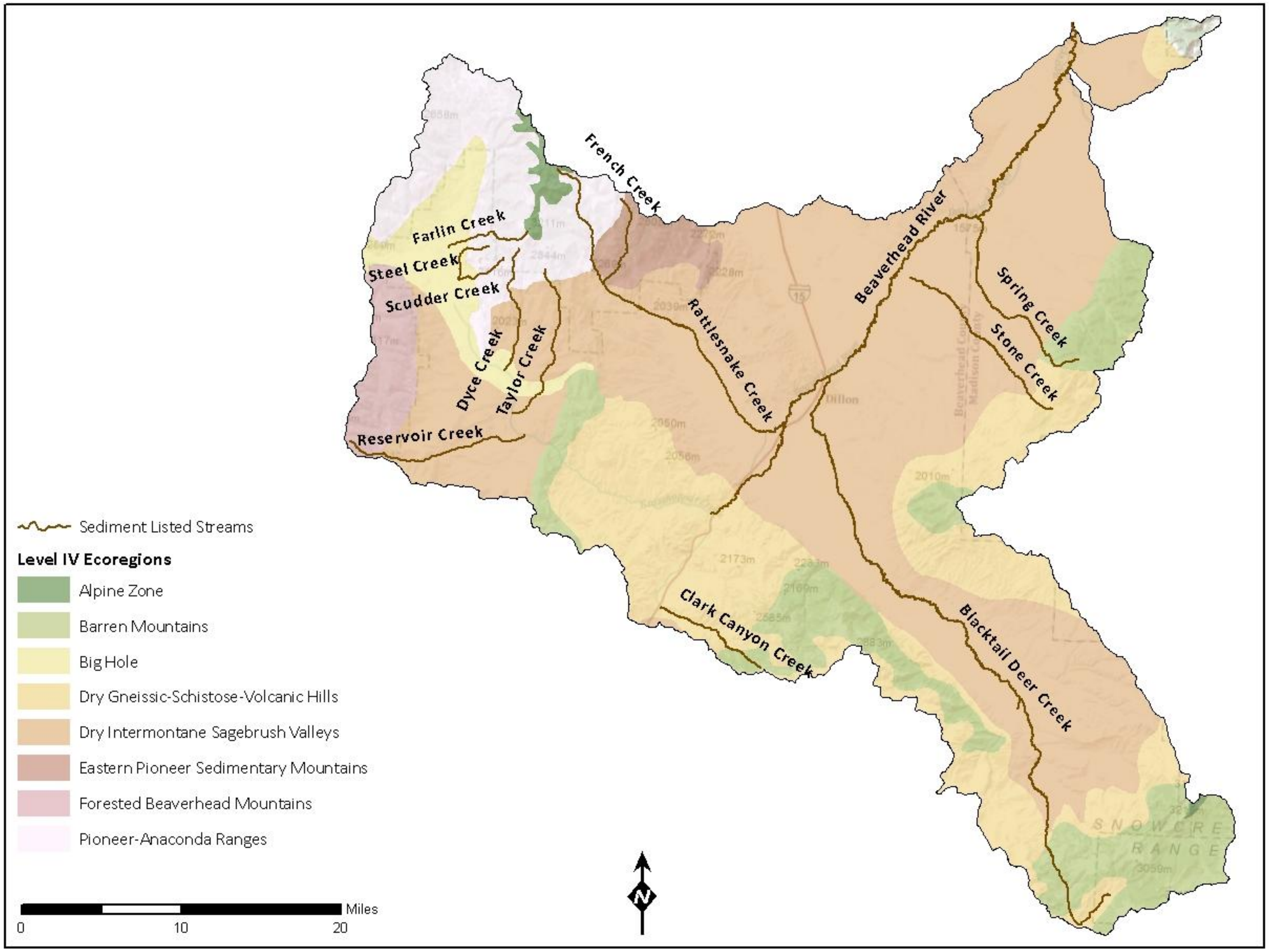
Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
STEEL CREEK, headwaters to mouth (Driscol Creek), T6S R12W S18	MT41B002_160	Phosphorus (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Solids (Suspended/Bedload)	Sediment	Aquatic Life & Primary Contact Recreation	Sediment TMDL contained in this document
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Arsenic	Metals	Agricultural, Drinking Water, & Aquatic Life	To be completed in a future project
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
STONE CREEK, confluence with unnamed creek in T6S R7W S34 near Beaverhead/Madison county border	MT41B002_131	Phosphorus (Total)	Nutrients	Primary Contact Recreation	To be completed in a future project
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life & Primary Contact Recreation	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Arsenic	Metals	Agricultural, Drinking Water, & Aquatic Life	To be completed in a future project
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL in this document
STONE CREEK, Left Fork and Middle Fork to confluence of un-named tributary, T6S R7W S34	MT41B002_132	Turbidity	Sediment	Aquatic Life	Addressed by sediment TMDL in this document
		Nitrates	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life & Primary Contact Recreation	Sediment TMDL contained in this document
		Low flow alterations	Not Applicable; Non-Pollutant	Aquatic Life & Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL

Table A-1. 2012 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Beaverhead TPA

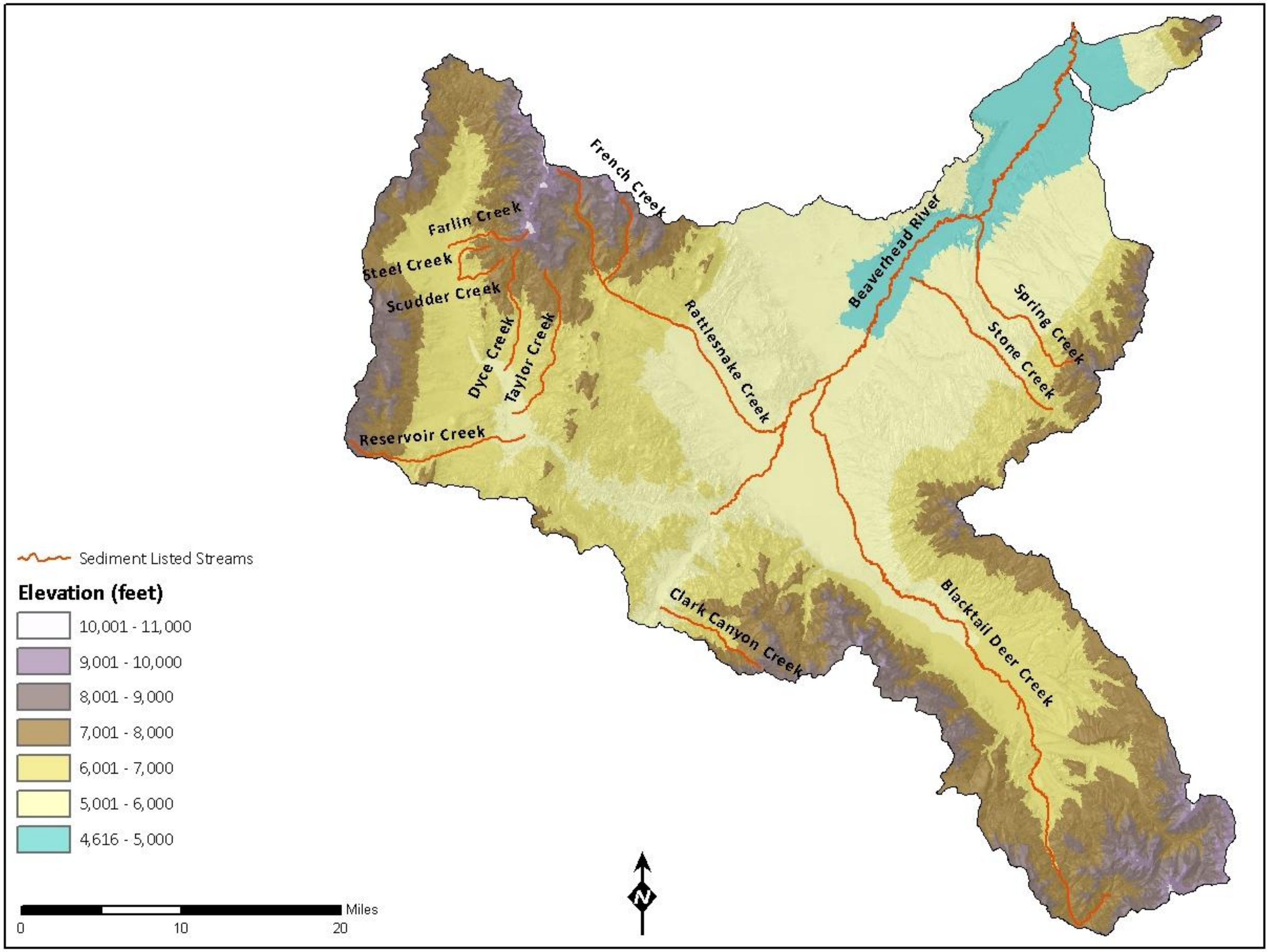
Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
TAYLOR CREEK, headwaters to mouth (Grasshopper Creek)	MT41B002_170	Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL
WEST FORK BLACKTAIL DEER CREEK, headwaters to mouth (Blacktail Deer Creek)	MT41B002_060	Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Arsenic	Metals	Agricultural & Drinking Water	To be completed in a future project
		Chlorophyll-*a*	Not Applicable; Non-Pollutant	Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL
WEST FORK DYCE CREEK, headwaters to mouth (Dyce Creek)	MT41B002_070	Nitrogen (Total)	Nutrients	Aquatic Life	To be completed in a future project
		Sedimentation/Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
		Manganese	Metals	Aquatic Life	To be completed in a future project
		Alteration in streamside or littoral vegetative covers	Not Applicable; Non-Pollutant	Aquatic Life	Addressed by sediment TMDL



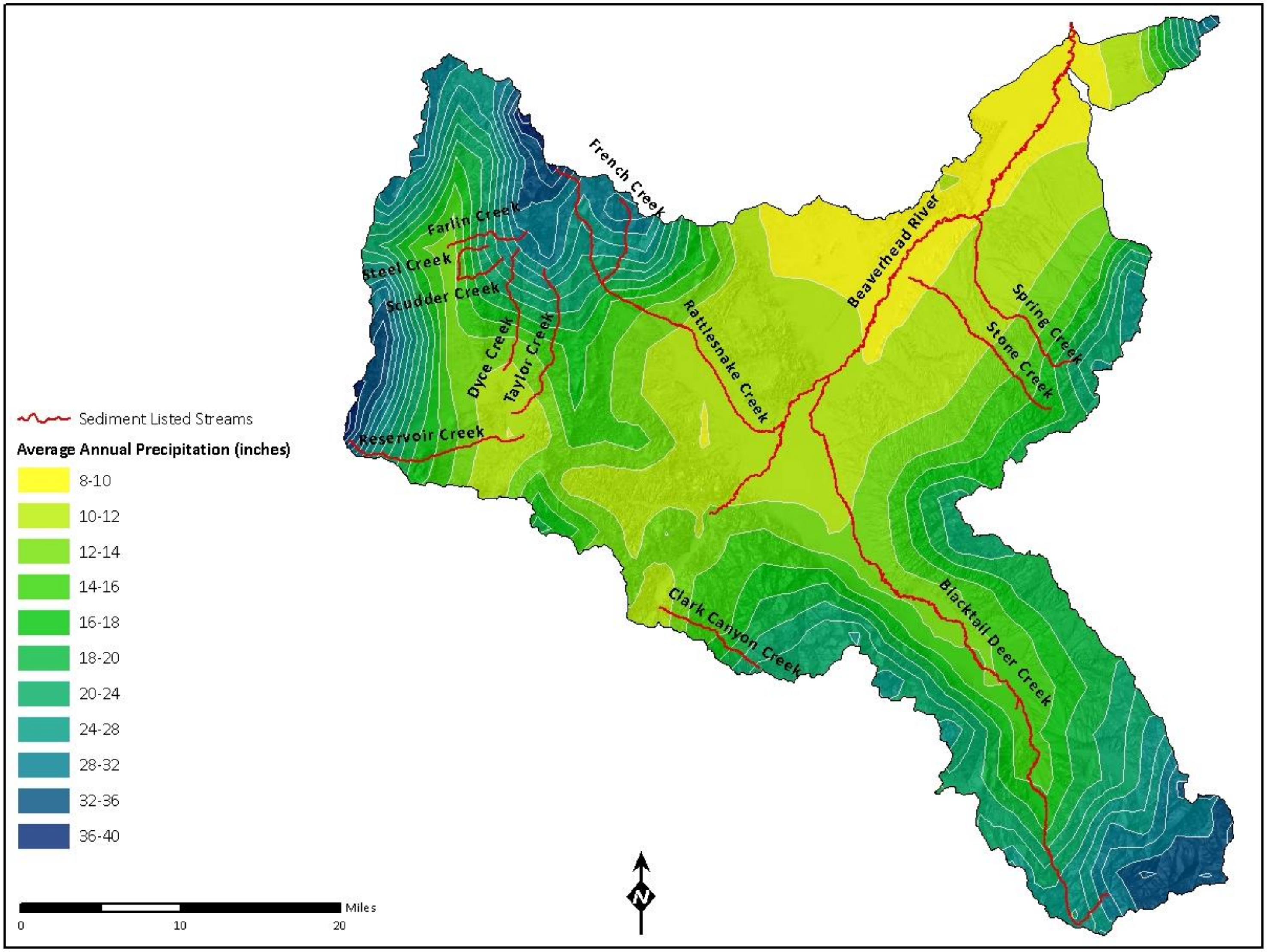
Map A-2. Beaverhead TMDL planning area location map



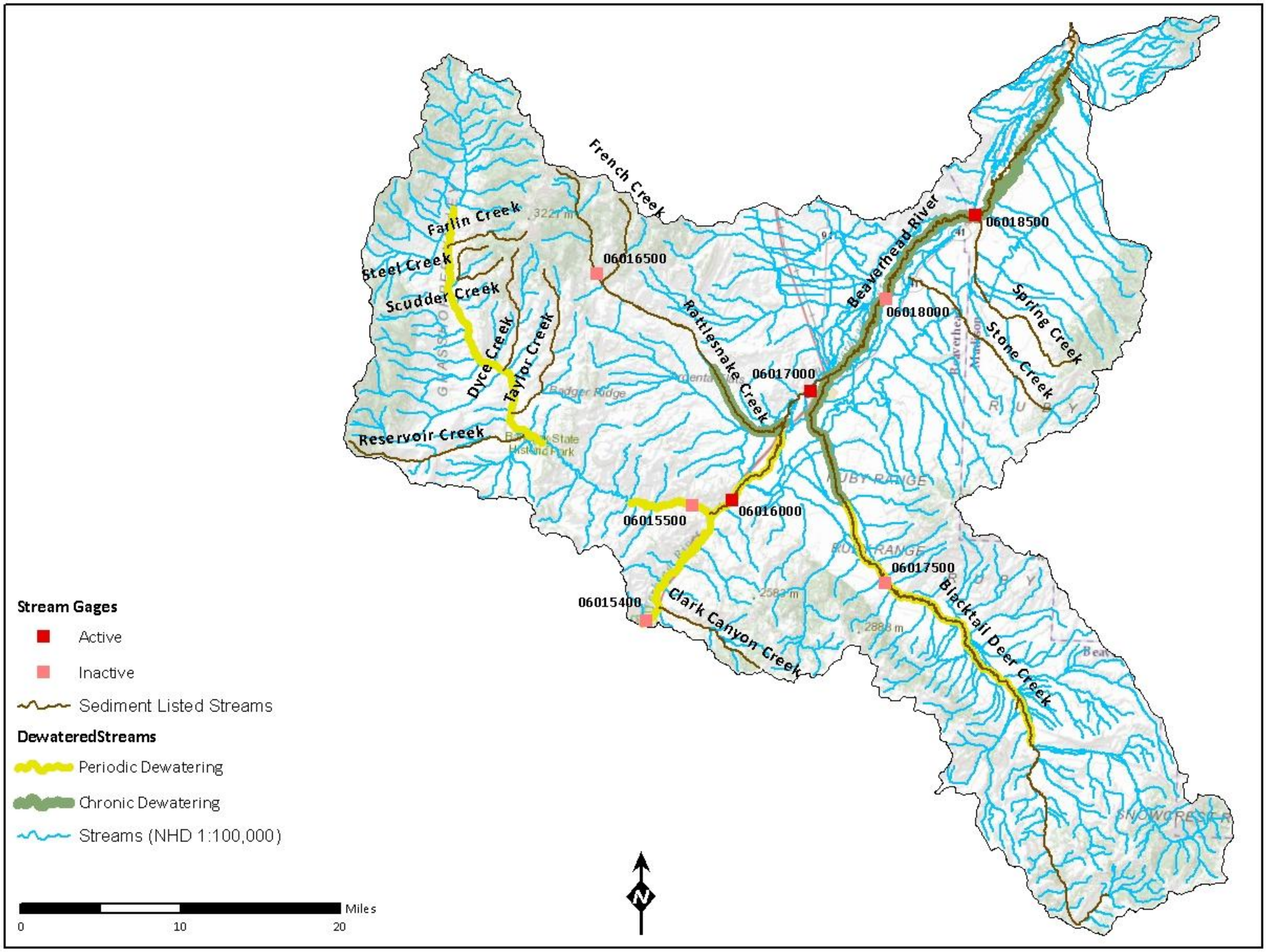
Map A-3. Level IV Ecoregions in the Beaverhead TMDL planning area



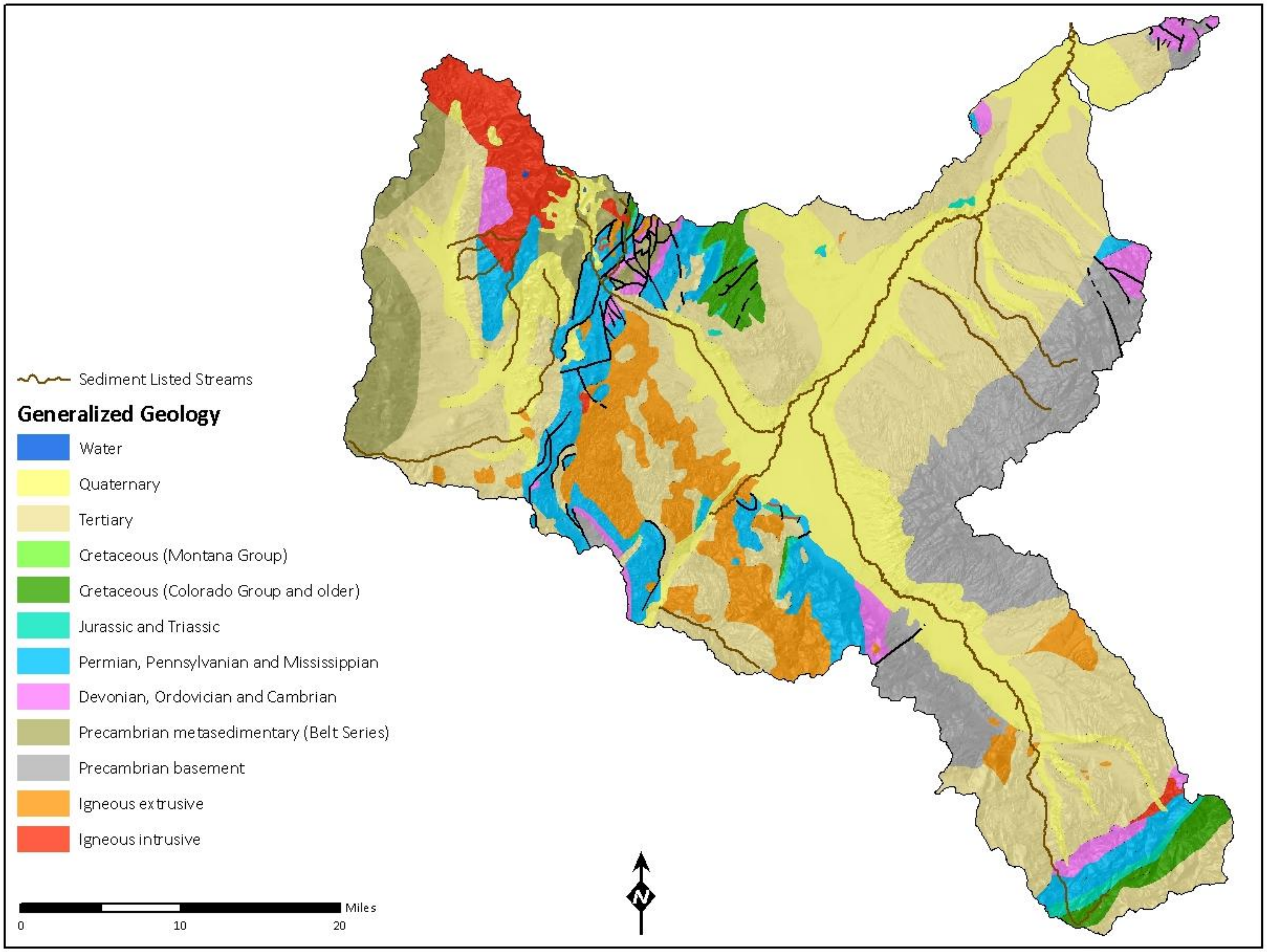
Map A-4. Topography in the Beaverhead TMDL planning area



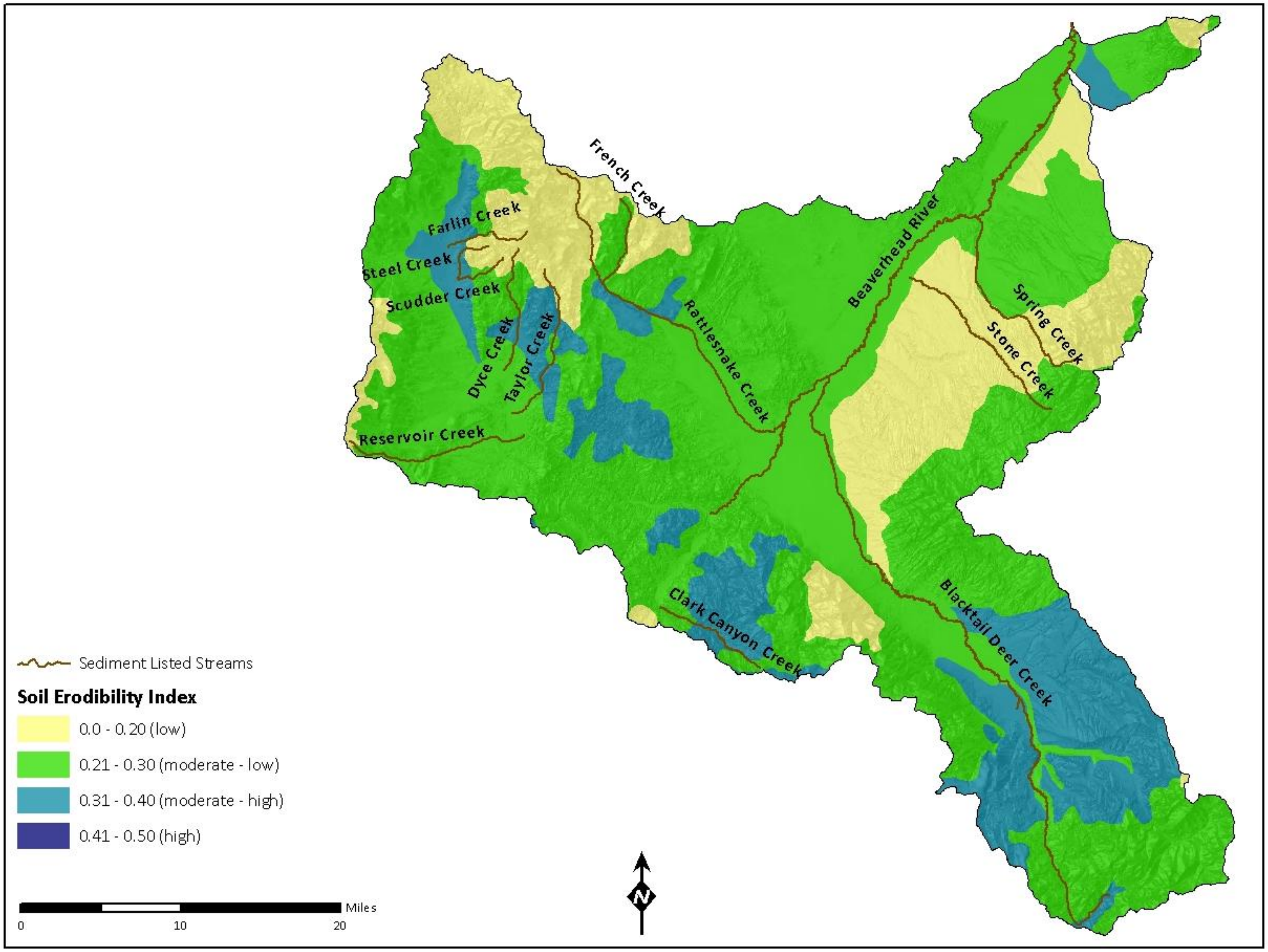
Map A-5. Precipitation in the Beaverhead TMDL planning area



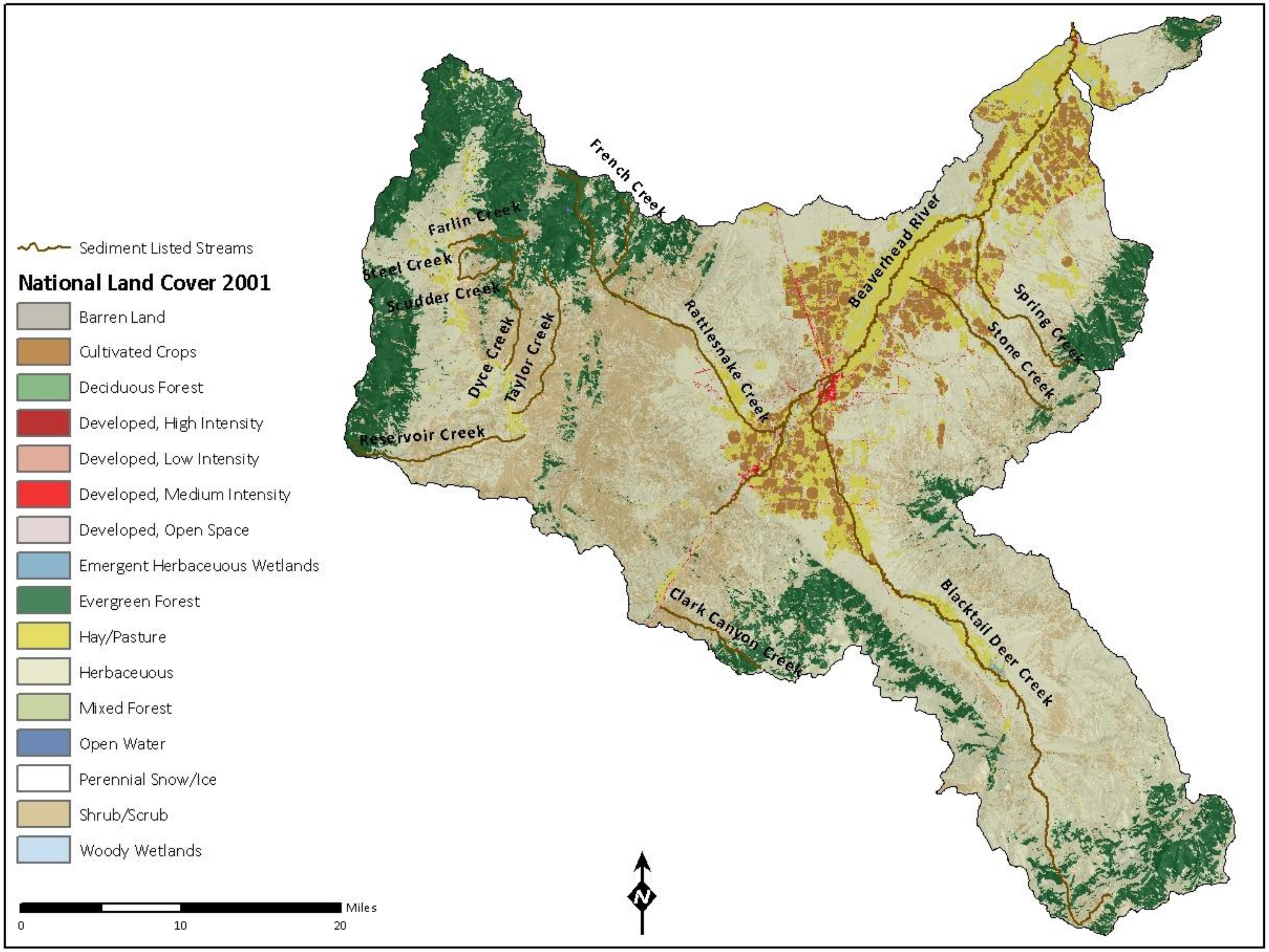
Map A-6. Dewatered streams in the Beaverhead TMDL planning area



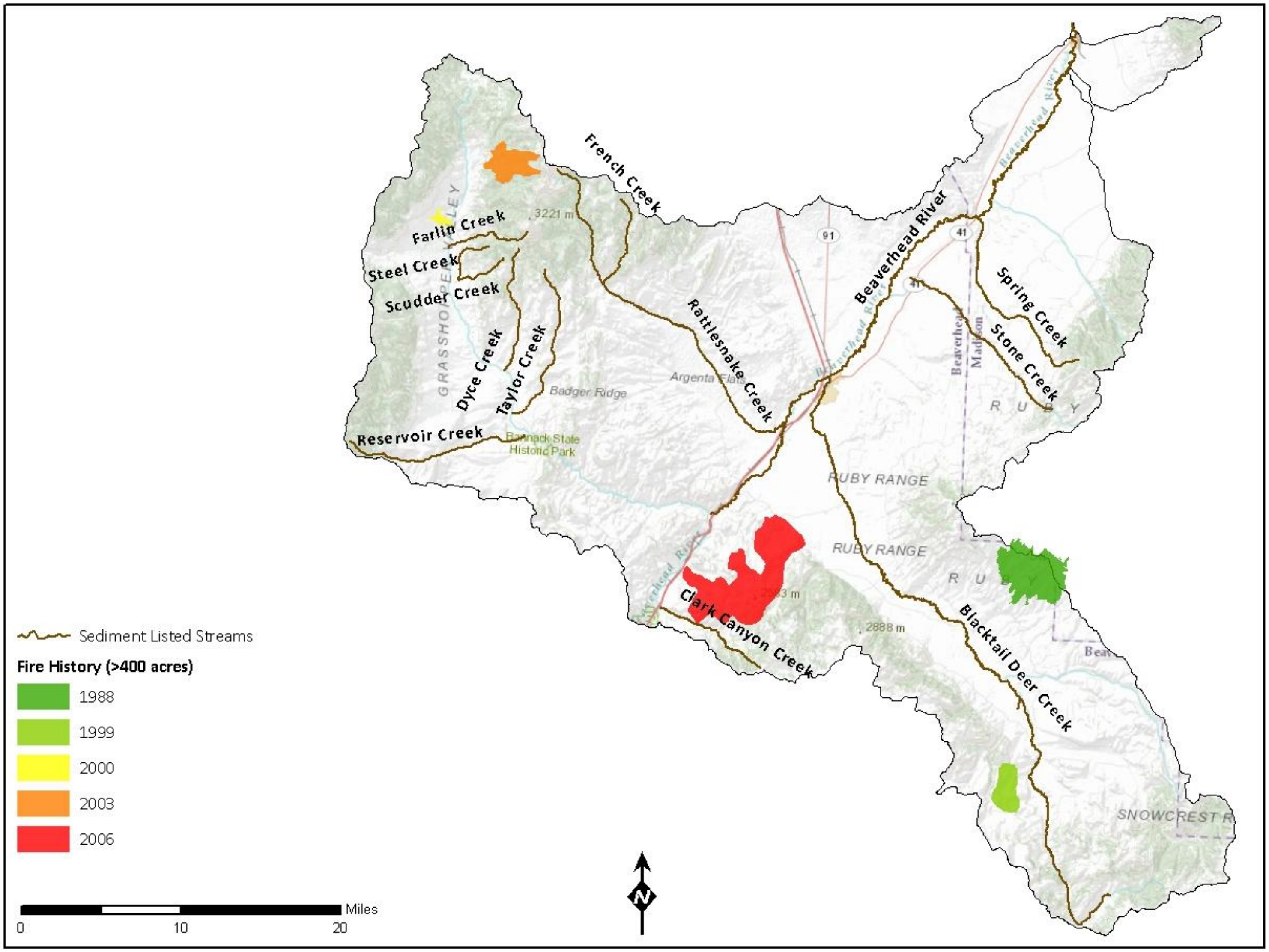
Map A-7. Geology in the Beaverhead TMDL planning area



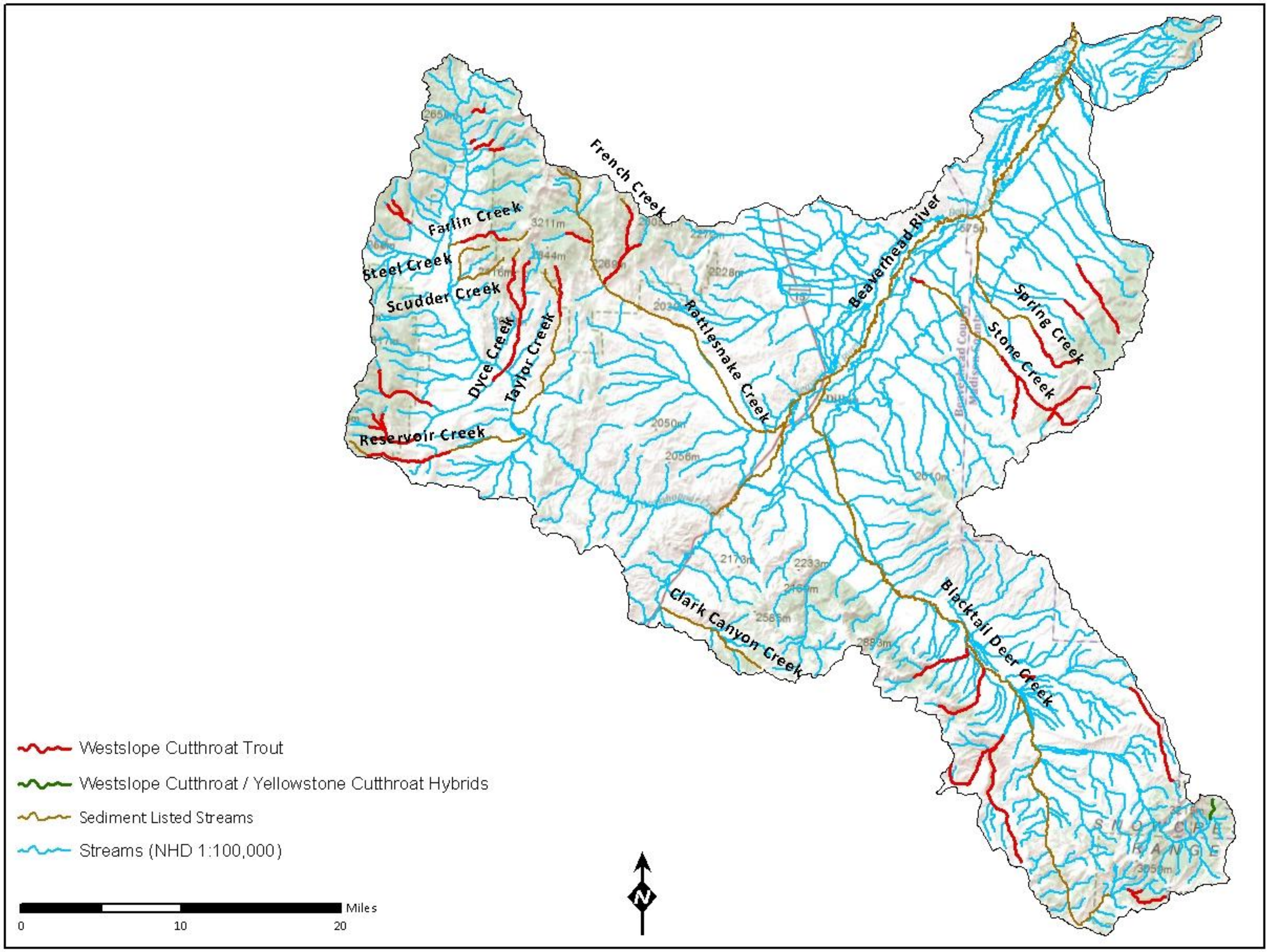
Map A-8. Susceptibility to erosion in the Beaverhead TMDL planning area



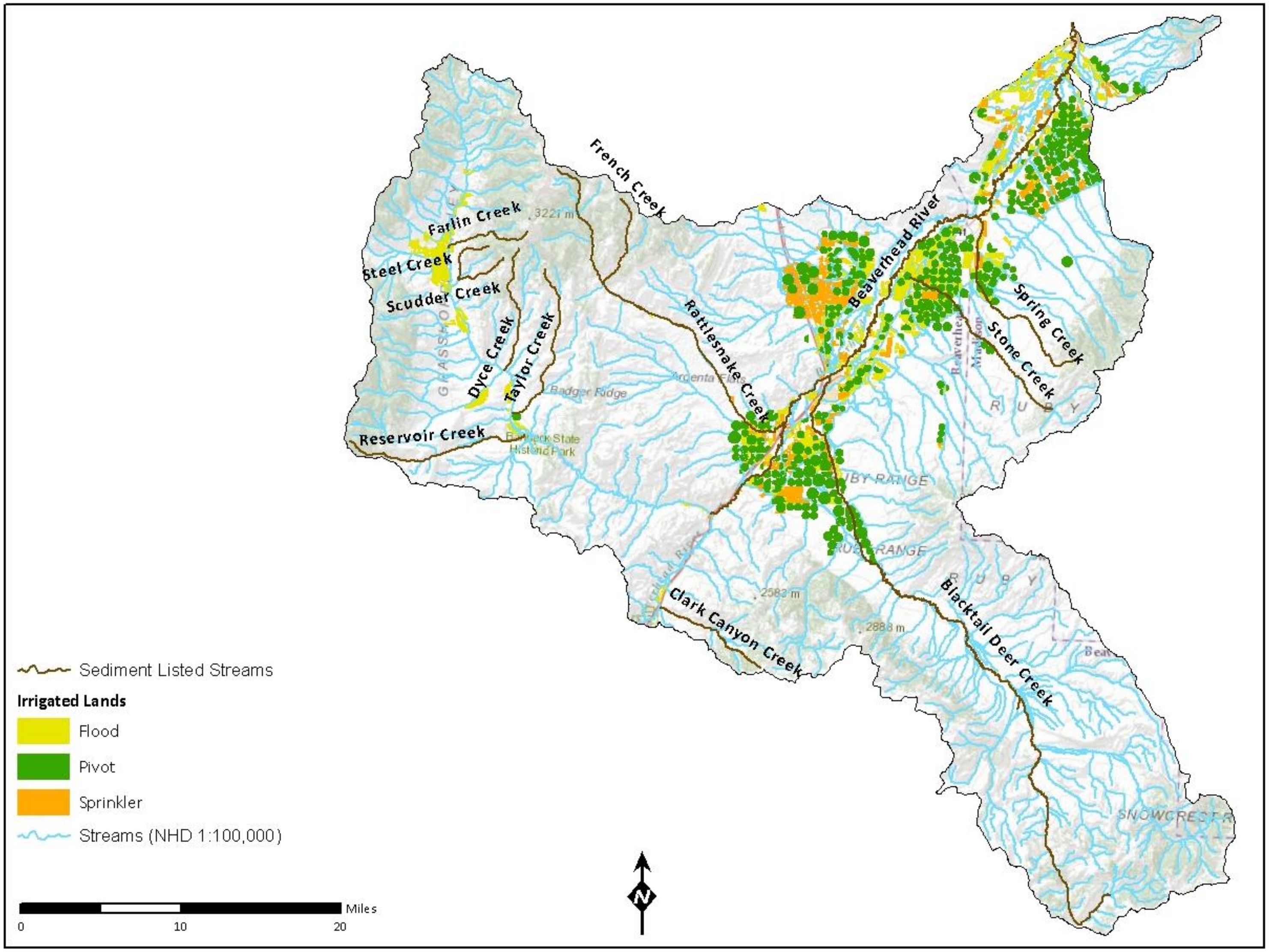
Map A-9. Land cover in the Beaverhead TMDL planning area



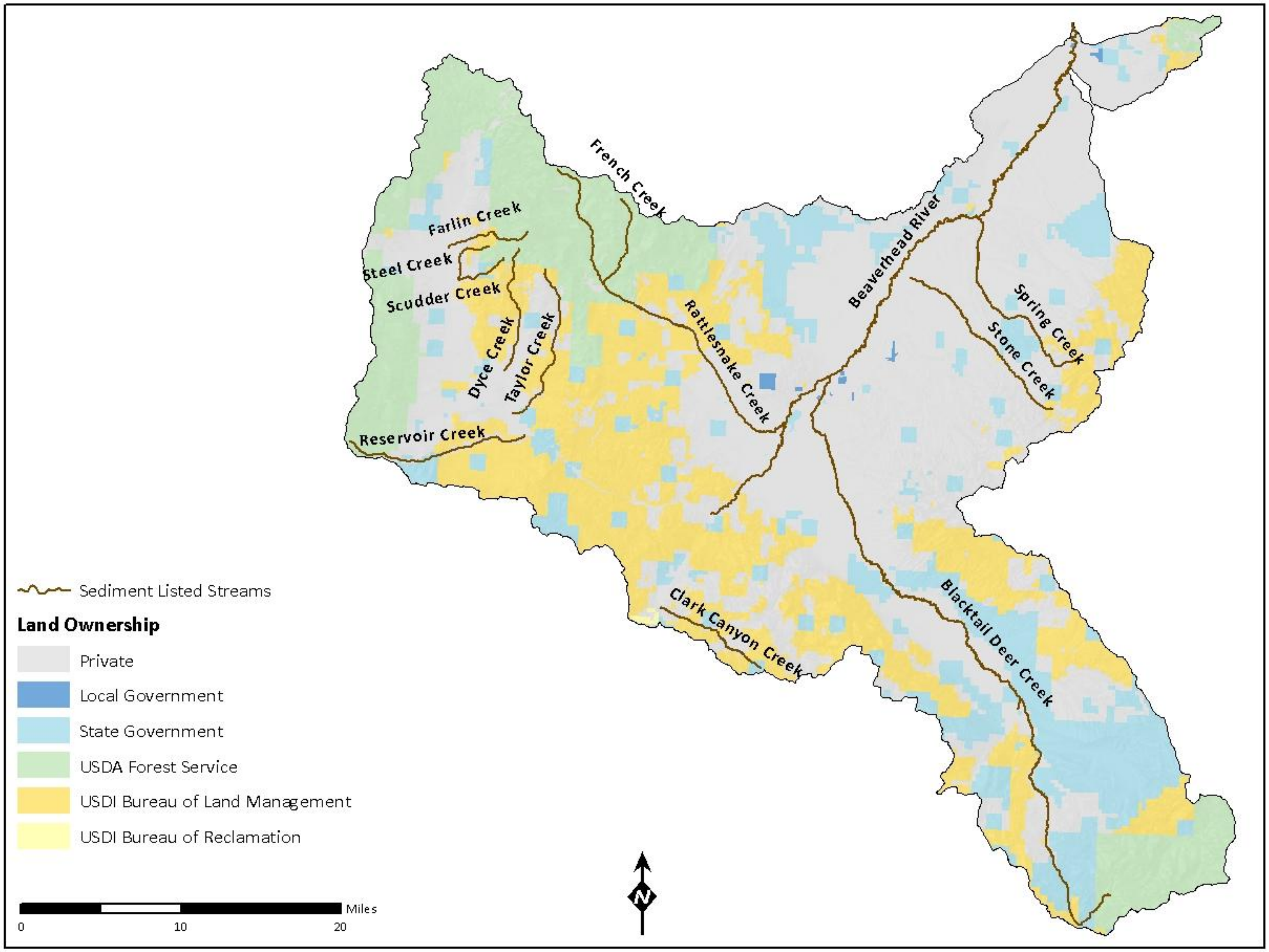
Map A-10. Recent significant fires in the Beaverhead TMDL planning area



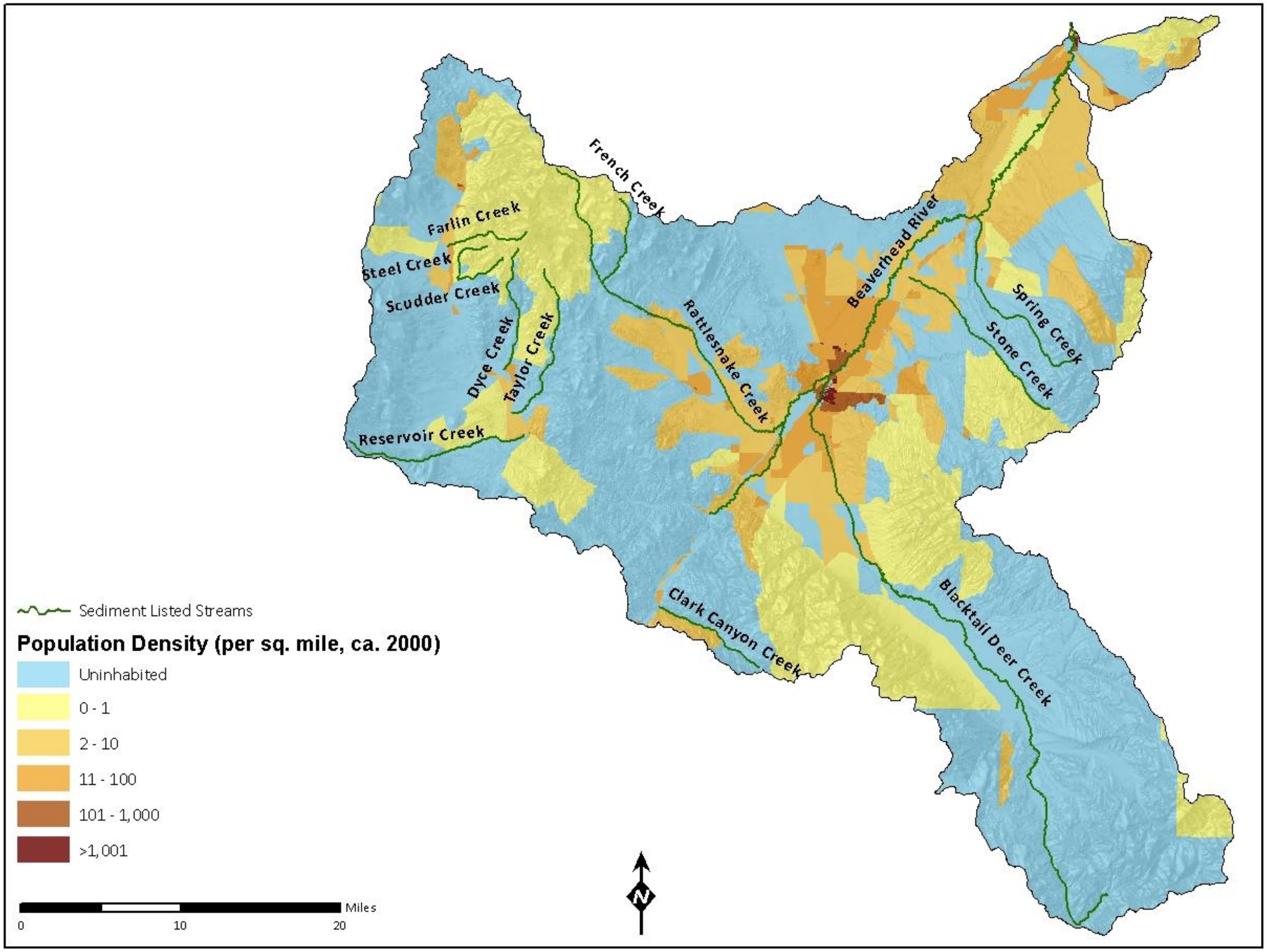
Map A-11. Fish distribution in the Beaverhead TMDL planning area



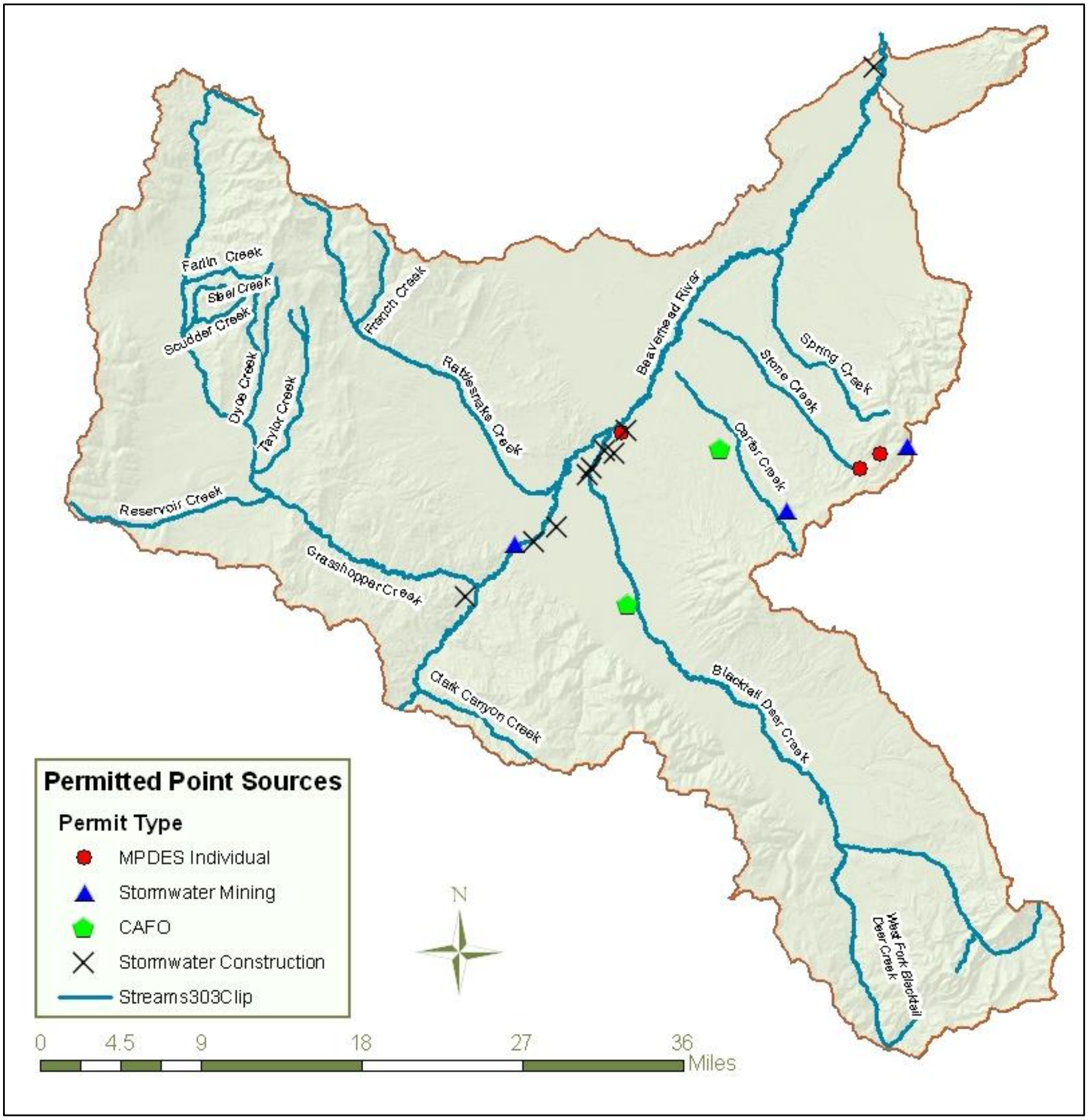
Map A-12. Irrigation in the Beaverhead TMDL planning area



Map A-13. Land ownership in the Beaverhead TMDL planning area



Map A-14. Population in the Beaverhead TMDL planning area



Map A-15. Point sources in the Beaverhead TMDL planning area

APPENDIX B – REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

B1.0 TMDL DEVELOPMENT REQUIREMENTS

Waterbodies, or individual waterbody segments where streams have been split into multiple segments, can become impaired from a variety of causes defined as either pollutants or non-pollutants. Pollutants include sediment, temperature or specific types of nutrients or metals. Non-pollutants include flow alterations and different forms of habitat degradation. Section 303 of the Federal CWA and the Montana WQA (Section 75-5-703) require development of TMDLs for impaired waterbodies where one or more pollutants are the cause of impairment within the waterbody segment of interest.

Section 303(d) requires states to submit a list of impaired waterbodies in need of TMDL development to EPA every two years. This list is referred to the 303(d) list, and only includes waterbodies with impairment causes linked to a pollutant as defined under the CWA. The 303(d) list also includes the suspected source(s) of the pollutants of concern such as various land use activities. Prior to 2004, EPA and DEQ defined the 303(d) list as the list of all impaired waterbodies and associated impairment causes (pollutants and non-pollutants), versus just those waters with impairment causes linked to pollutants. Montana integrates the 303(d) list within the 305(b) report, which contains an assessment of Montana's water quality, information on streams impaired by non-pollutants, TMDL development status, and a description of Montana's water quality programs. This 305(b) report is also referred to as the Integrated Water Quality Report.

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable WQS (Montana Water Quality Act; Section 75-5-103(11)). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency; the actual methodology is identified in DEQ's Water Quality Assessment Process and Methods (Montana Department of Environmental Quality, 2006). This methodology was developed via a public process and was incorporated into the EPA-approved 2000 version of the 305(b) report.

A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (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 WQA; Section 75-5-103(31)). State law and Section 303 of the CWA also require TMDL development for waterbodies threatened by a pollutant cause. There are no threatened waterbodies within the Beaverhead TPA.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded. TMDLs are often expressed in terms of an amount, or mass, of a particular pollutant over a particular time period (e.g. pounds of total nitrogen per day). TMDLs can also be expressed in other appropriate measures such as a percent reduction in pollutant loading. TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS.

To satisfy the Federal CWA and Montana state law, TMDL development will eventually be needed for each waterbody-pollutant combination identified on Montana's 2012 303(d) List of impaired waters in the Beaverhead TPA, unless new data and associated analyses is sufficient to remove a pollutant cause of impairment from one or more waterbodies. State law (Administrative Rules of Montana 75-5-703(8)) also directs Montana 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 waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

B2.0 Applicable Water Quality Standards

Water Quality Standards (WQS's) include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Water quality standards form the basis for the targets described in **Section 5.0**. This section provides a summary of the applicable water quality standards for sediment. The sediment TMDLs presented in this document also inherently address the additional non-pollutant causes of impairment identified in **Section 1**, **Table 1-1**.

B2.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana Water Quality Act directs the Board of Environmental Review (BER) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (§ 75-5-301(1),MCA) and to adopt standards to protect those uses ((§ 75-5-301(1),MCA).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source activities or pollutant discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 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.

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table B-1**. All waterbodies within the Beaverhead TPA are classified as B-1, except for the upper segment of Rattlesnake Creek, which is classified as A-1.

Table B-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply. Degradation which will impact established beneficial uses will not be allowed.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

B2.2 NUMERIC AND NARRATIVE WATER QUALITY STANDARDS

In addition to the Use Classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface WQS have been developed for many parameters to protect human health and aquatic life. Most of these standards are contained within the Department Circular WQB-7 (Montana Department of Environmental Quality, 2010). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

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

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

The standards applicable to the TMDLs addressed in this Beaverhead TPA document are summarized below.

Sediment
Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B2**. The standards applicable to a B-1 classification are used in **Table B-2** and are the same for A-1 classification unless otherwise noted within **Table B-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table B-2**). Naturally occurring levels are evaluated using a reference approach as defined in **Section B-3**.

Table B-2. Applicable Water Quality Standards for Sediment

Rule(s)	Standard or Definition
17.30.623(2) [B-1 classification section number; same language applies for A-1 classification]	No person may violate the following specific water quality standards for waters classified B-1:
17.30.623(2)(f) [B-1 classification section number; same language applies for A-1 classification]	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.
17.30.623(2)(d) [B-1 classification]	The maximum allowable increase above naturally occurring turbidity five nephelometric turbidity units except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.622(3)(d) [A-1 classification]	No increase above naturally occurring turbidity or suspended sediment is allowed except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.637(1 a & d) [this section applies to B-1 and A-1 classifications)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; ….. and (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602 (same definitions for A-1 and B-1 classifications)	DEFINITIONS
	"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation, or biological activity.
	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Turbidity

Turbidity is a measure of light scatter in water. Suspended or colloidal solids like phytoplankton, metal precipitates or clay may cause the light scatter. As identified in **Table B-2**, the allowable change in turbidity (above naturally occurring levels) is 5 nephelometric turbidity units (NTUs) for a B-1 stream, and no increase above naturally occurring for an A-1 stream. The likely direct effects of increased turbidity are on recreation and aesthetics as well as drinking water supplies. Increased turbidity can indirectly be linked to potential increased concentrations in pathogens, total recoverable metals and total suspended sediment. In some cases it may be a useful surrogate for total suspended solids (TSS) based on a statistical correlation between paired turbidity and TSS data collected during varying flow conditions; preferably a full hydrograph for the stream of interest.

B2.3 Nondegradation

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to the waterbody. Although these nondegradation rules are not integrated into TMDL development, they help limit pollutant loading in waters where designated uses are currently satisfied. Some of these waters may be healthy tributaries to waters where a TMDL is developed; thus nondegradation can help implement TMDL related pollutant controls at a watershed scale.

B3.0 Reference Conditions

B3.1 DEQ Approach For Defining A Reference Condition

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic land use activities. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated beneficial uses because they are based on the reference approach, which strives for the highest possible condition.

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Montana WQS do not contain specific provisions addressing detrimental modifications of habitat. However, detrimental modifications of habitat may often lead to or result from increases above naturally occurring concentrations of sediment, etc. and therefore the reference condition approach is used to help determine if beneficial uses are supported when habitat modifications are present. The reference approach can also be used to develop riparian and shade target parameters when evaluating temperature.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions. The following methods may be used to determine reference conditions:

Primary Approach

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

Secondary Approach

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

DEQ uses the primary approach for determining reference condition if adequate regional or other primary reference data is available, and uses the secondary approach to estimate reference condition when primary approach data is limited or unavailable. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

B3.2 Use of Statistics For Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution; whereas, water resources data tend to have a non-normal distribution (Helsel and Hirsch, 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are far less influenced by such observations.

Figure B-1 is an example boxplot presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (Buck, et al., 2000) Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is "good" confidence in the quality of the reference sites and resulting information (Suplee, 2004). If it is determined that there is only a "fair" confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is "very high" confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be "fair" to "good" quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

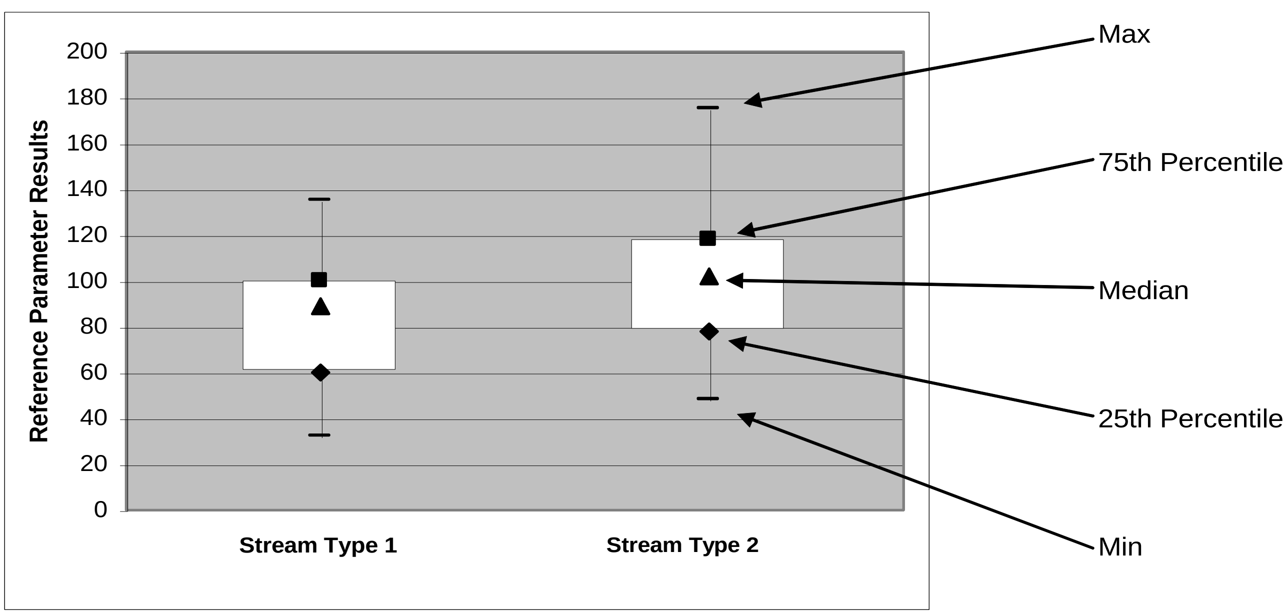


Figure B-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table B-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with DEQ guidance and WQS (Suplee, 2004). Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations.

Where the data does suggest a normal distribution, or reference data is presented in a way that precludes use of non-normal statistics, the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying a statistical approach like above is not possible. Under these conditions, the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development.

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck, et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure B-2** is an example statistical distribution where higher values represent better water quality. In **Figure B-2**, the median and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

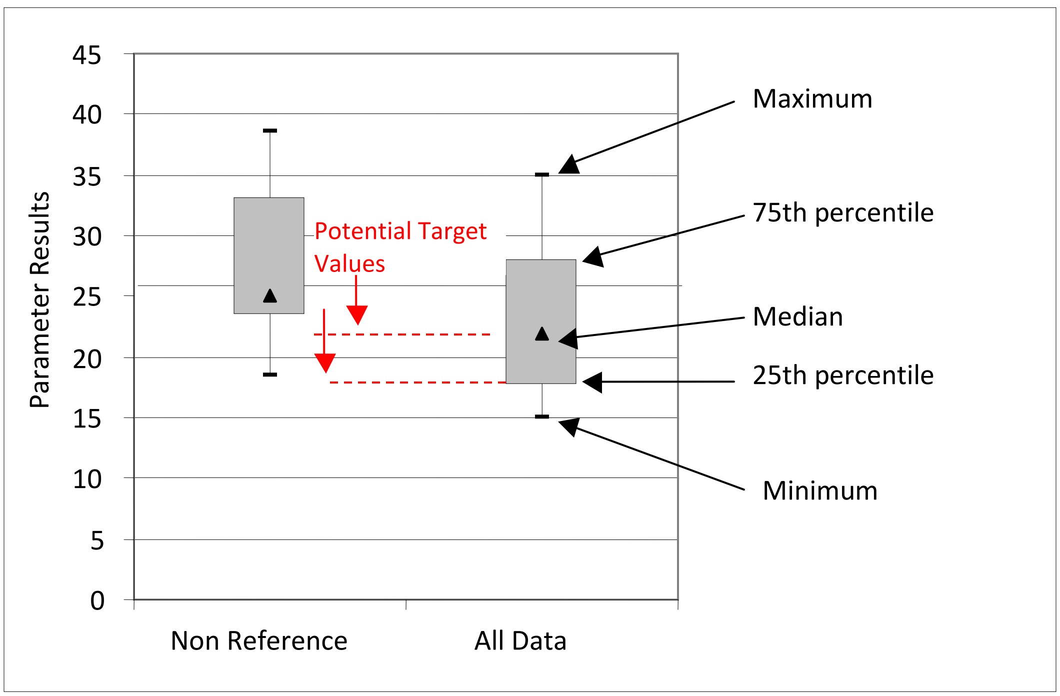


Figure B-2. Boxplot example for the use of all data to set targets.

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APPENDIX C – 2010/2011 SEDIMENT AND HABITAT DATA COLLECTION METHODS AND DATA SUMMARY – BEAVERHEAD TPA

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C1.0 Introduction

The majority of the Beaverhead TMDL Planning Area (TPA) is located within Beaverhead County and encompasses the entire Beaverhead River watershed below Clark Canyon Reservoir. The Beaverhead River within the TPA begins at the outlet of the Clark Canyon Reservoir and flows northeast for 79.5 miles before its confluence with the Big Hole River. The watershed drains an area 3,619 square miles (2,316,160 acres), coinciding with the fourth-code hydrologic unit code (HUC) 10020002.

Under Montana law, an impaired waterbody is defined as a waterbody for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103 (2011)). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired waterbodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years in an "Integrated Report" (formerly referred to as the "303(d) list"). The Montana Water Quality Act further directs states to develop TMDLs for all waterbodies appearing on the 303(d) list as impaired or threatened by "pollutants" (MCA 75-5-703).

Within the Beaverhead TPA, 17 stream segments are listed as impaired due to sediment in the 2010 Integrated Report. These streams include *West Fork Dyce Creek, West Fork Blacktail Deer Creek, Taylor Creek, Stone Creek (two listed segments), Steel Creek, Spring Creek, Scudder Creek, Reservoir Creek, Rattlesnake Creek (two segments), French Creek, Farlin Creek, Dyce Creek, Clark Canyon Creek, Blacktail Deer Creek* and the *Beaverhead River segment from Grasshopper Creek to the Big Hole River* (referred to as "lower Beaverhead").

A detailed sediment and habitat assessment of streams in the Beaverhead TPA was conducted to facilitate the development of sediment TMDLs. During this assessment, streams were first analyzed in GIS using color aerial imagery and broken into similar reaches based on landscape characteristics. Following the aerial assessment reach stratification process, field data were collected at 32 monitoring sites during September of 2010 and April of 2011. Field data were then used to quantify stream condition variables at assessment reaches within the Beaverhead TPA and to estimate sediment loads from eroding streambanks to facilitate the development of sediment TMDLs. On STEL 10-01, which was a dry channel, field notes were taken, but no data were collected. CLCK 18-02 was only assessed for BEHI. A list of data collected for each monitored reach is included in **Section C3.1**.

The following sections are descriptions of two main components of this project: the aerial assessment reach stratification and the sediment and habitat assessment. The sections are excerpts from the *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA* (Watershed Consulting, LLC, 2011), which is on file at the DEQ and contains the complete assessment database.

C2.0 Aerial Assessment Reach Stratification

C2.1 Methods

An aerial assessment of streams in the Beaverhead TPA was conducted using National Agricultural Imagery Program (NAIP) color imagery from 2009 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey

1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (Montana Department of Environmental Quality, 2008).

The reach stratification methodology involves breaking a waterbody stream segment into stream reaches and sub-reaches. Montana DEQ tracks stream water quality status by stream segment, which may encompass the entire stream or just a portion of the stream. Each of the stream segments in the Beaverhead TPA was initially divided into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Stream reaches classified by these four criteria were then further divided into sub-reaches based on the surrounding vegetation and land-use characteristics, including predominant vegetation type, adjacent land-use, riparian area condition, anthropogenic (human) influences on streambank erosion, level of development, and the presence of anthropogenic activity within 100 feet of the stream channel. This stratification resulted in a series of stream reaches and sub-reaches delineated based on landscape and land-use factors which were compiled into an Aerial Assessment Database for the Beaverhead TPA.

C2.1.1 Reach Types

As described above, the aerial assessment reach stratification process involved dividing each stream segment into distinct reaches based on ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a "**reach type**" in this report. Reach types were labeled using the following naming convention based on landscape features in the order listed below:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Landscape feature values and associated reach type identifiers are presented in **Table C-1**:

Table C-1. Reach Type Identifiers

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-<2%	0
	2-<4%	2
	4-<10%	4
	>10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
	fifth order	5
	sixth order	6
	seventh order	7
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as MR-2-2-U is a mid gradient (2-<4%), 2rd order, unconfined stream in the Middle Rockies Level III ecoregion.

C2.2 Reach Stratification Results

A total of 612 reaches were delineated during the aerial assessment reach stratification process covering 321.3 miles of stream in the Beaverhead TPA (**Table C-2**). These reaches were divided further into a total of 610 subreaches (**Table C-2**) based on vegetation and land use, as described in **Section C.1**. Based on the reach type identifiers listed in **Table C-1**, 27 distinct reach types were delineated in the Beaverhead TPA and field data were collected in ten of these reach types. The complete Aerial Assessment Database is provided in *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA (Watershed Consulting, LLC, 2011)*, which is on file at the DEQ

Table C-2. Aerial Assessment Stream Segments

Stream Segment	Number of Reaches	Number of Reaches and Sub-Reaches	Length (Miles)
Beaverhead River	9	34	74.4
Blacktail Deer Creek	2	38	39.9
East Fork Blacktail Deer Creek	28	38	19.4
West Fork Blacktail Deer Creek	8	19	15.9
Clark Canyon Creek	32	35	8.4
Dyce Creek	5	8	4.1
East Fork Dyce Creek	20	21	4.7
West Fork Dyce Creek	18	20	4.6
Farlin Creek	29	32	6.0
French Creek	34	37	6.5
Grasshopper Creek	20	64	47.5
Indian Creek	18	18	2.7
Rattlesnake Creek	60	77	27.0
Reservoir Creek	20	28	12.2
Scudder Creek	14	17	4.7
Spring Creek	33	51	14.9
Steel Creek	11	12	3.8
Stone Creek	22	26	13.4
Taylor Creek	32	35	11.4

C3.0 Sediment and Habitat Assessment

C3.1 Methods

Sediment and habitat data were collected following the methodology described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments (Montana Department of Environmental Quality, 2010)*. Additional methods were developed for non-wadeable reaches, as discussed in **Section C3.1.5**. Field monitoring sites were selected in relatively low-gradient segments of the study streams where sediment deposition is likely to occur. Other considerations in selecting field monitoring sites included representativeness of the reach to other reaches of the same slope, order, confinement and ecoregion, the extent of anthropogenic impacts relative to other reaches, and ease of access.

Sediment and habitat assessments were performed at 32 field monitoring sites, which were selected based on the aerial assessment in GIS and on-the-ground reconnaissance conducted in August, 2010.

Sediment and habitat data were collected within ten reach types (**Table C-3**, **Figure C-1)**.

Table C-3. Reach Types and Monitoring Sites

Reach Type	Number of Reaches	Sites Monitored	Methods Used
MR_2_1_U	14	SCUD 11-01	All Sed/Hab Methods
MR_4_1_U	48	STEL 05-01	All Sed/Hab Methods
		WFDY 17-01	All Sed/Hab Methods
MR_0_2_U	53	CLKC 32-01	All Sed/Hab Methods
		DYCE 02-02	All Sed/Hab Methods
		SPRG 31-01	All Sed/Hab Methods
		STON 20-02	All Sed/Hab Methods
		STON 22-02	All Sed/Hab Methods
		STON 22-02B	All Sed/Hab Methods
		TAYL 32-01	All Sed/Hab Methods
MR_2_2_C	29	FREN 23-01	All Sed/Hab Methods
MR_2_2_U	51	CLKC 19-02	All Sed/Hab Methods
		FARL 28-01	All Sed/Hab Methods
		RESR 11-01	All Sed/Hab Methods
		STON 05-01	All Sed/Hab Methods
		TAYL 27-01	All Sed/Hab Methods
MR_4_2_U	26	CLKC 18-02	BEHI Only
MR_0_3_U	62	RATT 54-04	All Sed/Hab Methods
		RATT 60-04	All Sed/Hab Methods
		WFBK 08-04	All Sed/Hab Methods
MR_0_4_U	34	GRAS 12-01	All Sed/Hab Methods
		GRAS 20-11	All Sed/Hab Methods
MR_0_5_U	30	BLKD 02-08	All Sed/Hab Methods
		BLKD 02-14	All Sed/Hab Methods
		BLKD 02-30	All Sed/Hab Methods
MR_0_7_U	32	BEAV 04-02	Cross-sections only
		BEAV 04-05	Cross-sections only
		BEAV 09-04	Non-wadeable reach methods
		BEAV 09-06	Non-wadeable reach methods with std. cross-sections
		BEAV 09-11	Non-wadeable reach methods
		BEAV 09-14	Non-wadeable reach methods
		BEAV 09-15	Non-wadeable reach methods

The length of the monitoring site was based on the bankfull channel width. A monitoring site length of 500 feet was used at 18 sites in which the bankfull width was less than 10 feet and a monitoring site length of 1,000 feet was used at 9 sites in which the bankfull width was between 10 feet and 50 feet. A monitoring site length of 1500 was used at two sites in which the bankfull width was between 50 and 60 feet. A monitoring site length of 2000 feet was used a three sites in which the bankfull width was greater than 60 feet. Each monitoring site was divided into five equally sized study cells numbered 1 through 5 progressing in an upstream direction. Sites were evaluated from downstream to upstream.

The following sections provide brief descriptions of the field methodologies employed during this assessment. A more in-depth description is available in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010).

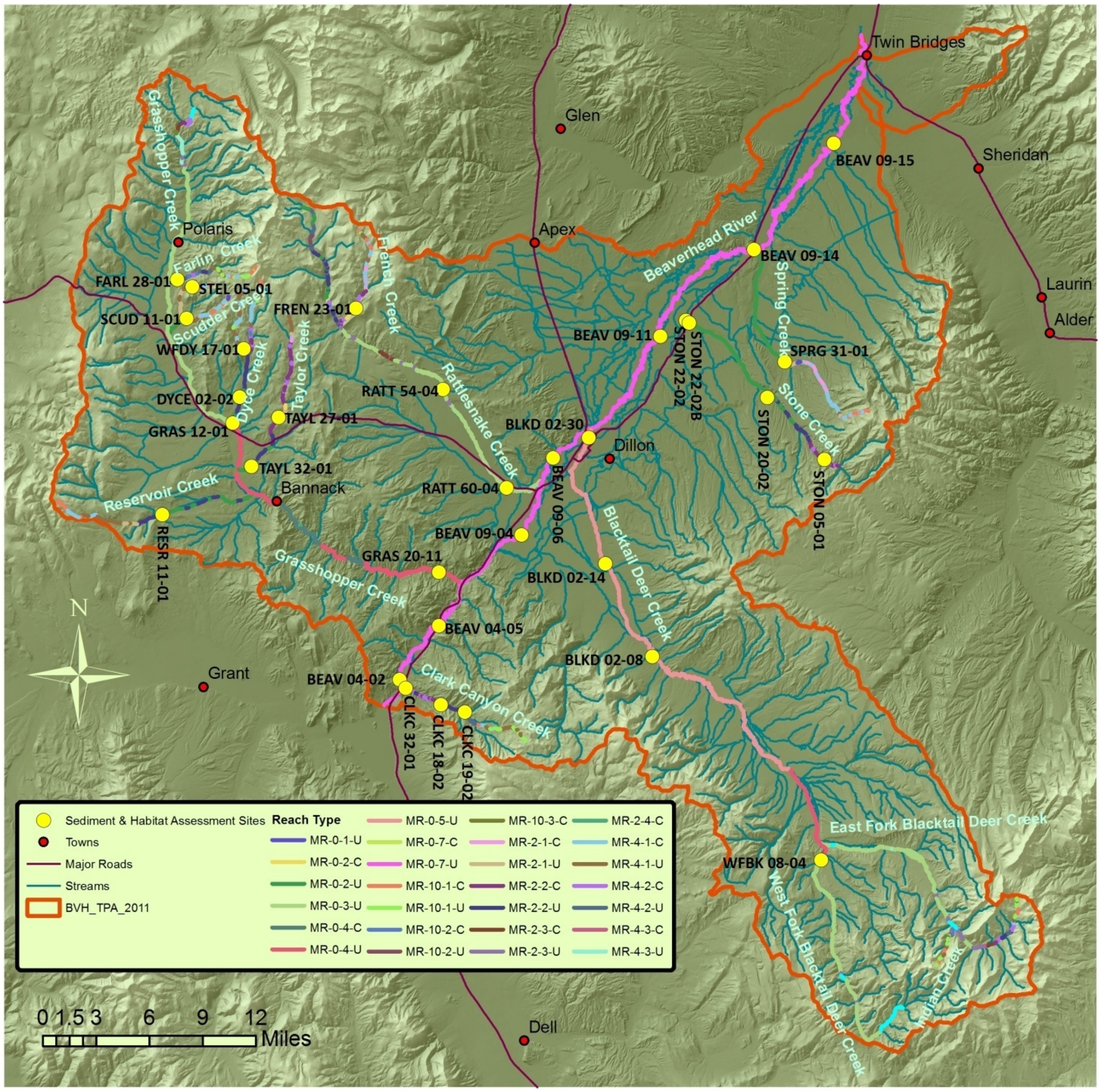

Figure C-1. Aerial Assessment Reach Type Stratification.

C3.1.1 Channel Form and Stability Measurements

Channel form and stability measurements include the field determination of bankfull, channel cross-sections, floodprone width, and surface water slope.

C3.1.1.1 Field Determination of Bankfull

The bankfull elevation was determined for each monitoring site. Bankfull is a concept used by hydrologists to define a regularly occurring channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold (1978):

> "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels."

Indicators that were used to estimate the bankfull elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, staining of rocks, and inundation features. Multiple locations and bankfull indicators were examined at each site to determine the bankfull elevation, which was then applied during channel cross-section measurements.

C3.1.1.2 Channel Cross-sections
Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.1.3 Floodprone Width Measurements
The floodprone elevation was determined by multiplying the maximum depth value by two (Rosgen, 1996). The floodprone width was then measured by stringing a tape from the bankfull channel margin on both the right and left banks until the tape (pulled tight and "flat") touched the ground at the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, the floodprone width was estimated by pacing or making a visual estimate.

C3.1.1.4 Water Surface Slope
Water surface slope measurements were estimated using a clinometer. This measurement was used to evaluate the slope assigned in GIS based on the aerial assessment. The field measured slope was used when evaluating the Rosgen stream type at each monitoring site.

C3.1.2 Fine Sediment Measurements
Channel cross-section measurements were performed at the first riffle in each cell using a leveled tape and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.2.1 Riffle Pebble Count
One Wolman pebble count (Wolman, 1954) was performed at the first riffle encountered in four cells, providing a minimum of 400 particles measured within each assessment reach. Particle sizes were measured along their intermediate length axis (b-axis) using a gravelometer and results were grouped into size categories. The pebble count was performed from bankfull to bankfull using the "heel to toe" method.

C3.1.2.2 Riffle Grid Toss
The riffle grid toss was performed at the same location as the pebble count measurement. The riffle grid toss measures fine sediment accumulation on the surface of the streambed. Grid tosses were performed prior to the pebble count to avoid disturbances to surface fine sediments.

C3.1.2.3 Pool Tail-out Grid Toss
A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at each pool in which potential spawning gravels were identified. Three measurements were taken in each pool with appropriate sized spawning gravels using a 49-point grid. The spawning potential was recorded as “Yes” (Y) or “No” (N), in cases where gravels of appropriate size were scarce or not available. No grid toss measurements were made when the substrate was observed to be too large to support spawning. Grid toss measurements were performed when the substrate was observed to be too fine to support spawning since the goal of this assessment is to quantify fine sediment accumulation in spawning areas.

C3.1.2.4 Riffle Stability Index
A Riffle Stability Index (RSI) evaluation was performed in streams that had well-developed point bars. For assessment sites in which well-developed point bars were present, a total of three RSI measurements were taken, which consisted of the intermediate axis (b-axis) measurements of 15 particles determined to be among the largest size group of recently deposited particles that occur on over 10% of the point bar. During post-field data processing, the riffle stability index was determined by calculating the geometric mean of the dominant bar particle size measurements and comparing the result to the cumulative particle distribution from the riffle pebble count in an adjacent or nearby riffle.

C3.1.3 Instream Habitat Measurements
Instream habitat measurements include channel bed morphology, residual pool depth and width, and pool habitat quality (cover type and woody debris quantification).

C3.1.3.1 Channel Bed Morphology
The length of each monitoring site occupied by pools and riffles was recorded progressing in an upstream direction. The upstream and downstream stations of “dominant” riffle features were recorded. A riffle is considered “dominant” when occupying over 50% of the bankfull channel width (Heitke, et al., 2006). Pools were documented if they were concave in profile, bounded by and “head crest” at the upstream end and a “tail crest” at the downstream end, and had a maximum depth at least 1.5 times the pool-tail depth (Kershner, et al., 2004). Dammed pools were also assessed; backwater pools were not assessed.

C3.1.3.2 Residual Pool Depth
At each pool encountered, the maximum depth and the depth of the pool tail crest at its deepest point was measured. The difference between the maximum depth and the tail crest depth is considered the residual pool depth. No pool tail crest depth was recorded for dammed pools.

C3.1.3.3 Pool Habitat Quality
Qualitative assessments of each pool feature were undertaken, including pool type, size, formative feature, and cover type, along with the depth of any undercut banks associated with the pool. The total number of pools was also quantified.

C3.1.3.4 Woody Debris Quantification
The amount of large woody debris (LWD) within each monitoring site was recorded. Large pieces of woody debris located within the bankfull channel that were relatively stable so as to influence the channel form were counted as either single, aggregate or “willow bunch”. The term “willow bunch”

refers to dead, decadent or living riparian shrubs (not just willows) that are influencing the channel bed morphology. A single piece of large woody debris was counted when it was greater than 9 feet long or spanned two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton, et al., 1997).

C3.1.4 Riparian Health Measurements

Riparian health was quantified using the riparian greenline assessment.

C3.1.4.1 Riparian Greenline Assessment

Along each monitoring site, an assessment of riparian vegetation cover was performed. Vegetation types were recorded at 10-foot intervals, with the number of sampled points depending on the bankfull channel width. The riparian greenline assessment described the general vegetation community type of the groundcover, understory and overstory on both banks. At 50-foot intervals, the riparian buffer width was estimated on either side of the channel. The riparian buffer width corresponds to the belt of vegetation buffering the stream from adjacent land uses.

C3.1.5 Methods for Non-wadeable Reaches

Assessment of sediment sources and habitat conditions on tributaries of the Beaverhead River followed Standard Operating Procedures (SOPs) described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010). Some methods in these SOPs, which are for wadeable streams, were not feasible in many areas of the Beaverhead River where high flows prevented wading during the assessment period. In some reaches, deep water prevented collection of pebble counts, grid toss fine sediment counts, precise cross-sectional measurements, and detailed habitat longitudinal profile.

Collection of less detailed cross-sectional measurements was accomplished in September 2010 by setting up a rope and tag line across the channel in reaches downstream of Barretts in a process described in more detail in following sections. Channel longitudinal profile measurements were collected in downstream reaches using a personal cataraft with a safety line held by crew on the shoreline to help slow the craft. The same method was not feasible in upstream reaches because the dense willow cover along reaches upstream of Barretts and the deep water next to shore in those reaches prevented any sampling requiring access to the lower bank. However, in April of 2011 during lower flow, two cross-section measurements and pebble counts were taken in two reaches upstream of Barretts, using the methodology for wadeable streams.

Field crews conducted sediment source and habitat assessments throughout the Beaverhead watershed below Clark Canyon Reservoir during September of 2010 and April 2010. Sampling followed the SOPs for wadeable streams to the extent possible, with modifications implemented as site conditions dictated. Generally, crews were able to collect greenline, a less precise cross-section with categorical estimated substrate data, BEHI bank erosion data, and a longitudinal profile of channel depth and estimated substrate category (muck, sand, gravel, and cobble) following the thalweg as closely as possible.

Water safety is a prime consideration whenever crews work on large rivers. All crew working along the river wore a personal floatation device (pfd) at all times. . All crew were instructed on how to float properly with feet up and facing downstream and how to ferry to shore in the event anyone lost footing. A crew member with a throw rope was posted on the streambank downstream of the measuring crew whenever crew were working from the cataraft, even though water was seldom deeper than five feet in the assessment reaches.

The longitudinal profile methods required using a rope attached to the raft to slow downstream progression. The rope was clipped to the cataraft with a carabiner to allow the rope to be disconnected if necessary and was held and kept clear of obstacles by two crew members on shore. At no time was the raft tied to any object while crew members were on board.

Cross-sectional data fit into the existing data management structure with only minor modification in some instances. Cross-sectional data from Beaverhead River assessment reaches also were plotted in Excel with substrate size categorical data to illustrate variation in substrate size with channel depth among cross-sections and reaches. Longitudinal profile data collected with the non-wadeable stream methods were also plotted in Excel to show stream depth and corresponding substrate size class over the length of the reach. In some instances two floats were needed to access the deepest part of the channel. In these cases the data were entered into Excel and the deepest measurement with corresponding substrate size class at each station was used in the longitudinal profile plot.

C3.1.5.1 Greenline

Greenline inventory was completed in all reaches except in two upstream reaches where dense willow cover and deep water near shore prevented movement along the lower bank. In many cases the vegetation category along the bank opposite the investigator was estimated due to limited access. The only instances in which this estimated data may have increased error are those where grasses and wetland graminoids dominate the greenline and are mixed, making it difficult to tell which category occupied the measurement point. Vegetation was classified as 'Wetland' where both grass and wetland graminoid species occupied the measurement point. Banks were not accessible in the two upstream-most reaches due to dense willow cover and deep water near the bank, thus greenline was not inventoried in those reaches in either the September 2010 or April 2011 sampling effort.

C3.1.5.2 Cross-sections

Cross-sectional measurements were collected in non-wadeable reaches (BEAV 09-04, BEAV 09-11, BEAV 09-14, and BEAV 09-15) below Barretts with use of a personal cataraft guided along a rope and tagline strung across the stream. The guide rope and tag line marked with feet and tenths were secured to 6 foot T posts driven into both streambanks, or were tied to branches of willows growing along the streambank. One person guided the cataraft, one person collected measurements, and one person recorded data. The data recorder called out the measurement intervals based on the width of the channel, as in the SOPs. One person on the cataraft sat in the seat of the craft and held the rope, guiding the cataraft to the needed intervals and across the stream. The data collector sat on the cargo rack of the cataraft and held an 8 foot long rebar marked in 1 foot intervals (**Figure C-2**). The data collector called out stream depths at the given intervals and gave an estimate of the size class of stream substrate, generally easily determined by sound and feel of the substrate against the rebar. Floodprone width was estimated based on the maximum depth collected and all other cross-section variables were collected following the standard calculations specified in the SOPs.

Figure C-2. Cross-sectional measurement using cataraft.

C3.1.5.3 Longitudinal Profile

Field crews measured depth and substrate profiles at a coarse scale by floating down the length of the reach and recording data every 20 feet. The crew for these measurements included one person to call out every 20 feet and record data, two people managing the safety rope, and two people on the cataraft (**Figure C-3**). One person on the raft served as oarsman, rowing upstream to slow the downstream progression and guide the raft to the thalweg. The other person on the raft measured stream depth and estimated substrate size class using an 8 foot length of rebar marked in foot increments. The two crew members holding the rope slowed progression of the raft when necessary and otherwise maintained contact with the raft to avoid obstacles. The crew holding the rope worked together to keep the rope free of obstacles and help direct the raft to the thalweg.

Figure C-3. Longitudinal profile measurement using cataraft and marked rebar.

C3.1.5.4 Bank Stability using Bank Erosion Hazard Index (BEHI)

Collection of BEHI data followed the SOP even in non-wadeable streams, except that the bankfull mean depth measurements used to calculate near-bank stress were not collected where wading was not possible. BEHI measurements were collected in all reaches sampled in September 2010, but were not collected in the upper reaches of the Beaverhead in April 2011 because of dense willow cover at the bank's edge and deep instream flow.

C3.1.5.5 Large Woody Debris
Large woody debris was recorded on the Beaverhead River in the rare case where any was present. Generally the valley bottom and streambanks are grass- and willow-dominated, and no large woody debris was found.

C3.2 RESULTS

In the Beaverhead TPA, sediment and habitat parameters were assessed in September 2010 at 29 monitoring sites. An additional three sites (STEL 05_01, BEAV 04_02 and BEAV 04_05) were visited in April 2011 at low flow. Sediment and habitat assessments were performed in ten reach types out of the 28 reach types delineated in the GIS-based stratification, with a focus on low gradient reach types. A statistical analysis of the sediment and habitat data is presented by reach type and for individual monitoring sites in the following sections. The complete sediment and habitat dataset is presented in *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA (Watershed Consulting, LLC, 2011)*, on file at DEQ**.**

C3.2.1 Reach Type Analysis
This section presents a statistical analysis of sediment and habitat base parameters for each of the reach types assessed in the Beaverhead TPA. Reach type discussions are based on mean values, while summary statistics for the minimum, 25th percentile, median, 75th percentile and maximum values are also provided since these may be more applicable for developing sediment TMDL targets. Sediment and habitat analysis is provided by reach type for the following metrics:

- width/depth ratio
- entrenchment ratio riffle pebble count <2mm
- riffle pebble count <6mm
- riffle grid-toss <6mm
- pool tail-out grid toss <6mm
- residual pool depth
- pool frequency
- LWD frequency
- greenline understory shrub cover
- greenline bare ground

Only BEHI data were collected for reach CLCK 18-02. Because this was the only reach visited in reach type MR_4_2_U, this reach type is not included in data summaries in the sections that follow.

C3.2.1.1 Width/Depth Ratio
The channel width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). The channel width/depth ratio is one of several standard measurements used to classify stream channels, making it a useful variable for comparing conditions between reaches with the same stream type (Rosgen, 1996). A comparison of observed and expected width/depth ratios is also a useful indicator of channel overwidening and aggradation, which are often linked to excess streambank erosion and/or sediment inputs from sources upstream of the study reach. Channels that

are overwidened are often associated with excess sediment deposition and streambank erosion, contain shallower and warmer water, and provide fewer deepwater habitat refugia for fish.

Figure C-4 illustrates trends in width/depth ratio among reach types. Mean width/depth ratios for assessed reach types ranged from 7.6 in MR_4_1_U to 39.1 in MR_0_7_U (**Table C-4**). A higher stream order indicates a larger, thus generally wider, stream.

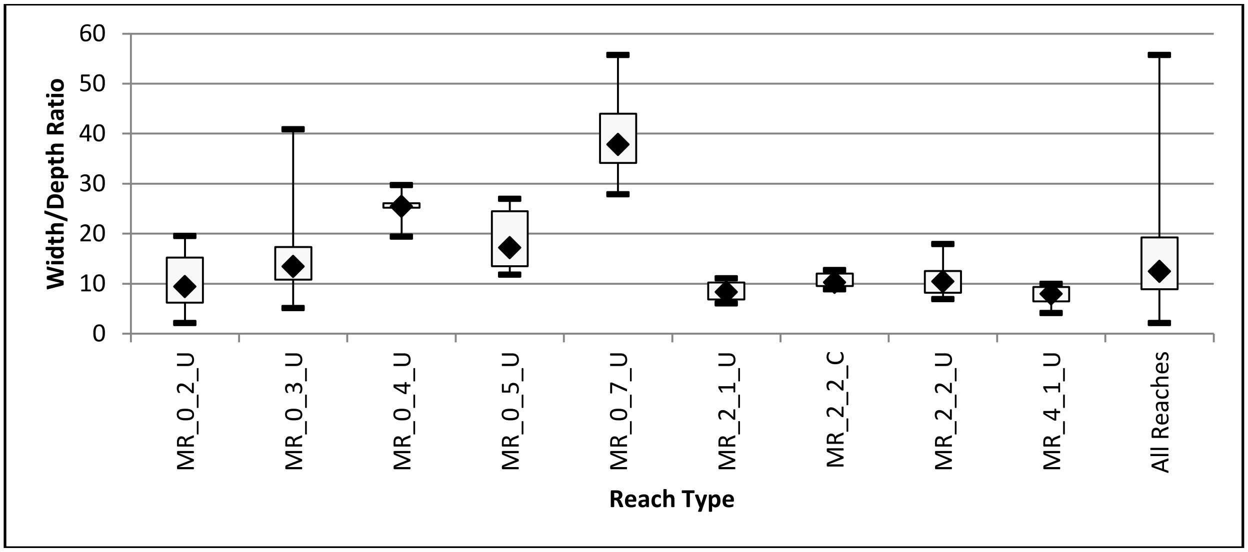

Figure C-4. Width/Depth Ratio.

Table C-4. Width/Depth Ratio.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	7	1	1	5	2	32
Sample Size	34	14	8	13	17	5	5	25	8	129
Minimum	2.17	5.16	19.44	11.84	27.91	6.09	8.91	6.95	4.17	2.17
25th Percentile	6.22	10.8	25.19	13.5	34.17	6.83	9.55	8.21	6.48	8.91
Median	9.46	13.48	25.5	17.24	37.87	8.37	10.3	10.48	8	12.5
Mean	10.39	14.94	25.35	18.65	39.13	8.53	10.71	10.90	7.61	16.29
75th Percentile	15.23	17.33	26.12	24.48	44	10.27	12.03	12.56	9.37	19.44
Maximum	19.57	40.91	29.75	27	55.76	11.11	12.76	17.96	10	55.76

Based on data from assessed reaches in the Beaverhead TPA, the width/depth ratio generally increases as stream order increases, with the exception of fourth vs. fifth order streams.

C3.2.1.2 Entrenchment Ratio

A stream's entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen, 1996). The entrenchment ratio is used to help determine if a stream shows departure from its natural stream type and is an indicator of stream incision that describes how easily a stream can access its floodplain. Streams can become incised due to detrimental land management activities or may be naturally incised due to landscape characteristics. A stream that is overly entrenched generally is more prone to streambank erosion due to greater energy exerted on the banks during flood events. Greater scouring energy along incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incision may be historical in nature, though sediment loading may continue to occur. The entrenchment ratio is an important measure of channel conditions since it relates to sediment loading and habitat condition.

Figure C-5 illustrates the distribution of values for entrenchment ratio among reach types. The mean entrenchment ratio for assessed reach types ranged from 2.1 in MR_2_2_C to 8.5 in MR_0_2_U (**Table C-5**).

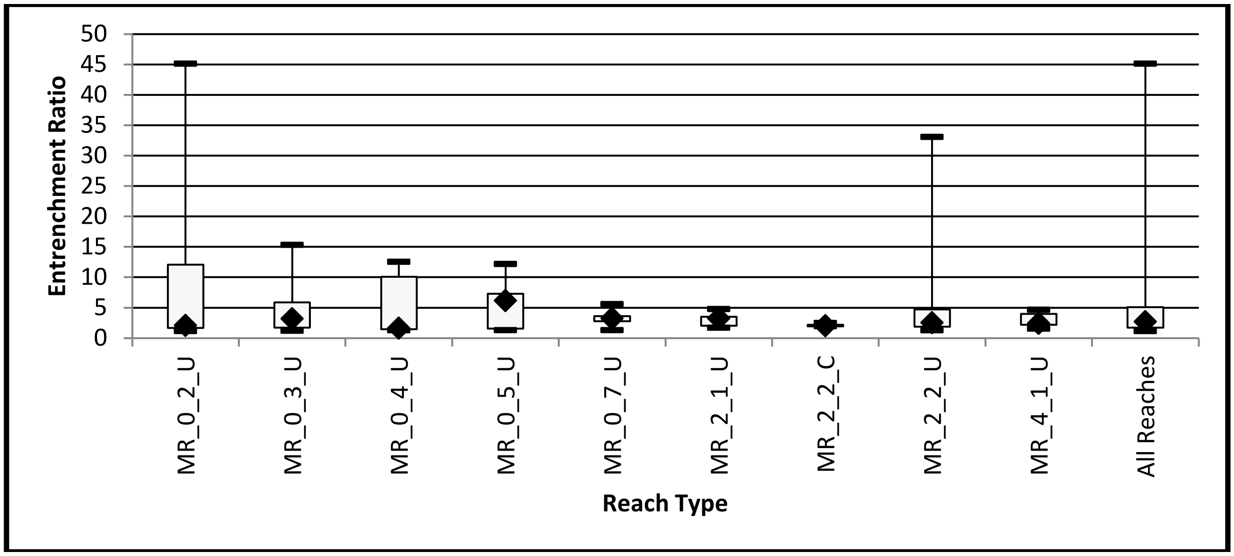

Figure C-5. Entrenchment Ratio.

Table C-5. Entrenchment Ratio.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	7	1	1	5	2	32
Sample Size	34	14	8	13	17	5	5	25	8	129
Minimum	1.16	1.21	1.29	1.31	1.31	1.71	1.95	1.3	1.56	1.16
25th Percentile	1.65	1.7	1.47	1.58	2.77	2.03	1.95	1.73	2.22	1.74
Median	2.09	3.19	1.64	6.17	3.24	3.25	2.04	2.14	2.43	2.71
Mean	8.52	4.30	5.60	5.38	3.34	3.05	2.12	5.21	3.04	5.44
75th Percentile	12.06	5.87	10.09	7.3	3.61	3.5	2.18	3.15	4	5.07
Maximum	45.12	15.33	12.55	12.19	5.59	4.78	2.49	33.1	4.67	45.12

C3.2.1.3 Riffle Pebble Count <2mm

Percent surface fine sediment provides a good measure of the siltation occurring in a river system. Surface fine sediment measured using the Wolman (1954) pebble count method is one indicator of aquatic habitat condition and can signify excessive sediment loading. The Wolman pebble count provides a survey of the particle distribution of the entire channel width, allowing investigators to calculate a percentage of the surface substrate (as frequency of occurrence) composed of fine sediment.

Figure C-6 illustrates the distribution of values for substrate size < 2mm from riffle pebble count among reach types. Mean values for the percent of fine sediment <2mm based on riffle pebble counts ranged from 14% in MR_0_4_U to 43% in MR_4_1_U (**Table C-6**). Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

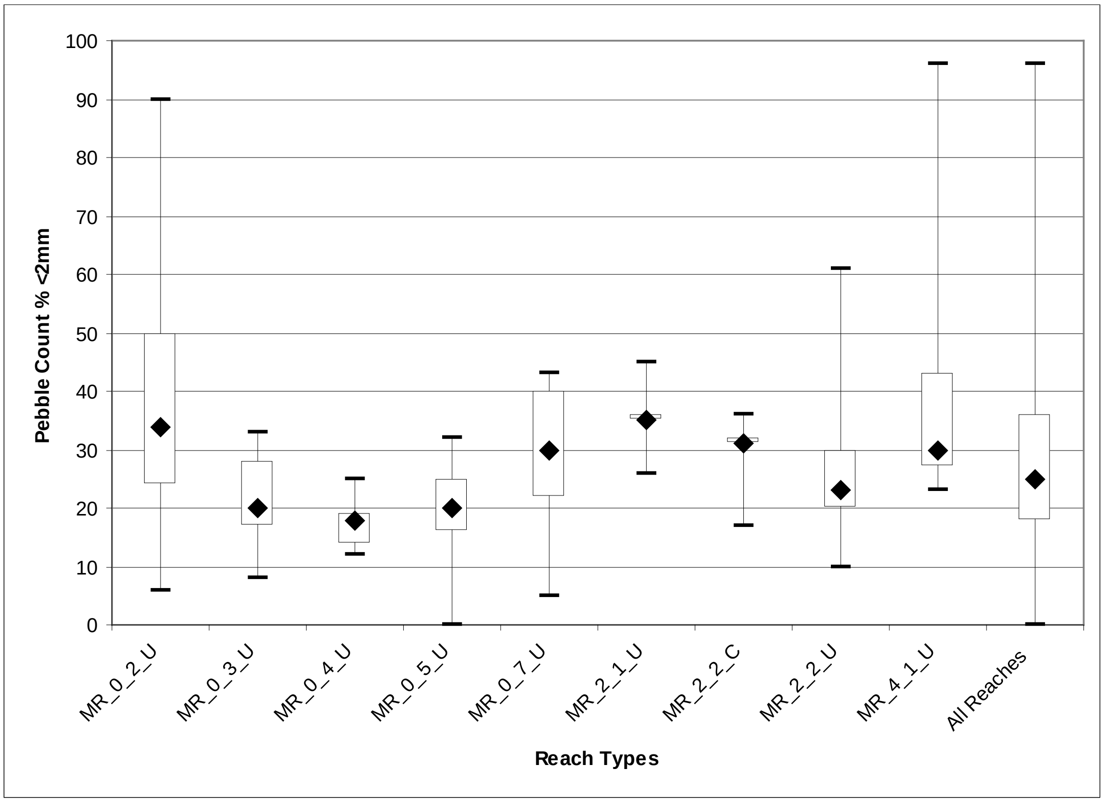

Figure C-6. Riffle Pebble Count <2mm.

Table C-6. Riffle Pebble Count <2mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	5	1	1	4	2	26
Sample Size	20	12	4	13	9	4	4	16	8	90
Minimum	6	8	12	0	5	26	17	10	23	0
25th Percentile	16	17	12	16	22	35	31	23	27	17
Median	33	20	12	20	30	35	31	25	30	25
Mean	41	21	14	18	28	36	29	29	43	30
75th Percentile	55	28	14	25	40	36	32	33	43	36
Maximum	90	33	18	32	43	45	36	61	96	96

C3.2.1.4 Riffle Pebble Count <6mm

As with surface fine sediment <2mm, an accumulation of surface fine sediment <6mm may indicate excess sedimentation and be detrimental to coldwater fish spawning. **Figure C-7** illustrates the distribution of values for surface fine sediment < 6mm from riffle pebble counts. Mean values for the percent of fine sediment <6mm based on pebble counts conducted in riffles ranged from 25% in MR_0_5_U to 79% in MR_2_1_U (**Table C-7**). The smallest order streams, even those with relatively high stream gradient, had high percent fines < 6mm compared to larger streams; this trend is unexpected for headwaters streams. Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

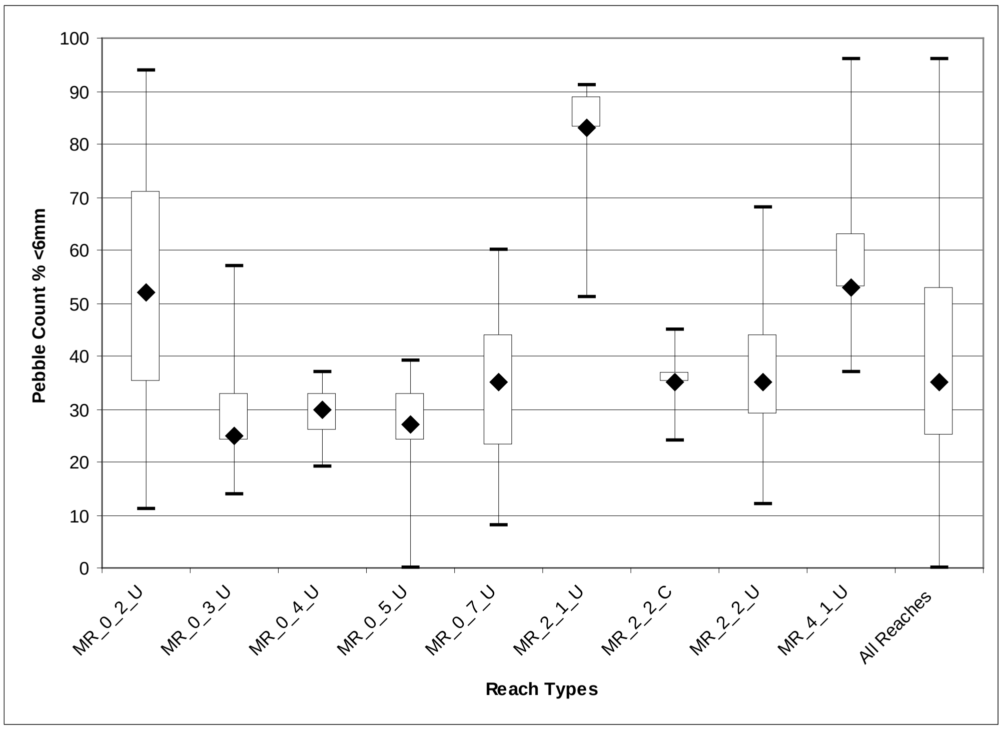

Figure C-7. Riffle Pebble Count %<6mm.

Table C-7. Riffle Pebble Count %<6mm.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	5	1	1	4	2	26
Sample Size	20	12	4	13	9	4	4	16	8	90
Minimum	11	14	19	0	8	51	24	12	37	0
25th Percentile	30	24	23	24	23	83	35	31	53	25
Median	44	25	23	27	35	83	35	37	53	36
Mean	53	30	28	25	33	79	35	40	61	41
75th Percentile	71	33	33	33	44	89	37	54	63	53
Maximum	94	57	37	39	60	91	45	68	96	96

C3.2.1.5 Riffle Grid Toss %<6mm

The riffle grid toss is a standard procedure frequently used in aquatic habitat assessment that provides complimentary information to the Wolman pebble count. **Figure C-8** illustrates the distribution of values for substrate < 6mm from riffle grid toss. Mean values for riffle grid toss fine sediment <6mm range from 0% in MR_0_7_U to 23.5% in MR_0_2_U **(Table C-8).** Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

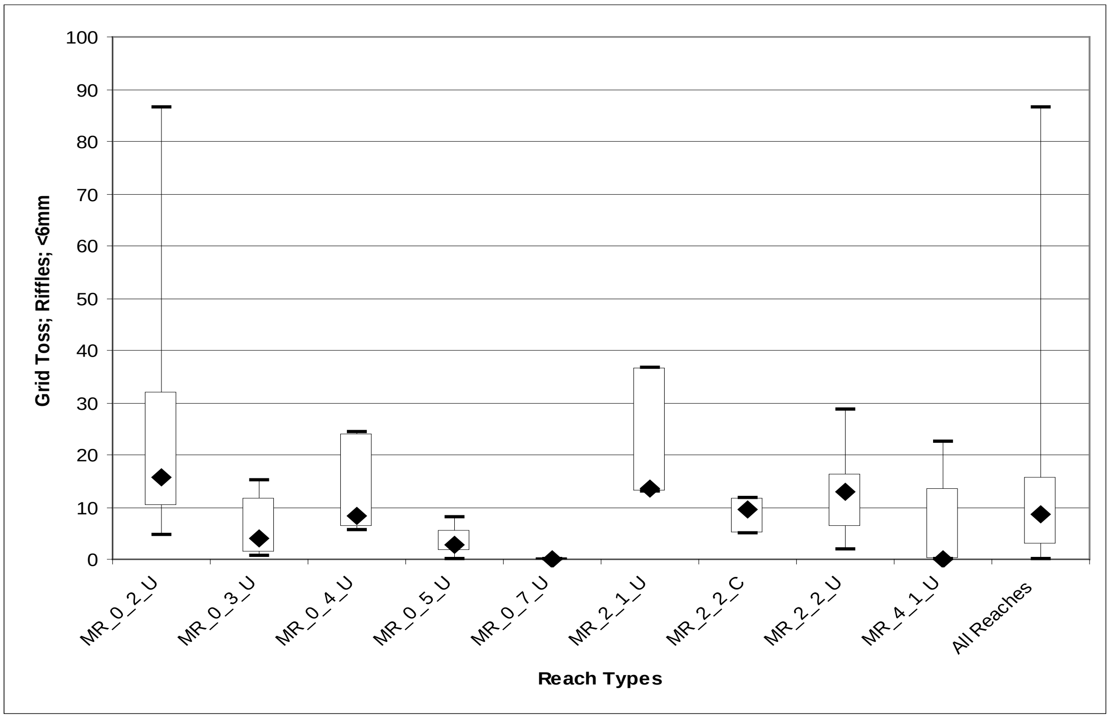

Figure C-8. Riffle Grid Toss Fine Sediment %<6mm.

Table C-8. Riffle Grid Toss Fine Sediment %<6mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	2	1	1	4	2	23
Sample Size	15	9	3	9	4	3	3	12	7	65
Minimum	0.7	0.7	18.3	0	0	12.9	4.8	2	0	0
25th Percentile	6.4	1.3	18.3	1.4	0	12.9	4.8	6.5	0	2
Median	13.6	4	24	2.7	0	13.4	9.5	12.9	0	7.5
Mean	23.5	6.1	22.2	3.3	0	21	8.6	12.7	5.5	12.1
75th Percentile	32.7	11.6	24.4	5.4	0	36.7	11.6	16.3	13.6	15.2
Maximum	86.4	15.2	24.4	8.1	0	36.7	11.6	28.6	22.4	86.4

C3.2.1.6 Pool Tail-out Grid Toss % <6mm

Grid toss measurements in pool tail-outs provide a measure of fine sediment accumulation in potential spawning sites, which may have detrimental impacts on aquatic habitat by cementing spawning gravels, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan, 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35mm and the emergence success of westslope cutthroat trout and bull trout.

Figure C-9 illustrates the distribution of values for substrate < 6mm from pool tail-out grid toss among reach types. Mean values for pool tail-out grid toss fine sediment <6mm range from 9.8% in MR_2_2_C to 86.6% in MR_2_1_U **(Table C-9)**. Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

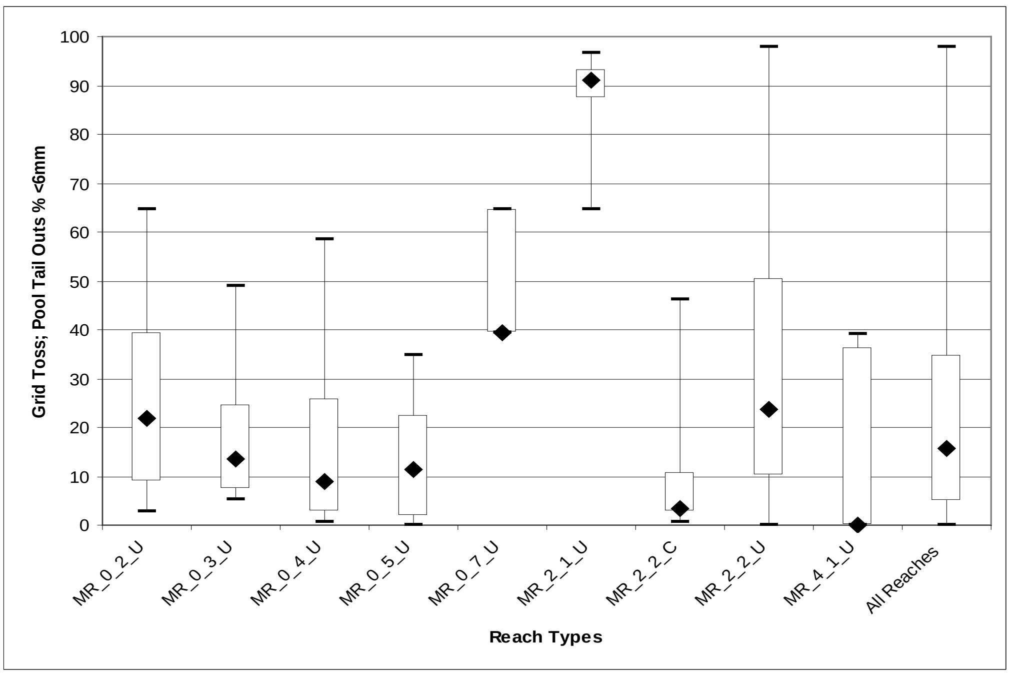

Figure C-9. Pool Tail-out Grid Toss % <6mm.

Table C-9. Grid Toss; Pool Tail Outs: <6mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	1	1	1	4	2	22
Sample Size	17	19	9	23	2	5	9	29	10	123
Minimum	2.7	5.1	0.7	0	39.4	64.6	0.7	0	0	0
25th Percentile	11.1	7.5	1.3	2	39.4	87.4	2.7	10.2	0	4.7
Median	19.7	13.6	2.7	11.5	39.4	91.1	3.4	28.6	0	14.3
Mean	23.6	17.8	5.8	13.1	52	86.6	9.8	35	17.7	23.6
75th Percentile	30.6	24.5	8.8	22.4	64.6	93.2	10.9	51.7	36.4	31.3
Maximum	64.6	49	22.4	34.7	64.6	96.6	46.2	98	39	98

C3.2.1.7 Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods. Residual pool depth is also an indirect measurement of sediment inputs to streams because an increase in sediment loading can cause pools to fill, thus decreasing residual pool depth over time.

Figure C-10 illustrates the distribution of values for residual pool depth among reach types. Mean residual pool depths ranged from 0.4 feet in MR_2_1_U to 1.5 feet in MR_0_4_U (**Table C-10**). In general, residual pool depths were greater for reaches on lower-gradient, larger streams, as would be expected.

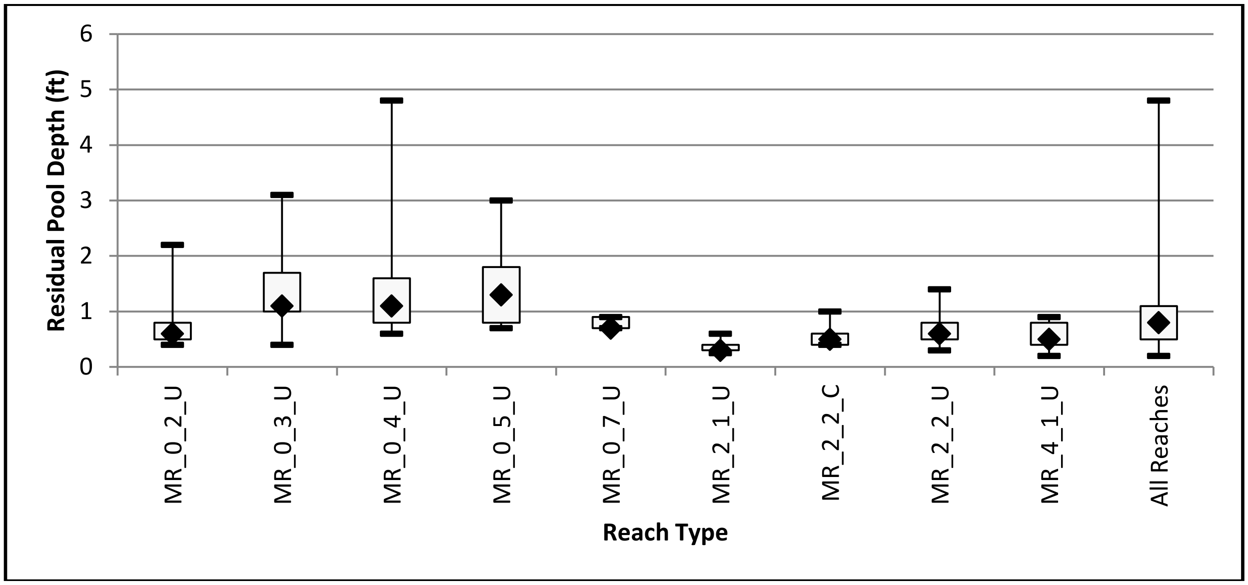

Figure C-10. Residual Pool Depth.

Table C-10. Residual Pool Depth.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	1	1	1	5	2	26
Sample Size	34	28	20	30	2	12	12	53	14	205
Minimum	0.4	0.4	0.6	0.7	0.7	0.25	0.4	0.3	0.2	0.2
25th Percentile	0.5	1	0.8	0.8	0.7	0.3	0.4	0.5	0.4	0.5
Median	0.6	1.1	1.1	1.3	0.7	0.3	0.5	0.6	0.5	0.8
Mean	0.8	1.4	1.5	1.4	0.8	0.4	0.6	0.7	0.6	0.9
75th Percentile	0.8	1.7	1.6	1.8	0.9	0.4	0.6	0.8	0.8	1.1
Maximum	2.2	3.1	4.8	3	0.9	0.6	1	1.4	0.9	4.8

C3.2.1.8 Pool Frequency

Pool frequency is a measure of the availability of pools to provide rearing habitat, cover, and refugia for salmonids. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be adversely affected by riparian habitat degradation resulting in a reduced supply of large woody debris or less scouring from stable root masses in streambanks.

Figure C-11 illustrates the distribution of values for pool frequency among reach types. The mean value for the number of pools per 1,000 feet ranged from one in MR_0_7_U to 24 in MR_2_2_C and MR_2_1_U (**Table C-11**). In the Beaverhead watershed, pool frequency was notably higher in reach types with 2-4% slope than in reach types of higher or lower slope; however, it should be noted that pools were not measured using the standard protocols on many of the reaches on the Beaverhead River, which results in a sample size of one for reach type MR_0_7_U.

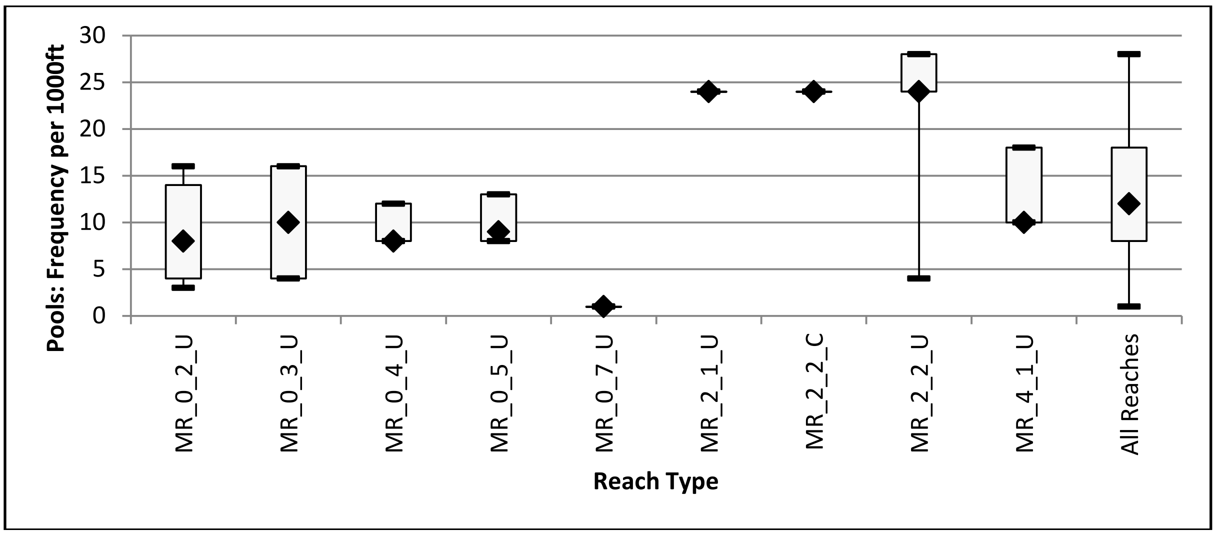

Figure C-11. Pools per 1000 Feet.

Table C-11. Pools per 1000 feet.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	1	1	1	5	2	26
Sample Size*	7	3	2	3	1	1	1	5	2	25
Minimum	3	4	8	8	1	24	24	4	10	1
25th Percentile	4	4	8	8	1	24	24	24	10	8
Median	8	10	8	9	1	24	24	24	10	12
Mean	9	10	10	10	1	24	24	22	14	13
75th Percentile	14	16	12	13	1	24	24	28	18	18
Maximum	16	16	12	13	1	24	24	28	18	28

*Sample sizes for pool frequency are lower than for pool residual depth because pool frequency is a metric calculated for the entire reach; thus, for certain reach types in which only one reach was assessed the sample size is 1.

C3.2.1.9 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of high-quality salmonid habitat, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD frequency can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under optimal conditions.

Figure C-12 illustrates the distribution of values for LWD frequency among reach types. The mean value for the amount of LWD per 1,000 feet ranged from two in MR_2_1_U to 54 in MR_2_2_C **(Table C-12).** LWD per mile is provided in **Table C-13**. LWD was not tallied on some reach types, specifically the non-wadeable reaches on the Beaverhead River. "Willow bunches" recorded in the field were not tallied with large woody debris; thus, these results do not include reaches in which the only LWD recorded were willow bunches.

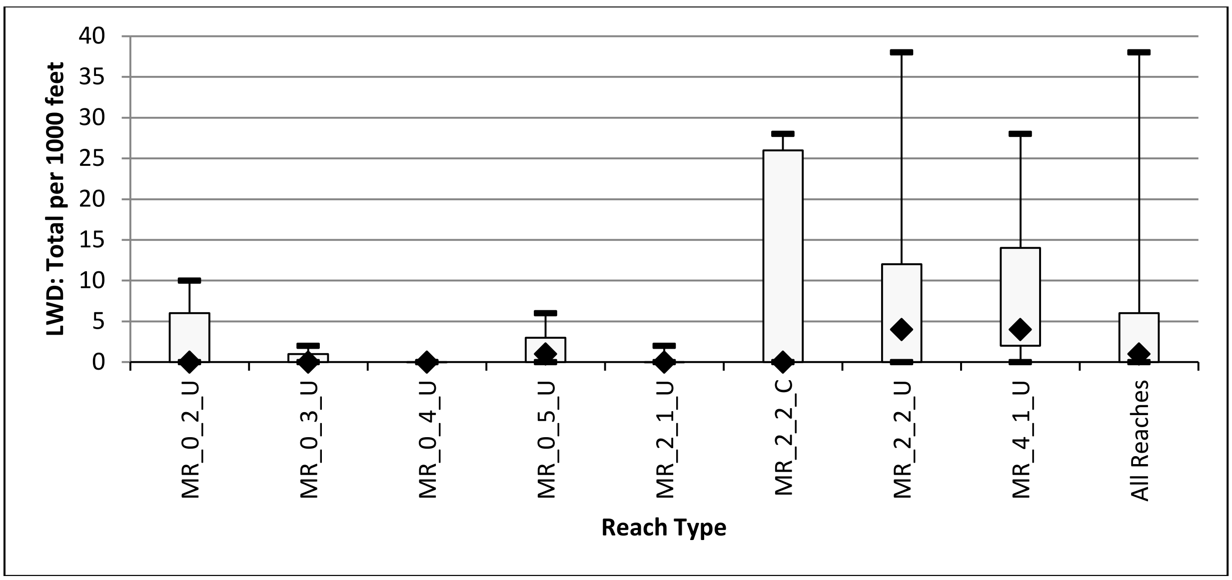

Figure C-12. Large Woody Debris per 1000 Feet.

Table C-12. Large Woody Debris per 1000 Feet.

	Reach Types								
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	3	2	2	3	1	1	4	2	19
Sample Size	11	10	6	6	5	4	15	10	67
Minimum	0	0	0	0	0	0	0	0	0
25th Percentile	0	0	0	0	0	0	0	2	0
Median	0	0	0	1	0	0	4	4	1
Mean	3	0.5	0	2	0.4	14	10	9	5
75th Percentile	6	1	0	3	0	26	12	14	6
Maximum	10	2	0	6	2	28	38	28	38

Table C-13. Large Woody Debris per Mile.

	Reach Types								
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	1	2	0	2	1	1	3	2	12
Sample Size	1	2	0	2	1	1	3	2	12
Minimum	0	0	0	0	0	0	0	0	0
25th Percentile	0	0	0	1	0	0	0	11	0
Median	0	0	0	11	0	69	21	26	0
Mean	14	3	0	11	2	71	51	50	0
75th Percentile	26	5	0	16	0	140	58	74	32
Maximum	53	11	0	32	10.56	148	201	147	201

C3.2.1.10 Greenline Understory Shrub Cover

Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one of the main food sources for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are also an important food source for fish.

Figure C-13 illustrates the distribution of values greenline understory shrub cover among reach types. The mean value for greenline understory shrub cover ranged from 17% in MR_0_2_U to 70% in MR_2_2_C (**Table C-14**).

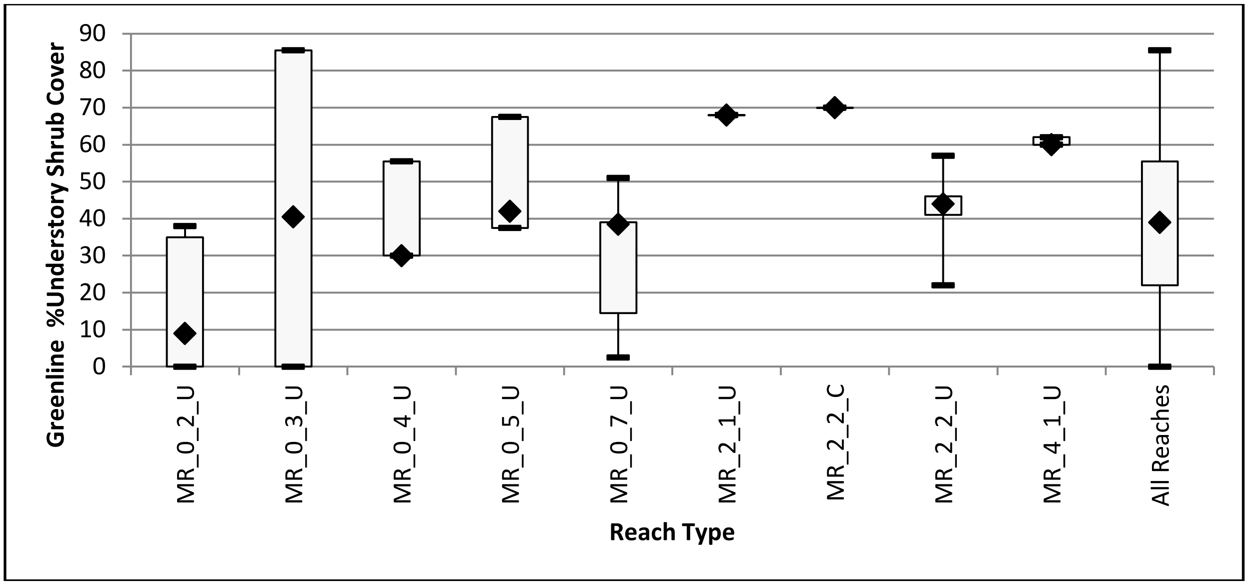

Figure C-13. Greenline % Understory Shrub Cover.

Table C-14. Greenline % Understory Shrub Cover

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	5	1	1	5	2	30
Sample Size	7	3	2	3	5	1	1	5	2	29
Minimum	0	0	30	37.5	2.5	68	70	22	60	0
25th Percentile	0	0	30	37.5	14.5	68	70	41	60	22
Median	9	40.5	30	42	38.5	68	70	44	60	39
Mean	17	42	42.8	49	29.1	68	70	42	33.3	37.6
75th Percentile	35	85.5	55.5	67.5	39	68	70	46	62	55.5
Maximum	38	85.5	55.5	67.5	51	68	70	57	62	85.5

C3.2.1.11 Greenline Bare Ground

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance has resulted in exposed bare soil. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels since sediment can wash in from unprotected areas during snowmelt, storm runoff and flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Figure C-14 illustrates the distribution of values for bare ground among reach types. The mean value for greenline bare ground ranged from 5% in MR_0_7_U to 21.3% in MR_0_4_U (**Table C-15**). Reach type MR_0_7_U represents many of the reaches on the lower Beaverhead River, which generally supported dense cover of riparian graminoid (grass-like) species or shrubs.

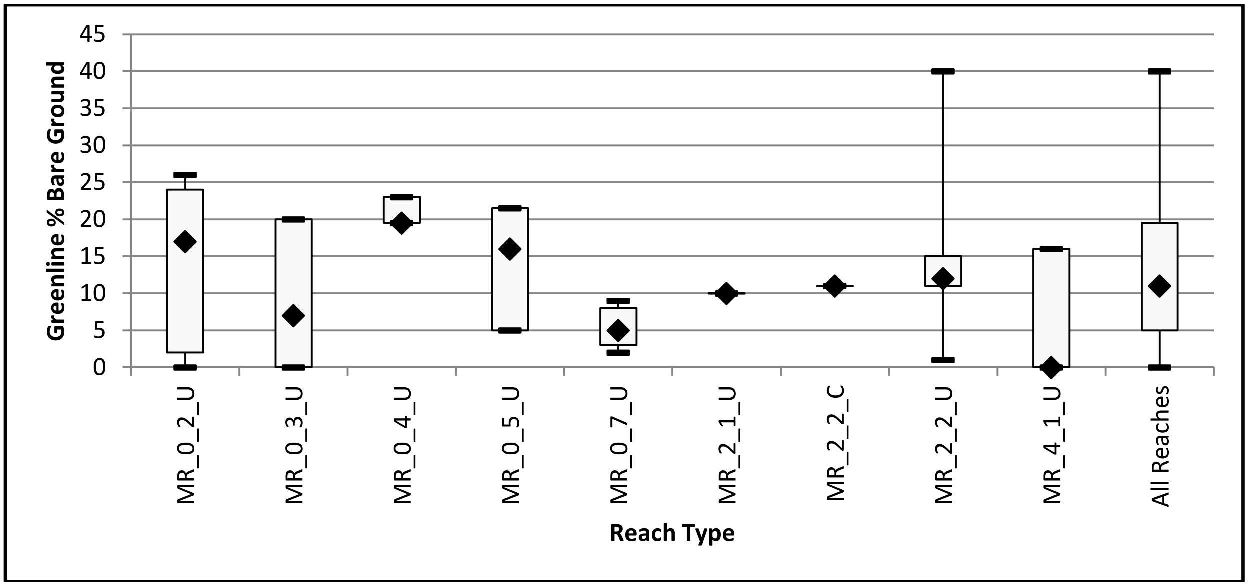

Figure C-14. Greenline Bare Ground.

Table C-15. Greenline Bare Ground.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	5	1	1	5	2	30
Sample Size	7	3	2	3	5	1	1	5	2	29
Minimum	0	0	19.5	5	2	10	11	1	0	0
25th Percentile	2	0	19.5	5	3	10	11	11	0	5
Median	17	7	19.5	16	5	10	11	12	0	11
Mean	14.6	9	21.3	14.2	5.4	10	11	15.8	8	12.3
75th Percentile	24	20	23	21.5	8	10	11	15	16	19.5
Maximum	26	20	23	21.5	9	10	11	40	16	40

C3.2.2 Monitoring Site Analysis

Sediment and habitat data collected at each monitoring site were reviewed individually in the following sections. Monitoring site discussions are based on median values, referencing the box plot statistics shown. Summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are presented graphically, since these may be more applicable for developing sediment TMDL criteria.

Reach STEL 10-01 was a dry channel, so data was not collected aside from field notes. For reach CLKC 18-02, only BEHI data were collected; therefore, this reach does not have data associated with it in several of the following figures. As noted in the previous section, healthy E-type channels often have higher levels of fine sediment than other channel types. Statistics from these channels are included in the following analysis. **Table C-16** outlines reaches by current channel type.

Table C-16 Reaches by Rosgen Stream Type

Existing Rosgen Stream Type	REACH_ID
A	STEL 05-01
B	FREN 23-01
	SCUD 11-01
C	BEAV 04-02
	BEAV 04-05
	BEAV 09-04
	BEAV 09-06
	BEAV 09-14
	BEAV 09-15
	BLKD 02-08
	BLKD 02-14
	BLKD 02-30
	CLKC 18-02
	FARL 28-01
	GRAS 12-01
	RATT 54-04
	STON 22-02
	TAYL 27-01
	WFBK 08-04
E	BEAV 09-11
	DYCE 02-02
	GRAS 20-11
	RESR 11-01
	TAYL 32-01
F	SPRG 31-01
	STON 22-02B
Undetermined	CLKC 19-02
	CLKC 32-01
	RATT 60-04
	STON 05-01
	STON 20-02
	WFDY 17-01

C3.2.2.1 Width/Depth Ratio

The highest median width/depth ratio was observed in BEAV 09-14, a reach in the lower Beaverhead River (**Figure C-15)**. TAYL-32-01, which is a stable E channel on Taylor Creek, had the lowest width/depth ratio. Width/depth ratio did not show a trend increasing from upstream to downstream sites on streams in the Beaverhead TPA.

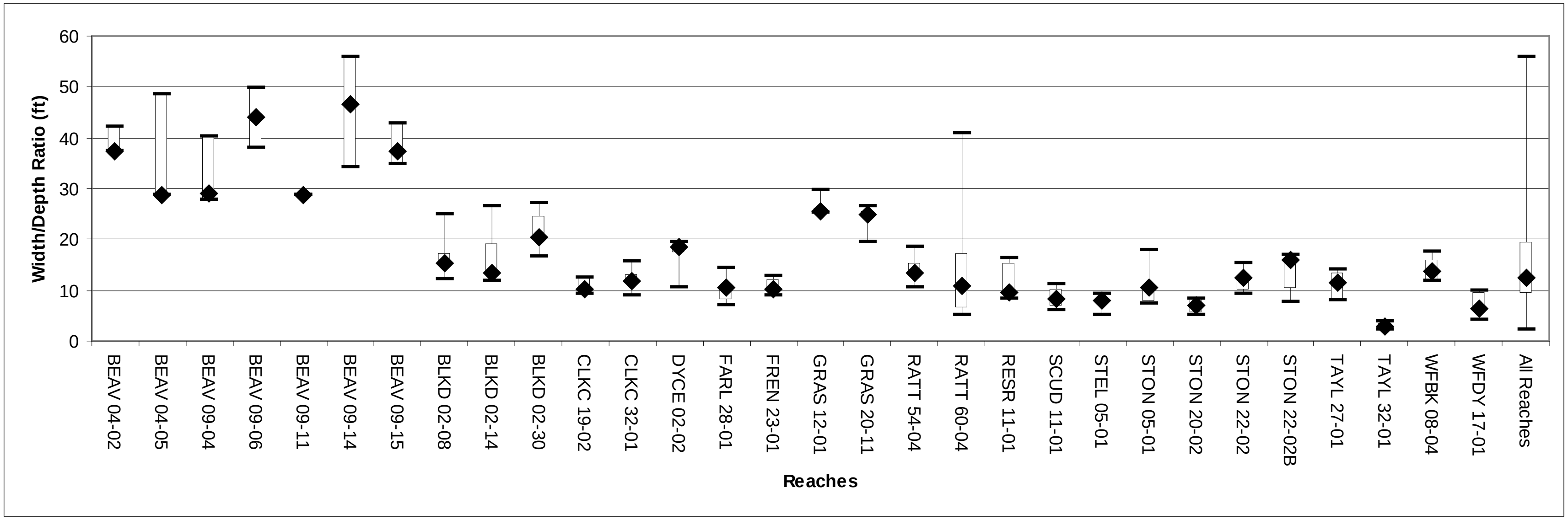

Figure C-15. Width/Depth Ratio.

C3.2.2.2 Entrenchment Ratio

Entrenchment ratio data collected within the Beaverhead River TPA indicates the following (**Figure C-16**):

1. TAYL 32-01 has the greatest amount of floodplain access out of the sites assessed. This reach also had the lowest width/depth ratio (**Figure C-16**).
2. Variation in entrenchment ratio was generally low within reaches.

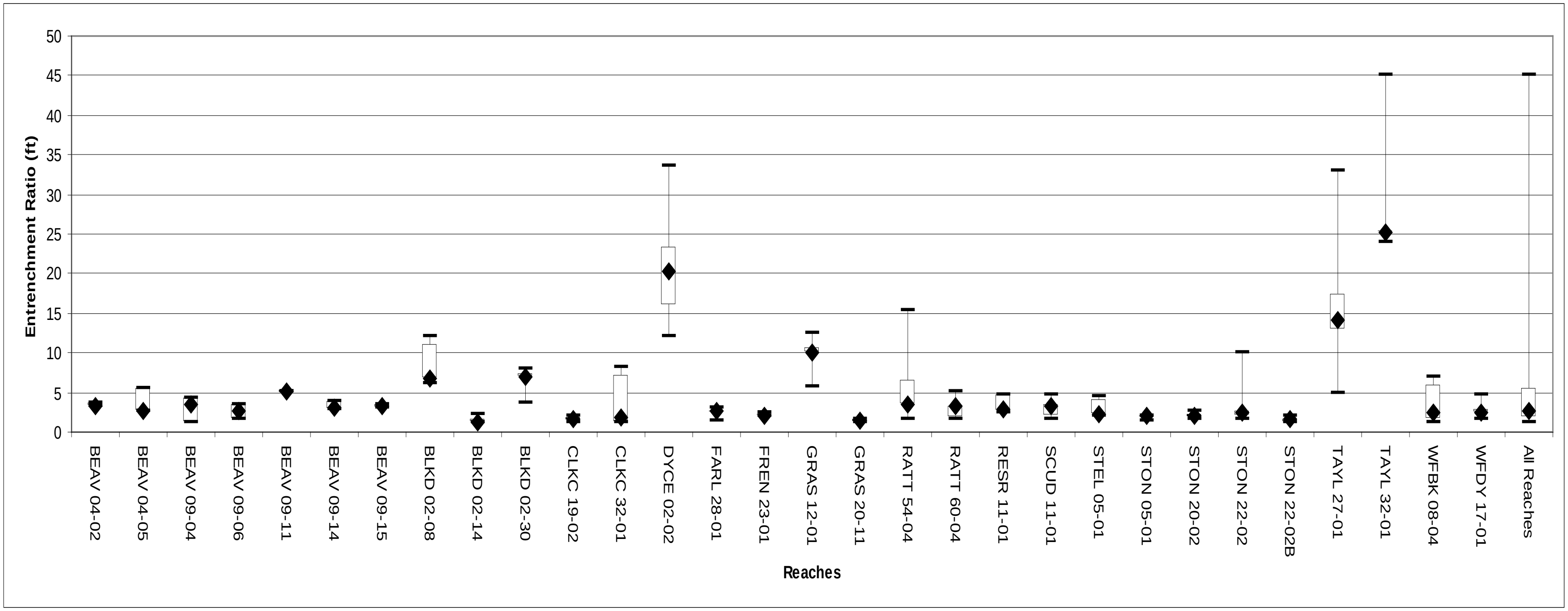

Figure C-16. Entrenchment Ratio.

C3.2.2.3 Riffle Pebble Count <2mm

The median percent of fine sediment in riffles <2mm as measured by a pebble count was highest in STON 22-02, and all STON reaches had relatively high fine sediment <2mm compared to other reaches. (**Figure C-17**).

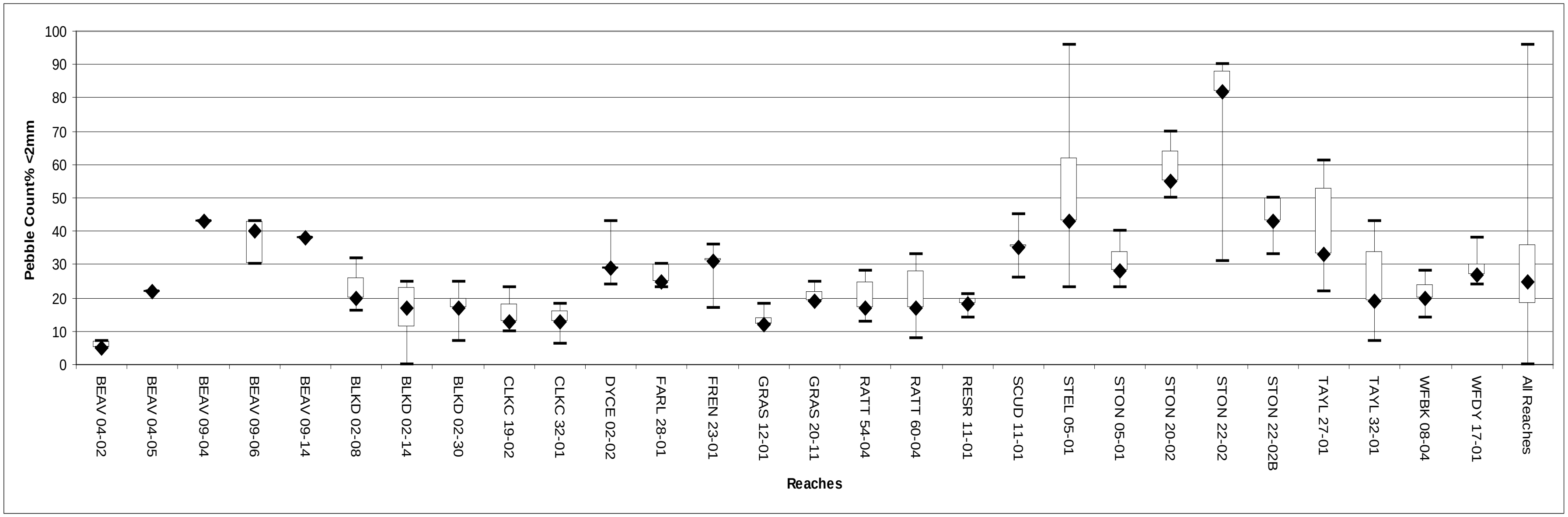

Figure C-17. Riffle Pebble Count <2mm

C3.2.2.4 Riffle Pebble Count <6mm

The percent of fine sediment in riffles <6mm as measured by a pebble count followed a similar trend as the percent of fine sediment <2mm, with the highest median value in STON 22-02. SCUD 11-01 also demonstrated a high median percentage (**Figure C-18**).

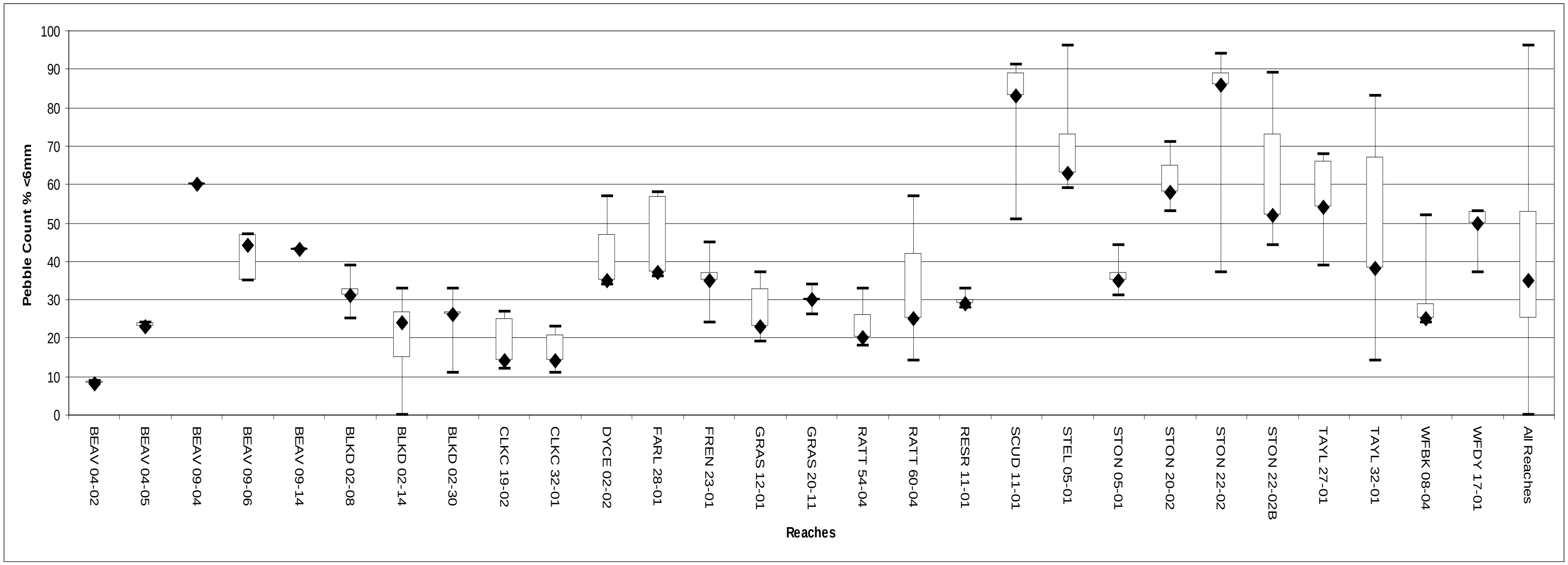

Figure C-18. Riffle Pebble Count <6mm.

C3.2.2.5 Riffle Grid Toss %<6mm

The median percent of fine sediment in riffles <6mm as measured by a grid toss was highest in STON 22-02 (**Figure C-19**). Grid toss was not conducted on most reaches of the Beaverhead River.

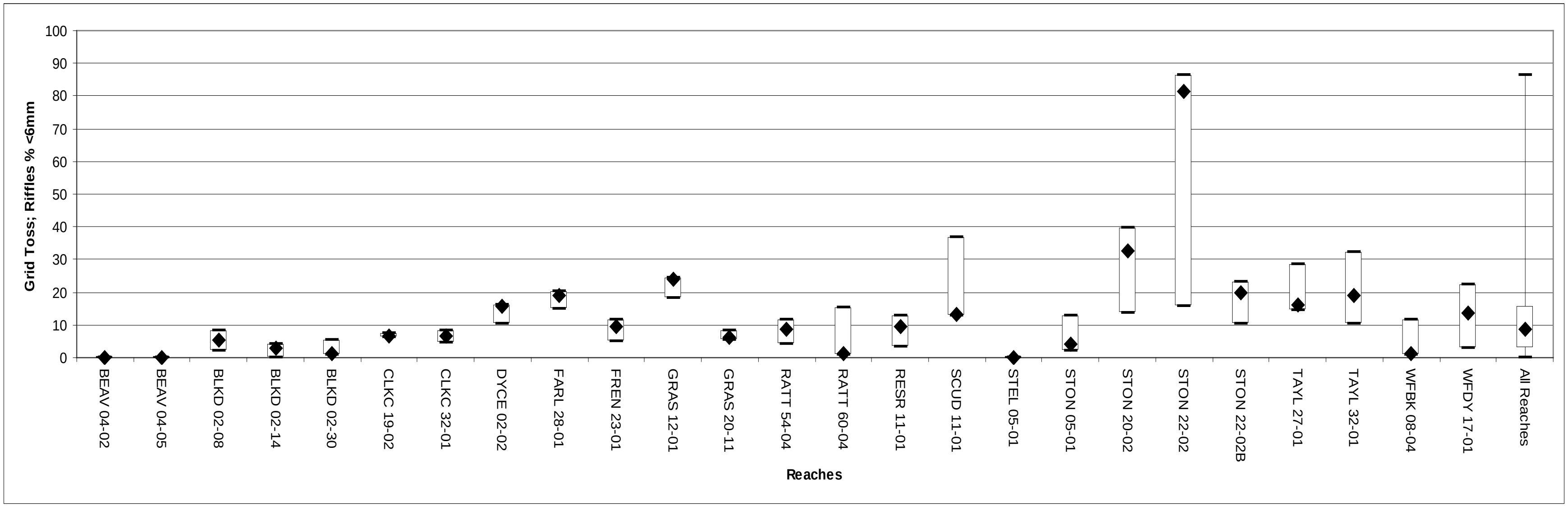

Figure C-19. Riffle Grid Toss %<6mm.

C3.2.2.6 Riffle Stability Index

The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles. The RSI addresses situations in which increases in gravel bedload from headwater activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds. In the Beaverhead TPA, very few gravel bars were encountered. RSI evaluations were, therefore, only performed in CLKC 19-02, CLKC 32-01, CLKC 32-01, GRAS 12-01 and BLKD 02-14, as outlined in **Table C-17**. The D50 is the median pebble size encountered in the pebble count taken in closest proximity to the gravel bar used for RSI, and is used in calculating the RSI value.

Table C-17. Riffle Stability Index Summary

	Pebble Count Analysis		RSI
	Cell	D50	
CLKC 19-02	3	19	111.56
CLKC 32-01	5	54.5	104.97
CLKC 32-01	1	27	104.97
GRAS 12-01	4	19	79.67
BLKD 02-14	4*	22.6	67.26

* D50 based on median from neighboring cell; no pebble count in cell 4.

C3.2.2.7 Pool Tail-out Grid Toss %<6mm

The median percent of fine sediment in pool tail-outs as measured with the grid toss was highest in SCUD 11-01, with FARL 28-01 only slightly lower. (**Figure C-20**).

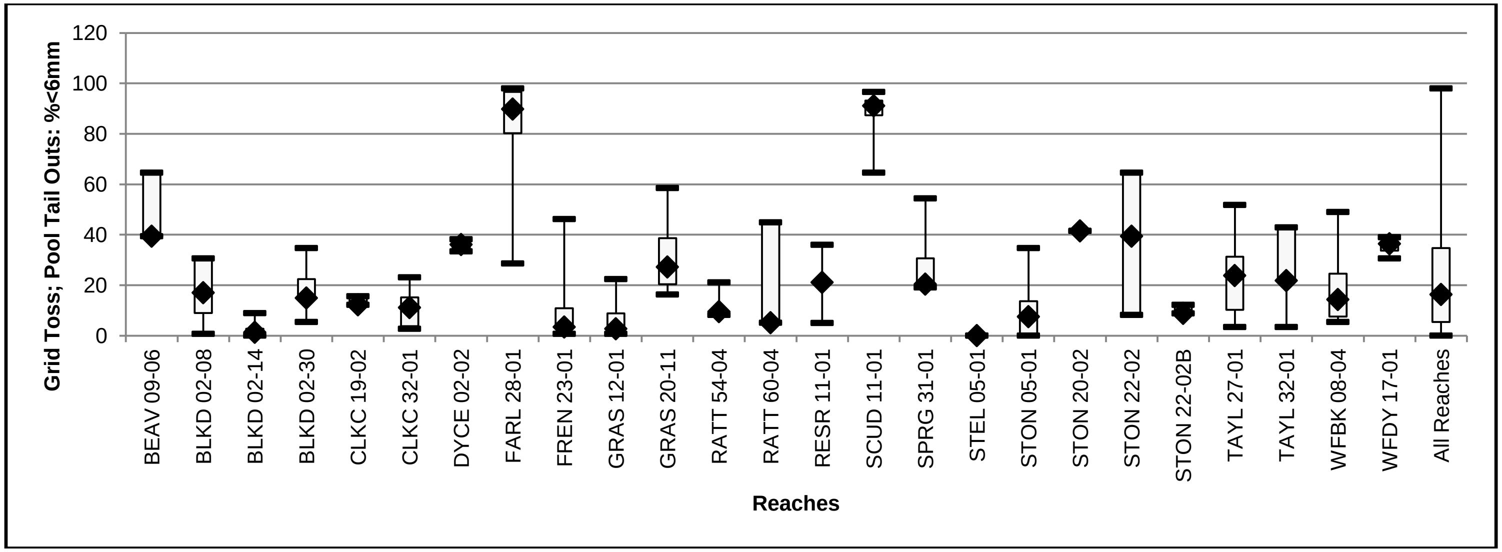

Figure C-20. Pool Tail-out Grid Toss %<6mm.

C3.2.2.8 Residual Pool Depth

The greatest median residual pool depth was measured in BLKD 02-08 (**Figure C-21**). The lowest residual pool depth was found in SCUD 11-01. Residual pool depths do not reliably increase in the downstream direction within the assessed streams, as they do for greater stream orders among reach types, indicating possible degradation of pools in some stream reaches.

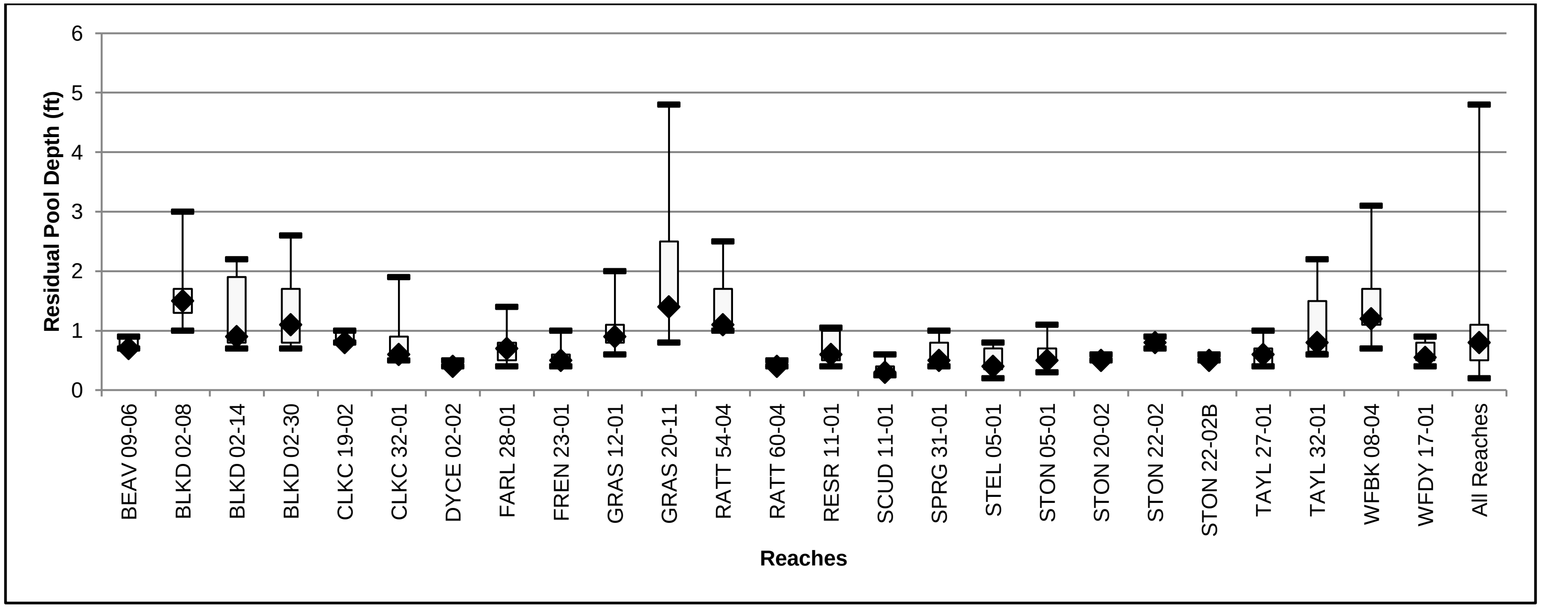

Figure C-21. Residual Pool Depth.

C3.2.2.9 Pool Frequency

The greatest number of pools per 1000 feet was found in FARL 28-01 and TAYL 27-01 (**Figure C-22**). However, FARL 28-01 displayed obvious signs of impairment, such as significant bank erosion and reduced riparian community structure; therefore pool frequency needs to be examined with other parameters in order to assess habitat condition. Pool frequency was not assessed in several reaches, specifically the non-wadeable reaches of the Beaverhead River.

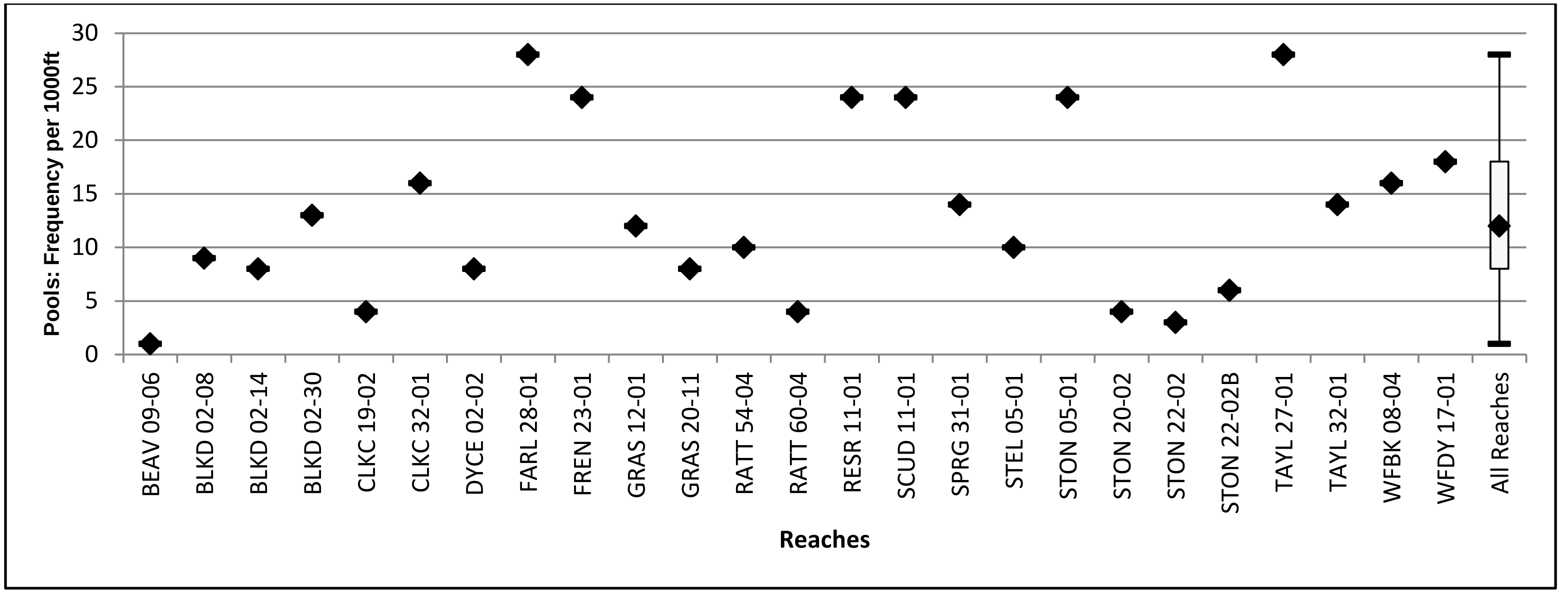

Figure C-22. Pool Frequency.

C3.2.2.10 Large Woody Debris Frequency

The greatest concentration of large woody debris was found in STON 05-01. Large woody debris was not sampled for most of the reaches on the Beaverhead River. (**Figure C-23**).

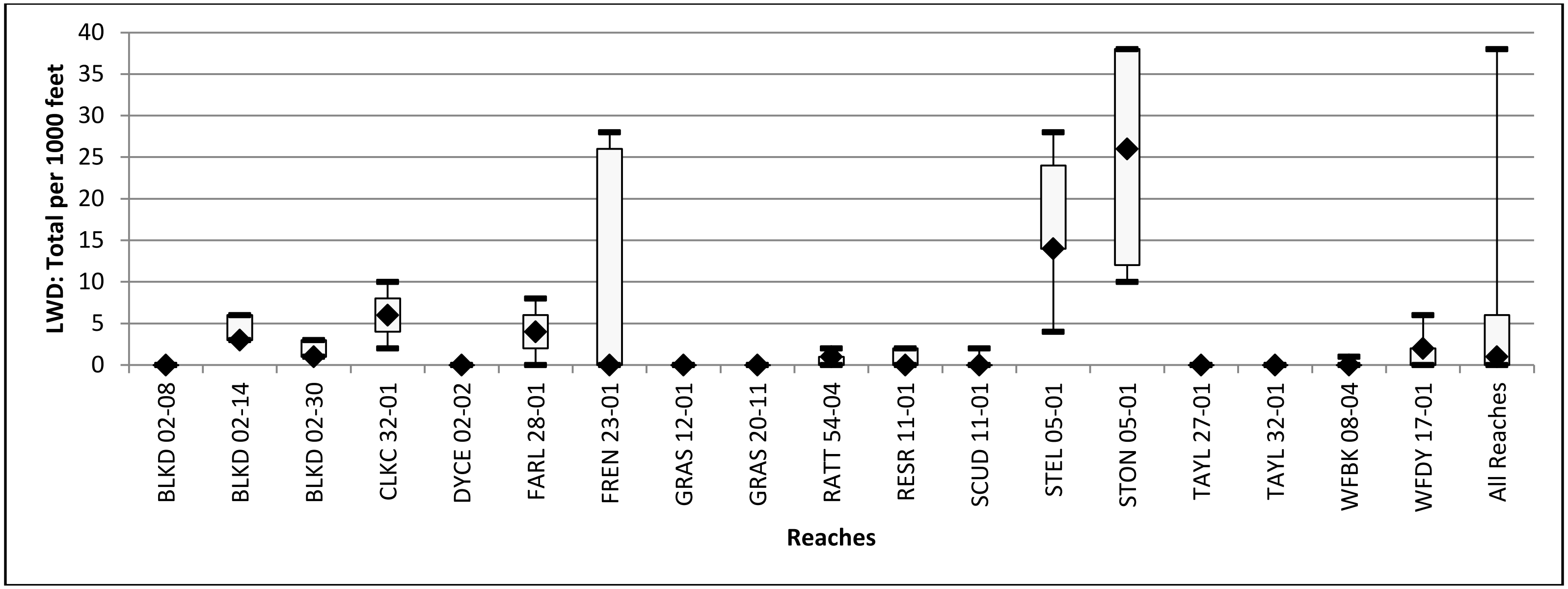

Figure C-23. Large Woody Debris Frequency.

C3.2.2.11 Greenline Understory Shrub Cover

RATT 54_04 had the highest percentage of understory shrub cover at 85.5%. Nineteen of the 33 reaches sampled (58%) had less than 50% shrub cover. Five of the 33 reaches sampled (15%) had less than 20% shrub cover. **(Figure C-24)**

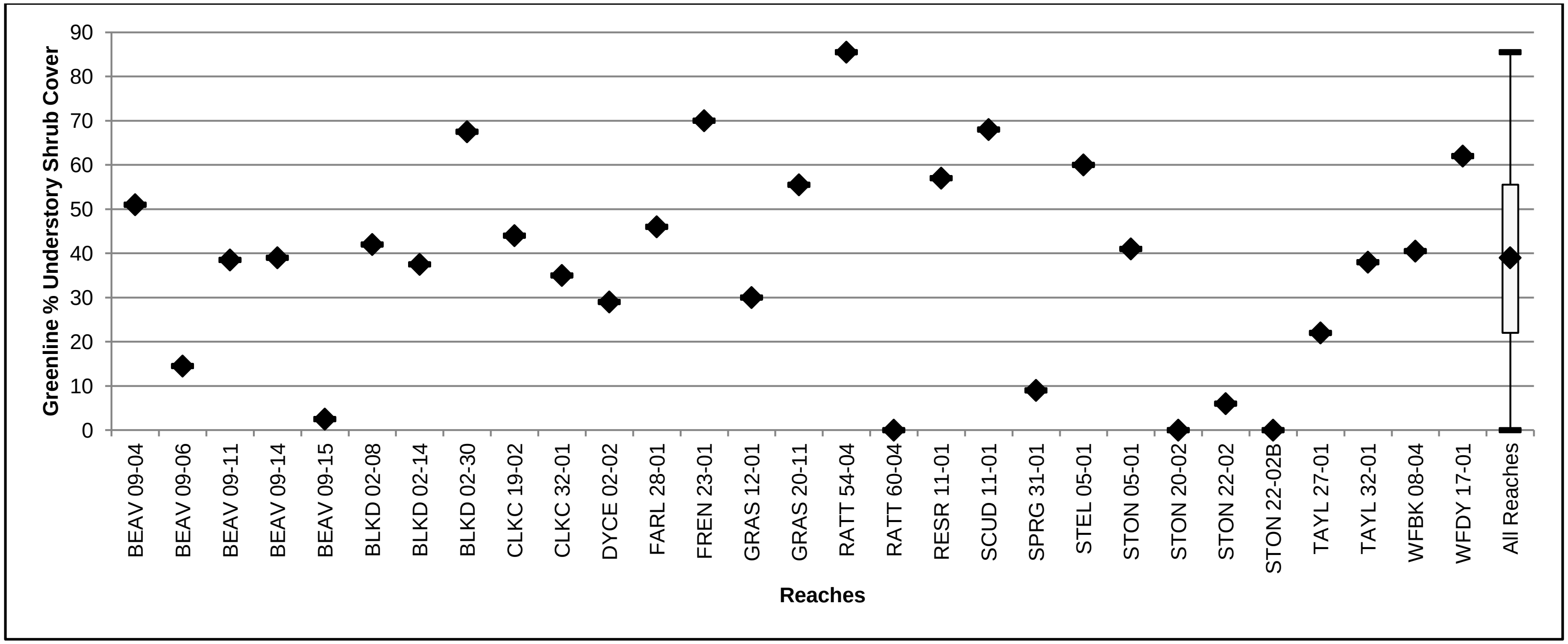

Figure C-24. Greenline Understory Shrub Cover

C3.2.2.12 Greenline Bare Ground

The highest percentage of bare ground was found at CLCK19_02. Six of the 29 sites surveyed (21%) had 20% or more bare ground, while approximately one-third of the reaches had lower than 10% bare ground **(Figure C-25)**.

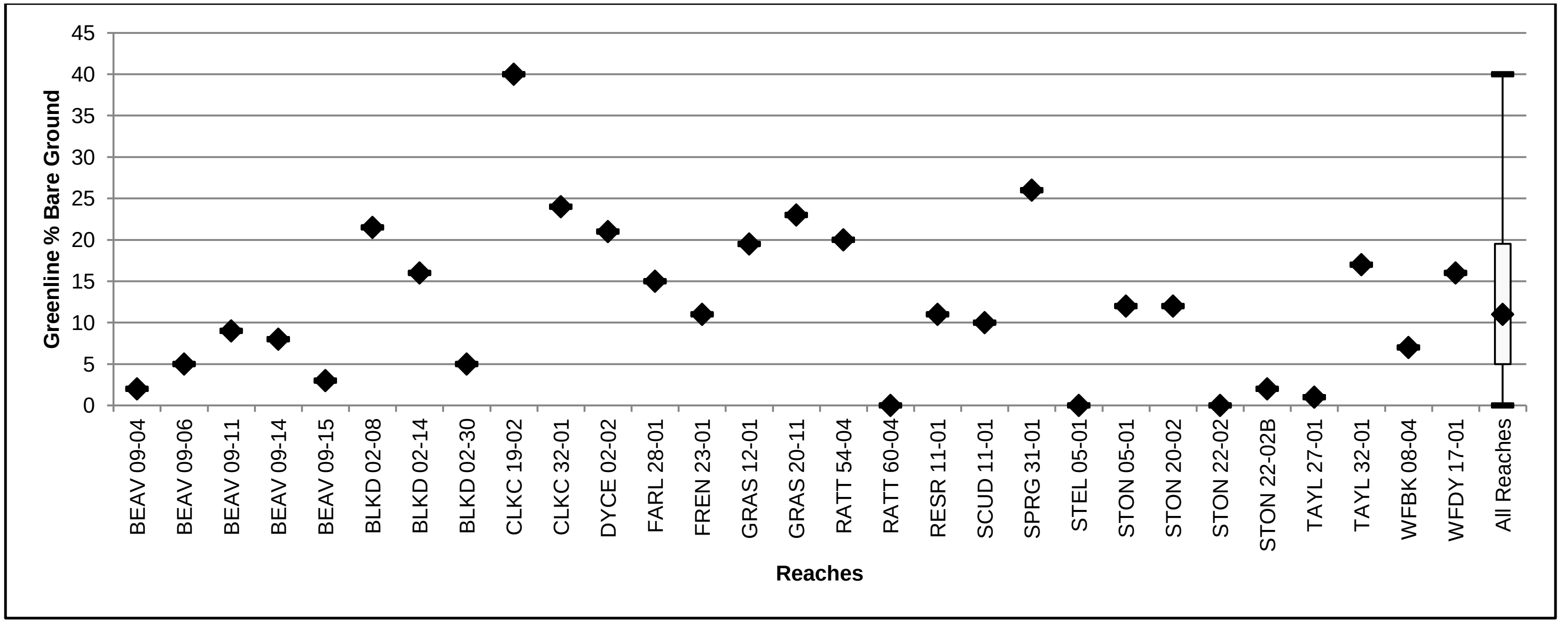

Figure C-25. Greenline Bare Ground

C3.2.2.13 Other Data from Non-Wadeable Reaches

Assessment methods were revised for some measurement variables to allow sampling in non-wadeable reaches. Categorical data for channel substrate collected on non-wadeable reaches of the Beaverhead River are summarized in **Table C-18**. These data provide a general picture of the size class of substrate in assessed non-wadeable reaches, but are not directly comparable to percent fine sediment data collected by Wolman pebble count.

Table C-18. Percent of Substrate by Reach for each Cross-section per Substrate Type

Reach Id	Substrate	% of Substrate			Reach Average
		XS1	XS2	XS3	
BEAV_09_04	Silt / Clay	5	23	1	10
	Sand	60	33	44	45
	Gravel	32	35	31	32
	Cobble	3	9	25	12
BEAV_09_11	Silt / Clay	12	-	-	12
	Sand	60	-	-	60
	Gravel	28	-	-	28
	Cobble	0	-	-	0
BEAV_09_14	Silt / Clay	9	1	20	10
	Sand	42	53	43	46
	Gravel	47	39	29	38
	Cobble	2	7	8	6
BEAV_09_15	Silt / Clay	26	19	15	20
	Sand	45	31	33	36
	Gravel	28	46	46	40
	Cobble	1	4	6	4

Additional data and data summaries for longitudinal profiles and channel cross-sections from non-wadeable reaches are included below (**Figures C26 – C41**). Few trends are evident from the data, but review of the cross-section plots reveals a high proportion of fine sediment in the downstream Beaverhead River reaches, and in some cross-sections of reaches further upstream.

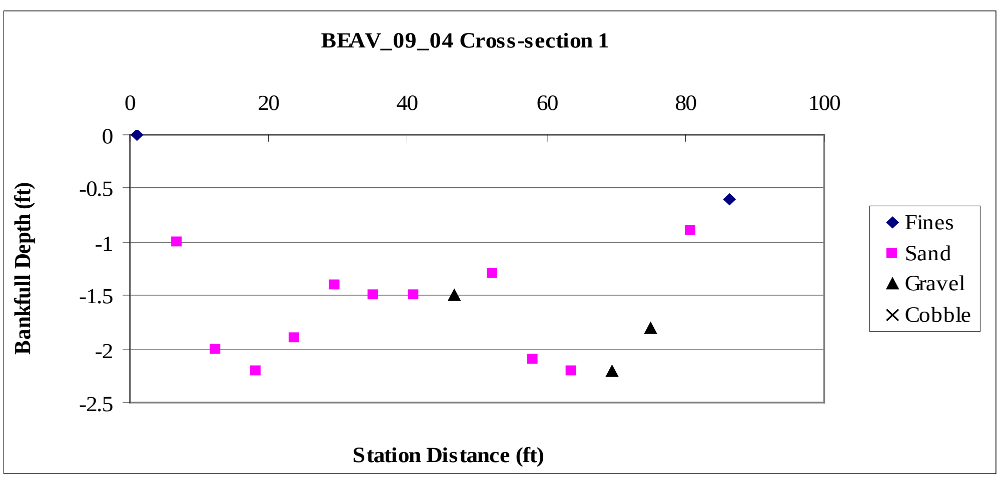

Figure C-26. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS1

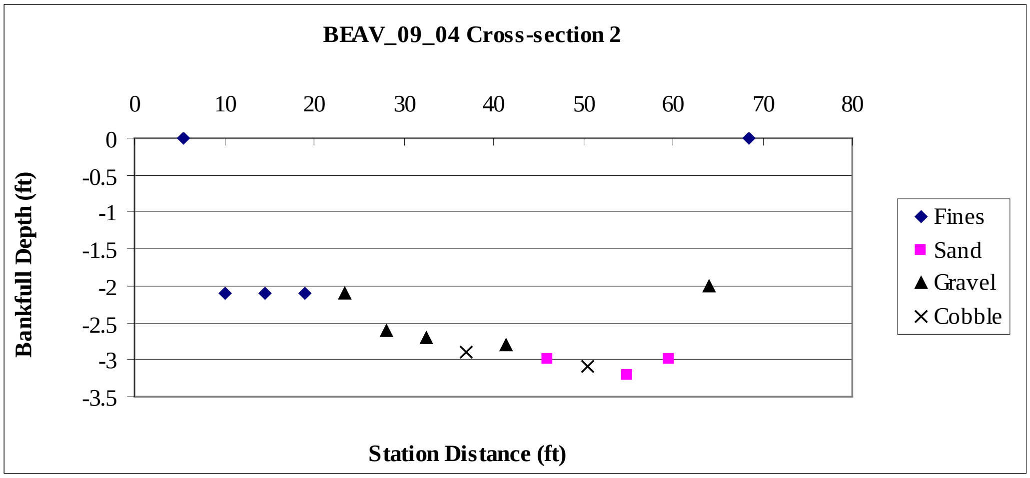

Figure C-27. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS2

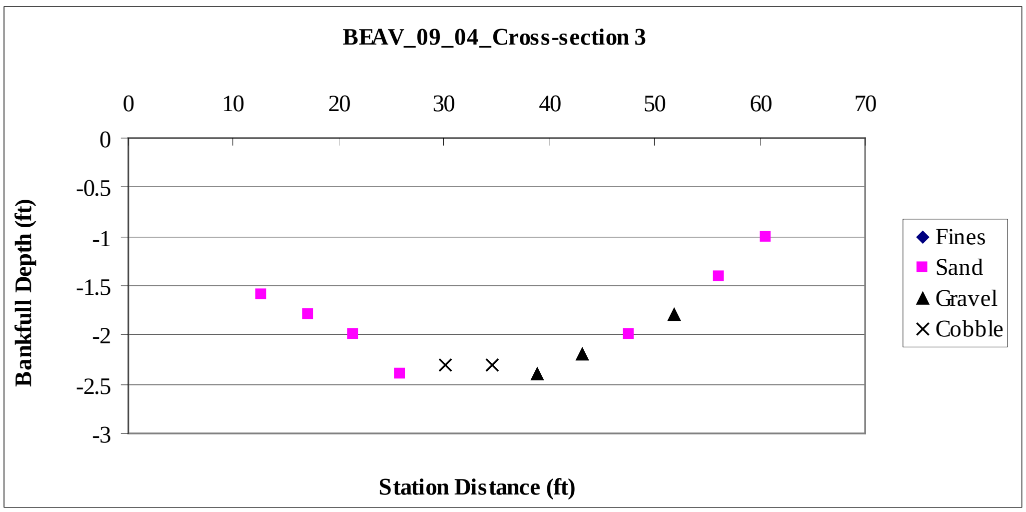

Figure C-28. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS3

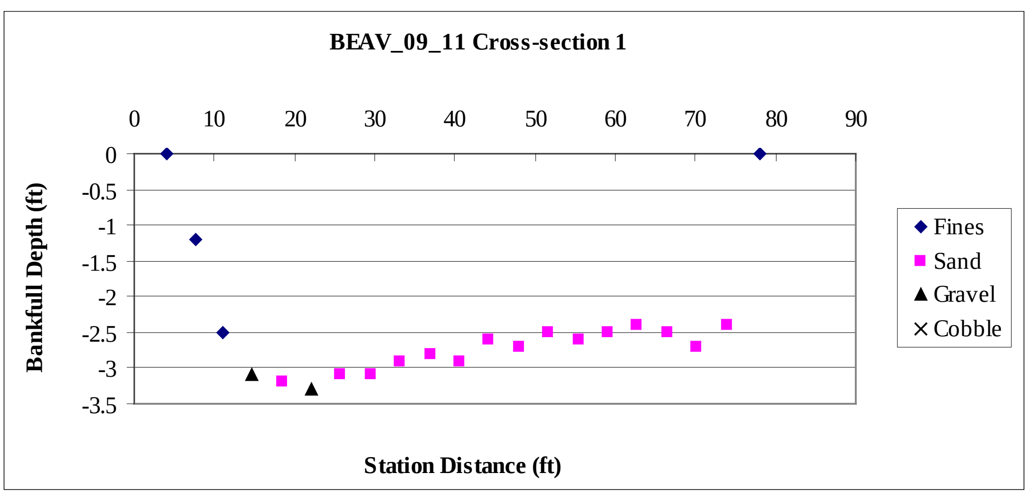

Figure C-29. Cross-Sections for Non-Wadeable Reach BEAV 09-11 XS1

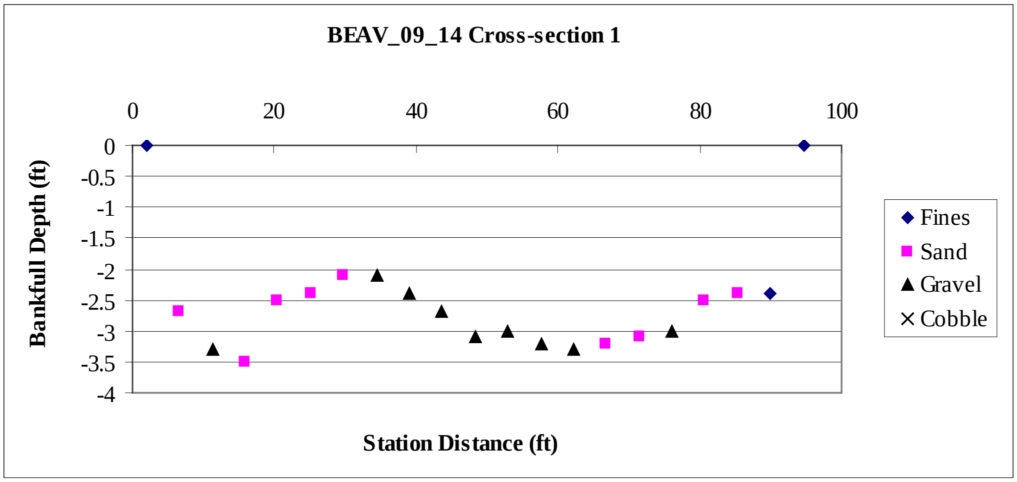

Figure C-30. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS1

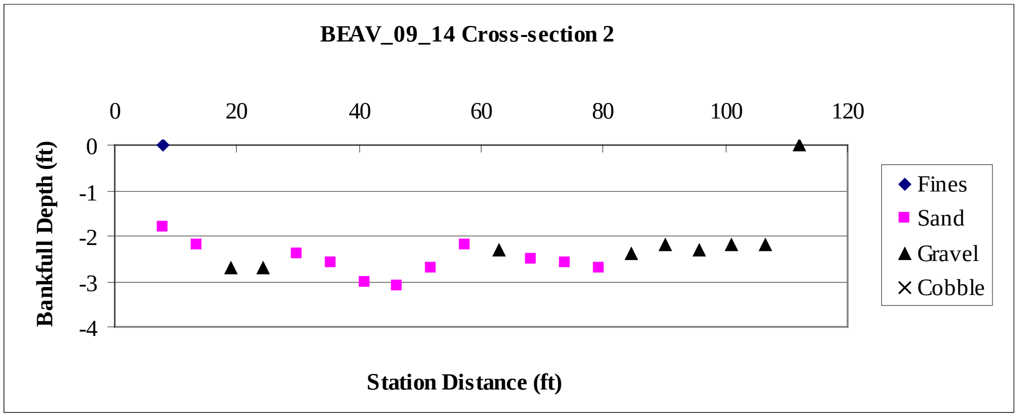

Figure C-31. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS2

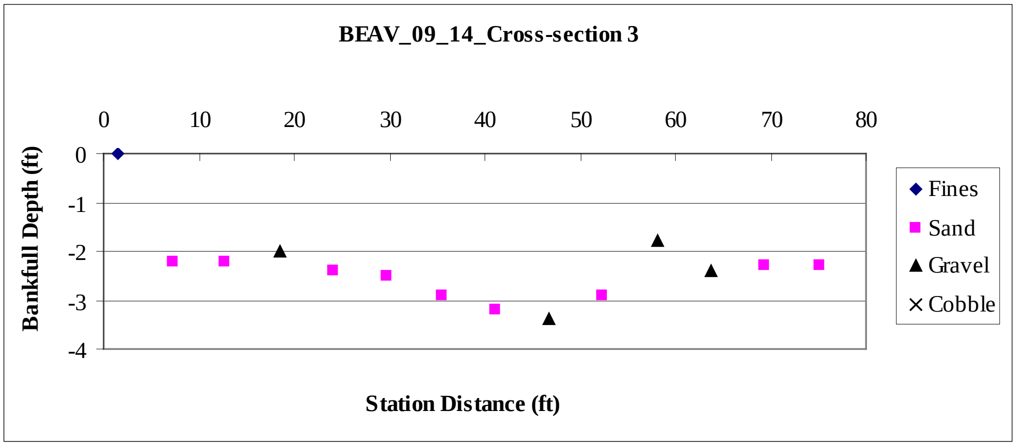

Figure C-32. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS3

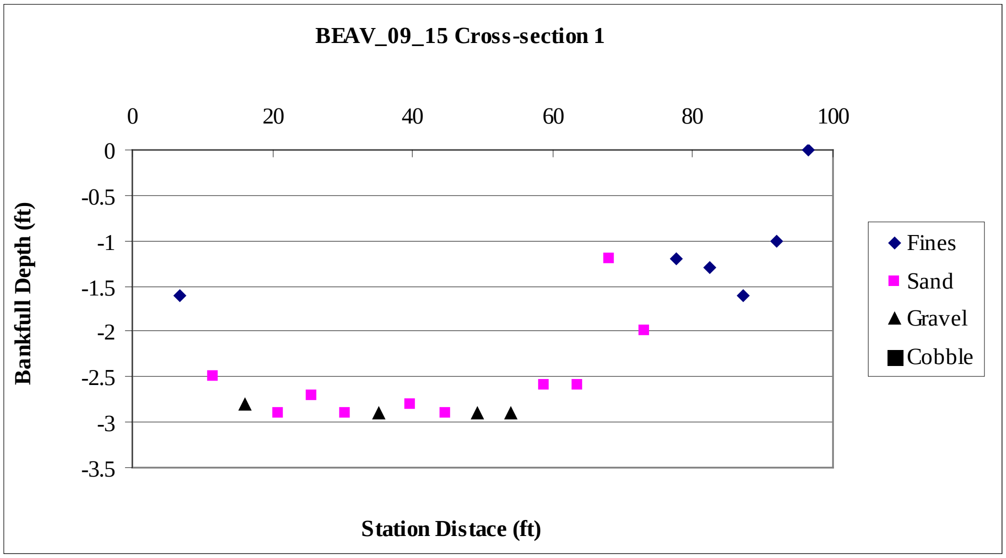

Figure C-33. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS1

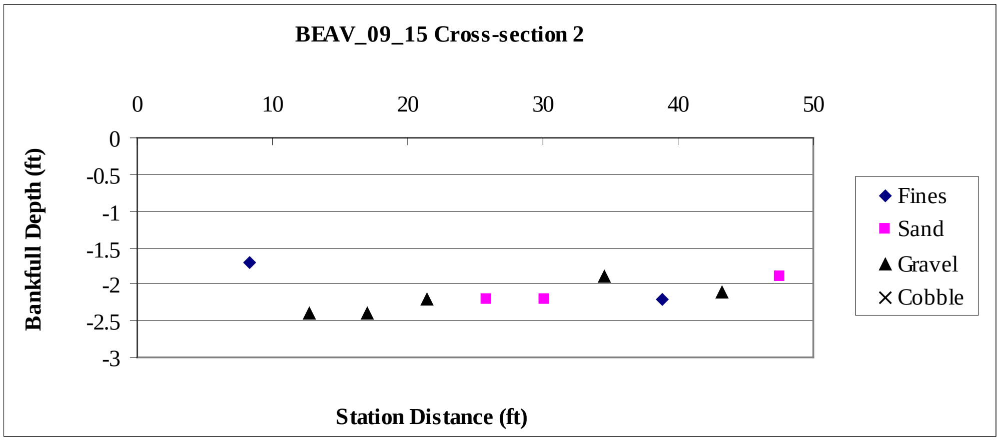

Figure C-34. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS2

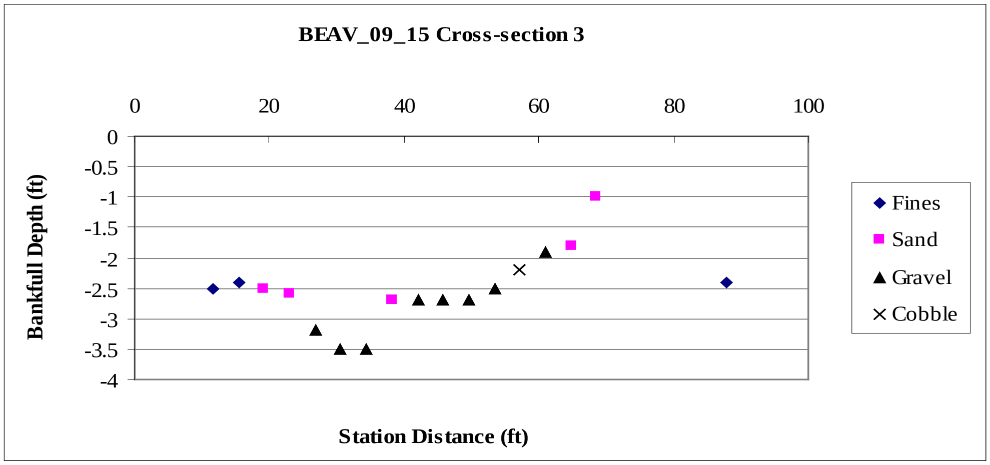

Figure C-35. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS3

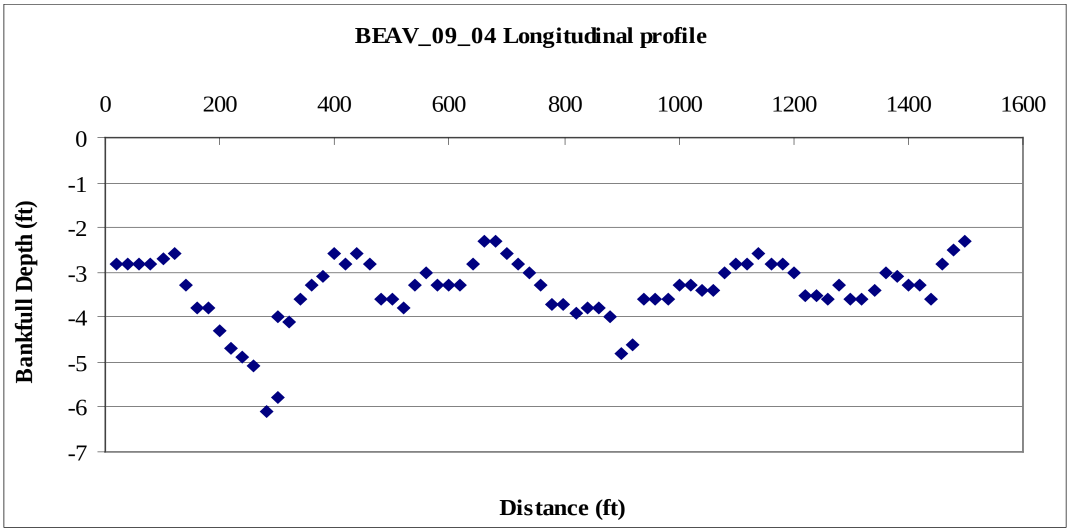

Figure C-36. Longitudinal Profile for Non-Wadeable Reach BEAV 09-04

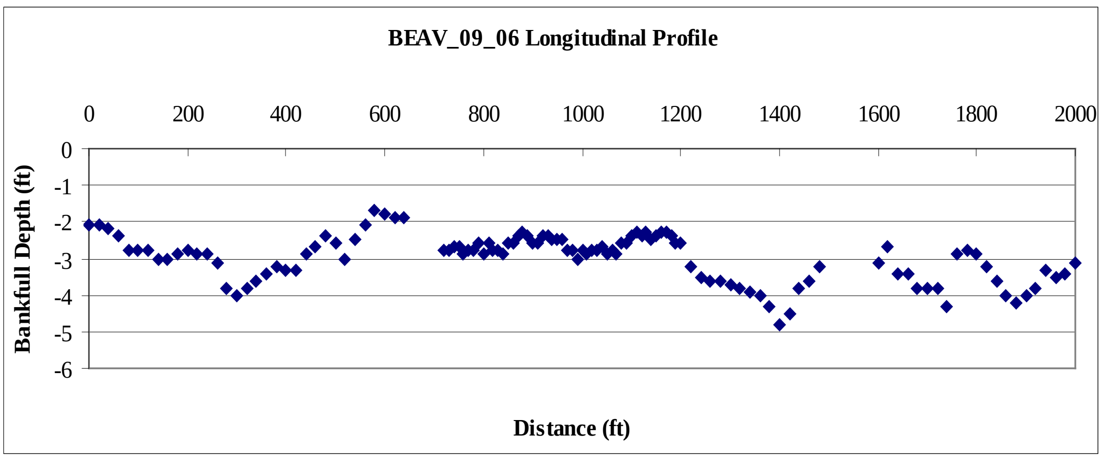

Figure C-37. Longitudinal Profile for Non-Wadeable Reach BEAV 09-06

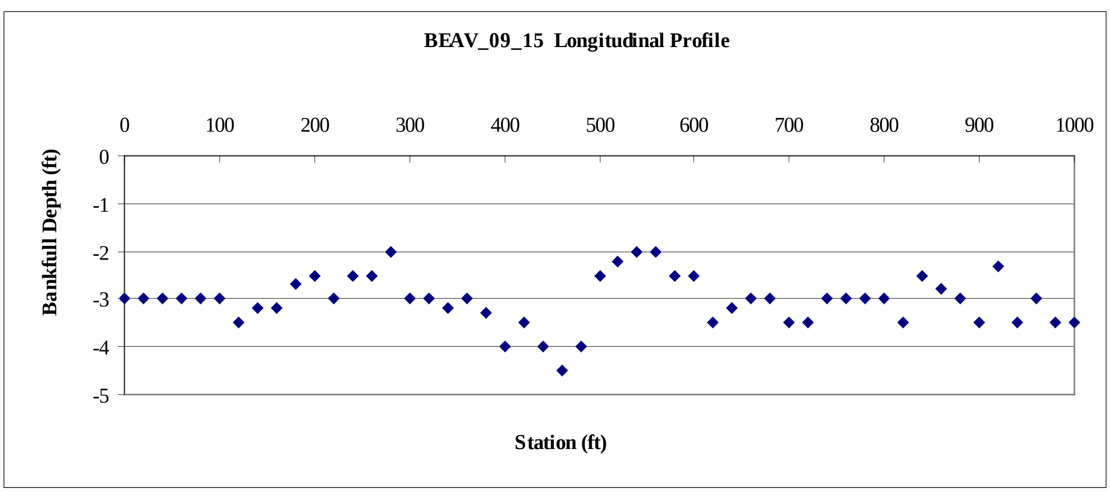

Figure C-38. Longitudinal Profile for Non-Wadeable Reach BEAV 09-15 Upstream of Bridge

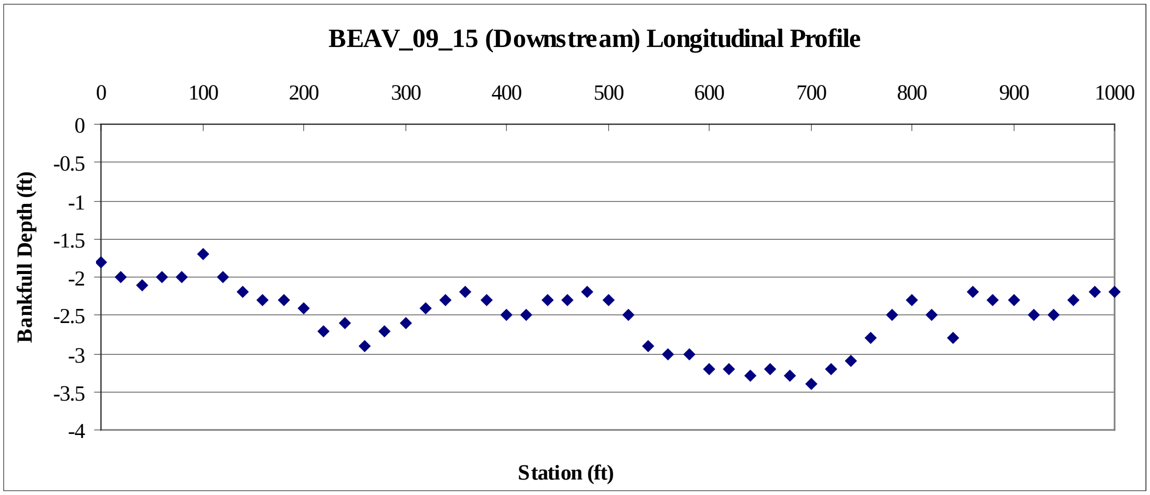

Figure C-39. Longitudinal Profile for Non-Wadeable Reach BEAV 09-15 Downstream of Bridge

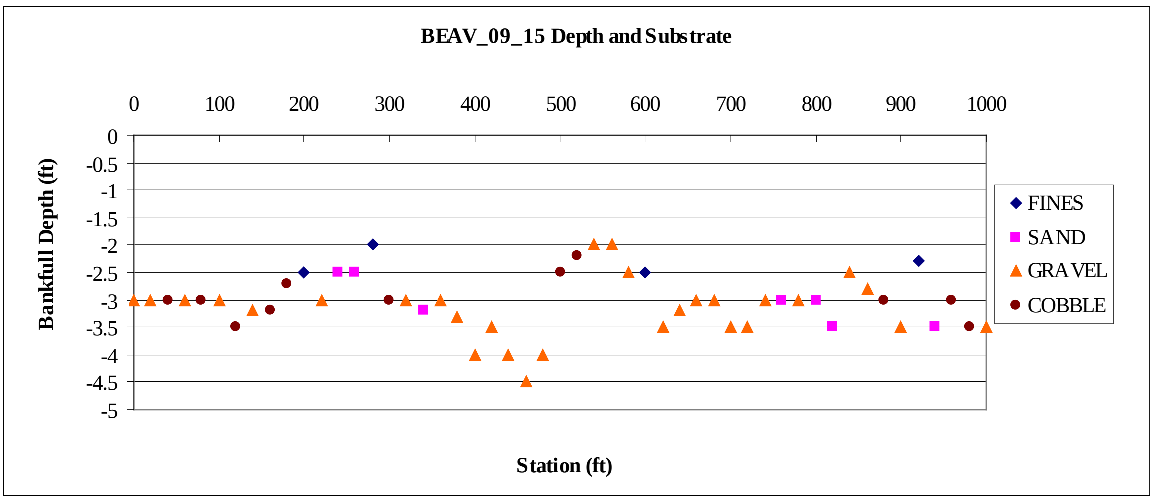

Figure C-40. Depth and Substrate for Non-Wadeable Reach BEAV 09-15 Upstream of Bridge

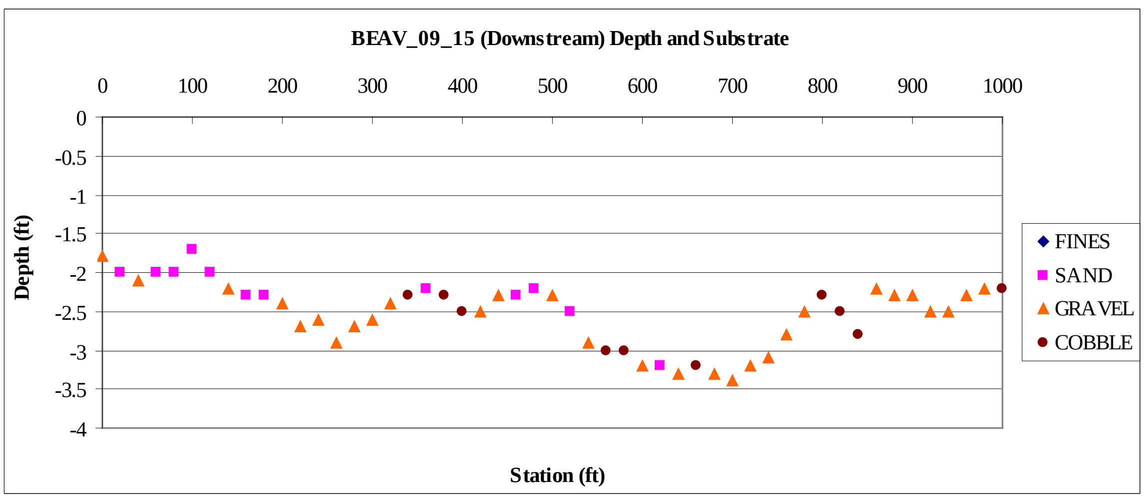

Figure C-41. Depth and Substrate for Non-Wadeable Reach BEAV 09-15 Downstream of Bridge

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APPENDIX D – ADDITIONAL SEDIMENT RELEVANT DATA COLLECTED IN THE BEAVERHEAD TPA

Table D-1 USGS SSC Data 2009-2010

Sample Date/time	Agency	Temp., water, deg C	Temp., air, deg C	Instantaneous discharge, ft3/s	Gage height, feet	Specific conductance, wat unf uS/cm@25 degC	Gage height, above datum, meters	Instantaneous discharge, m3/s	Suspended sediment, sieve diameter, percent smaller than 0.0625 millimeters	Suspended sediment concentration, milligrams per liter	Suspended sediment discharge, tons per day	Sampling method, code	Sampler type, code
4/30/2009 12:00	USGS-WRD	6.5	6	442	2.87	586	0.87	13					
6/2/2009 11:30	USGS-WRD	11	12.5	568	3.15	539	0.96	16					
7/15/2009 13:20	USGS-WRD	17	26	658	3.43	548	1.05	19					
8/24/2009 16:10	USGS-WRD	20	24.5	336	3.03	660	0.92	9.5					
10/7/2009 8:12	USGS-WRD	6.5			3.83	658	1.17						
3/16/2010 16:45	USGS-WRD	8			3.08	466	0.94						
5/26/2010 9:32	USGS-WRD	11			3.41	605	1.04						
6/8/2010 17:40	USGS-WRD	16.5			4.62	550	1.41						
6/8/2010 18:45	USGS-WRD	16.4	18	2030	4.61	550	1.41	57	52	133	729		
6/18/2010 9:12	USGS-WRD	10			5.45	540	1.66						
6/23/2010 12:25	USGS-WRD	14.4	20	2190	4.83	487	1.47	62	71	53	313	20	3001
7/8/2010 10:00	USGS-WRD	14.3	10.5	1980	4.58	468	1.4	56	75	57	305	10	3009
7/20/2010 14:32	USGS-WRD	20.5			3.35	520	1.02						
7/20/2010 15:05	USGS-WRD	20.5	37	674	3.35	520	1.02	19	76	39	71	10	3001
8/4/2010 14:10	USGS-WRD	19	30	376	2.98	588	0.91	11	61	31	31		
8/4/2010 14:27	USGS-WRD	19			2.98	588	0.91						
8/16/2010 11:00	USGS-WRD	16	25.7	653	3.56	635	1.09	18	69	74	130	10	3001
9/8/2010 10:02	USGS-WRD	12			3.82	607	1.16						
9/8/2010 10:35	USGS-WRD	12.2	15.2	830	3.82	607	1.16	24	63	53	119	10	3001
9/28/2010 9:20	USGS-WRD	12.5	12.8	648	3.55	625	1.08	18	57	39	68		
10/12/2010 15:25	USGS-WRD	10.5			3.63	625	1.11						
10/12/2010 16:00	USGS-WRD	10.4	16.8	690	3.63	625	1.11	20	82	48	89	10	3001
10/27/2010 13:35	USGS-WRD	5.4	8.4	896	3.89	625	1.19	25	40	70	169	10	3001
10/27/2010 14:10	USGS-WRD	5.5			3.89	625	1.19						
12/1/2010 9:30	USGS-WRD	0.2	3	833	3.6	650	1.1	24	67	47	106	10	3001

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
6/5/2010	[P]	[P]	[P]	4.78[A]	24[A 1]	358[A]

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
6/6/2010	[P]	[P]	[P]	4.81[A]	21[A 1]	364[A]
6/7/2010	[P]	[P]	[P]	4.83[A]	18[A 1]	366[A]
6/8/2010	[P]	[P]	[P]	4.58[A]	19[A 1]	294[A]
6/9/2010	[P]	[P]	[P]	4.49[A]	20[A 1]	267[A]
6/10/2010	[P]	[P]	[P]	4.23[A]	19[A 1]	204[A]
6/11/2010	[P]	[P]	[P]	4.30[A]	23[A 1]	220[A]
6/12/2010	[P]	[P]	[P]	4.45[A]	29[A 1]	253[A]
6/13/2010	[P]	[P]	[P]	4.42[A]	23[A 1]	247[A]
6/14/2010	[P]	[P]	[P]	4.25[A]	16[A 1]	209[A]
6/15/2010	[P]	[P]	[P]	4.04[A]	11[A 1]	165[A]
6/16/2010	[P]	[P]	[P]	4.44[A]	48[A 1]	257[A]
6/17/2010	[P]	[P]	[P]	5.37[A]	[P]	515[A]
6/18/2010	[P]	[P]	[P]	5.67[A]	[P]	616[A]
6/19/2010	[P]	[P]	[P]	5.79[A]	[P]	662[A]
6/20/2010	[P]	[P]	[P]	5.44[A]	57[A 1]	534[A]
6/21/2010	[P]	[P]	[P]	5.26[A]	42[A 1]	477[A]
6/22/2010	[P]	[P]	[P]	5.30[A]	35[A 1]	488[A]
6/23/2010	[P]	[P]	[P]	5.21[A]	30[A 1]	462[A]
6/24/2010	[P]	[P]	[P]	5.10[A]	35[A 1]	427[A]
6/25/2010	[P]	[P]	[P]	5.01[A]	28[A 1]	402[A]
6/26/2010	[P]	[P]	[P]	5.07[A]	31[A 1]	418[A]
6/27/2010	[P]	[P]	[P]	5.15[A]	30[A 1]	444[A]
6/28/2010	[P]	[P]	[P]	5.12[A]	27[A 1]	434[A]
6/29/2010	[P]	[P]	[P]	4.87[A]	25[A 1]	363[A]
6/30/2010	[P]	[P]	[P]	4.90[A]	25[A 1]	370[A]
7/1/2010	[P]	[P]	[P]	5.16[A]	22[A 1]	446[A]
7/2/2010	[P]	[P]	[P]	5.31[A]	20[A 1]	491[A]
7/3/2010	[P]	[P]	[P]	5.43[A]	22[A 1]	532[A]
7/4/2010	[P]	[P]	[P]	5.58[A]	21[A 1]	583[A]
7/5/2010	[P]	[P]	[P]	5.68[A]	21[A 1]	622[A]
7/6/2010	[P]	[P]	[P]	5.64[A]	20[A 1]	605[A]
7/7/2010	[P]	[P]	[P]	5.55[A]	18[A 1]	573[A]
7/8/2010	[P]	[P]	[P]	5.51[A]	19[A 1]	558[A]

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
7/9/2010	[P]	[P]	[P]	5.40[A]	15[A 1]	521[A]
7/10/2010	[P]	[P]	[P]	5.26[A]	13[A 1]	478[A]
7/11/2010	[P]	[P]	[P]	5.26[A]	15[A 1]	478[A]
7/12/2010	[P]	[P]	[P]	5.30[A]	15[A 1]	489[A]
7/13/2010	[P]	[P]	[P]	5.17[A]	13[A 1]	447[A]
7/14/2010	[P]	[P]	[P]	5.05[A]	12[A 1]	414[A]
7/15/2010	[P]	[P]	[P]	4.99[A]	7.0[A 1]	395[A]
7/16/2010	[P]	[P]	[P]	4.80[A]	3.5[A 1]	340[A]
7/17/2010	[P]	[P]	[P]	4.62[A]	3.0[A 1]	292[A]
7/18/2010	[P]	[P]	[P]	4.50[A]	2.0[A 1]	261[A]
7/19/2010	[P]	[P]	[P]	4.50[A]	2.0[A 1]	261[A]
7/20/2010	[P]	[P]	[P]	4.37[A]	2.0[A 1]	229[A]
7/21/2010	[P]	[P]	[P]	4.34[A]	2.5[A 1]	221[A]
7/22/2010	[P]	[P]	[P]	4.22[A]	1.5[A 1]	193[A]
7/23/2010	[P]	[P]	[P]	4.05[A]	1.5[A 1]	159[A]
7/24/2010	[P]	[P]	[P]	4.04[A]	2.5[A 1]	154[A]
7/25/2010	[P]	[P]	[P]	4.11[A]	2.0[A 1]	168[A]
7/26/2010	[P]	[P]	[P]	4.17[A]	[P]	180[A]
7/27/2010	[P]	[P]	[P]	4.09[A]	[P]	164[A]
7/28/2010	[P]	[P]	[P]	4.03[A]	[P]	152[A]
7/29/2010	[P]	[P]	[P]	4.13[A]	[P]	171[A]
7/30/2010	[P]	[P]	[P]	4.09[A]	[P]	162[A]
7/31/2010	[P]	[P]	[P]	4.12[A]	[P]	166[A]
8/1/2010	[P]	[P]	[P]	4.25[A]	[P]	193[A]
8/2/2010	[P]	[P]	[P]	4.33[A]	[P]	211[A]
8/3/2010	[P]	[P]	[P]	4.29[A]	[P]	202[A]
8/4/2010	[P]	[P]	[P]	4.24[A]	2.0[A 1]	190[A]
8/5/2010	[P]	[P]	[P]	4.20[A]	3.5[A 1]	181[A]
8/6/2010	[P]	[P]	[P]	4.21[A]	4.0[A 1]	183[A]
8/7/2010	[P]	[P]	[P]	4.33[A]	6.0[A 1]	212[A]
8/8/2010	[P]	[P]	[P]	4.37[A]	7.0[A 1]	221[A]
8/9/2010	[P]	[P]	[P]	4.42[A]	8.5[A 1]	234[A]
8/10/2010	[P]	[P]	[P]	4.52[A]	13[A 1]	260[A]

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
8/11/2010	[P]	[P]	[P]	4.64[A]	19[A 1]	291[A]
8/12/2010	[P]	[P]	[P]	4.75[A]	19[A 1]	321[A]
8/13/2010	[P]	[P]	[P]	4.75[A]	18[A 1]	319[A]
8/14/2010	[P]	[P]	[P]	4.89[A]	18[A 1]	361[A]
8/15/2010	[P]	[P]	[P]	4.90[A]	18[A 1]	362[A]
8/16/2010	[P]	[P]	[P]	4.99[A]	21[A 1]	390[A]
8/17/2010	[P]	[P]	[P]	4.91[A]	23[A 1]	367[A]
8/18/2010	[P]	[P]	[P]	4.70[A]	24[A 1]	308[A]
8/19/2010	[P]	[P]	[P]	4.54[A]	17[A 1]	269[A]
8/20/2010	[P]	[P]	[P]	4.51[A]	[P]	260[A]
8/21/2010	[P]	[P]	[P]	4.57[A]	[P]	276[A]
8/22/2010	[P]	[P]	[P]	4.55[A]	16[A 1]	271[A]
8/23/2010	[P]	[P]	[P]	4.71[A]	14[A 1]	312[A]
8/24/2010	[P]	[P]	[P]	4.72[A]	14[A 1]	315[A]
8/25/2010	[P]	[P]	[P]	4.66[A]	13[A 1]	299[A]
8/26/2010	[P]	[P]	[P]	4.63[A]	13[A 1]	293[A]
8/27/2010	[P]	[P]	[P]	4.64[A]	11[A 1]	295[A]
8/28/2010	[P]	[P]	[P]	4.66[A]	10[A 1]	301[A]
8/29/2010	[P]	[P]	[P]	4.80[A]	10[A 1]	336[A]
8/30/2010	[P]	[P]	[P]	4.99[A]	12[A 1]	391[A]
8/31/2010	[P]	[P]	[P]	5.08[A]	11[A 1]	418[A]
9/1/2010	[P]	[P]	[P]	5.18[A]	12[A 1]	450[A]
9/2/2010	[P]	[P]	[P]	5.22[A]	13[A 1]	463[A]
9/3/2010	[P]	[P]	[P]	5.13[A]	11[A 1]	432[A]
9/4/2010	[P]	[P]	[P]	5.00[A]	9.0[A 1]	395[A]
9/5/2010	[P]	[P]	[P]	4.93[A]	9.0[A 1]	372[A]
9/6/2010	[P]	[P]	[P]	4.96[A]	8.0[A 1]	382[A]
9/7/2010	[P]	[P]	[P]	4.97[A]	8.5[A 1]	384[A]
9/8/2010	[P]	[P]	[P]	4.91[A]	7.0[A 1]	368[A]
9/9/2010	[P]	[P]	[P]	5.01[A]	6.5[A 1]	395[A]
9/10/2010	[P]	[P]	[P]	5.23[A]	7.5[A 1]	467[A]
9/11/2010	[P]	[P]	[P]	5.30[A]	7.5[A 1]	489[A]
9/12/2010	[P]	[P]	[P]	5.31[A]	7.0[A 1]	494[A]

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
9/13/2010	[P]	[P]	[P]	5.25[A]	6.5[A 1]	474[A]
9/14/2010	[P]	[P]	[P]	5.18[A]	6.5[A 1]	451[A]
9/15/2010	[P]	[P]	[P]	5.30[A]	7.0[A 1]	491[A]
9/16/2010	[P]	[P]	[P]	5.29[A]	6.0[A 1]	488[A]
9/17/2010	[P]	[P]	[P]	5.26[A]	6.0[A 1]	476[A]
9/18/2010	[P]	[P]	[P]	5.37[A]	6.5[A 1]	514[A]
9/19/2010	[P]	[P]	[P]	5.51[A]	6.5[A 1]	562[A]
9/20/2010	[P]	[P]	[P]	5.43[A]	6.5[A 1]	536[A]
9/21/2010	[P]	[P]	[P]	5.36[A]	6.0[A 1]	511[A]
9/22/2010	[P]	[P]	[P]	5.28[A]	5.5[A 1]	487[A]
9/23/2010	[P]	[P]	[P]	5.25[A]	6.0[A 1]	477[A]
9/24/2010	[P]	[P]	[P]	5.17[A]	6.0[A 1]	449[A]
9/25/2010	[P]	[P]	[P]	5.05[A]	6.5[A 1]	414[A]
9/26/2010	[P]	[P]	[P]	5.02[A]	7.0[A 1]	403[A]
9/27/2010	[P]	[P]	[P]	4.96[A]	7.0[A 1]	388[A]
9/28/2010	[P]	[P]	[P]	4.73[A]	6.5[A 1]	326[A]
9/29/2010	[P]	[P]	[P]	4.64[A]	7.0[A 1]	303[A]
9/30/2010	[P]	[P]	[P]	4.62[A]	7.0[A 1]	297[A]
10/1/2010	[P]	[P]	[P]	4.65[A]	7.5[P 1]	306[A]
10/2/2010	[P]	[P]	[P]	4.61[A]	7.0[P 1]	295[A]
10/3/2010	[P]	[P]	[P]	4.61[A]	7.0[P 1]	295[A]
10/4/2010	[P]	[P]	[P]	4.59[A]	7.5[P 1]	290[A]
10/5/2010	[P]	[P]	[P]	4.60[A]	8.0[P 1]	291[A]
10/6/2010	[P]	[P]	[P]	4.63[A]	8.5[P 1]	300[A]
10/7/2010	[P]	[P]	[P]	4.66[A]	9.0[P 1]	308[A]
10/8/2010	[P]	[P]	[P]	4.59[A]	10[P 1]	292[A]
10/9/2010	[P]	[P]	[P]	4.56[A]	10[P 1]	284[A]
10/10/2010	[P]	[P]	[P]	4.60[A]	10[P 1]	294[A]
10/11/2010	[P]	[P]	[P]	4.61[A]	12[P 1]	298[A]
10/12/2010	[P]	[P]	[P]	4.69[A]	13[P 1]	319[A]
10/13/2010	[P]	[P]	[P]	4.88[A]	12[P 1]	369[A]
10/14/2010	[P]	[P]	[P]	4.83[A]	12[P 1]	354[A]
10/15/2010	[P]	[P]	[P]	4.79[A]	12[P 1]	346[A]

Table D-2 USGS SSC Data 2009-2010

Date	Temperature, water, deg C (Max.)	Temperature, water, deg C (Min.)	Temperature, water, deg C (Mean)	Gage height, feet (mean)	Turbidity, IR LED light, det ang 90deg, FNU (mean)	Discharge, ft3/s (mean)
10/16/2010	[P]	[P]	[P]	4.98[A]	14[P 1]	399[A]
10/17/2010	[P]	[P]	[P]	5.21[A]	14[P 1]	471[A]
10/18/2010	[P]	[P]	[P]	5.20[A]	12[P 1]	466[A]
10/19/2010	[P]	[P]	[P]	5.09[A]	11[P 1]	434[A]
10/20/2010	[P]	[P]	[P]	5.18[A]	12[P 1]	465[A]
10/21/2010	[P]	[P]	[P]	5.33[A]	13[P 1]	514[A]
10/22/2010	[P]	[P]	[P]	5.37[A]	13[P 1]	528[A]
10/23/2010	[P]	[P]	[P]	5.39[A]	12[P 1]	534[A]
10/24/2010	[P]	[P]	[P]	5.40[A]	12[P 1]	539[A]
10/25/2010	[P]	[P]	[P]	5.43[A]	13[P 1]	551[A]
10/26/2010	[P]	[P]	[P]	5.43[A]	12[P 1]	550[A]
10/27/2010	[P]	[P]	[P]	5.44[A]	12[P 1]	555[A]
10/28/2010	[P]	[P]	[P]	5.47[A]	13[P 1]	567[A]
10/29/2010	[P]	[P]	[P]	5.47[A]	13[P 1]	567[A]
10/30/2010	[P]	[P]	[P]	5.46[A]	14[P 1]	565[A]
10/31/2010	[P]	[P]	[P]	5.47[A]	14[P 1]	569[A]

Table D-3. HSI - Beaverhead TPA - Turbidity- 2008/2009

Activity ID	Characteristic ID	Result Value	Date	Time	Time Zone
BVD-BTDC-1_06022009_FM	RBP-TURB	Slight Turb.	6/2/2009	19:20:00	MDT
BVD-BTDC-1_09092008_FM	RBP-TURB	Clear	9/9/2008	14:10:00	MDT
BVD-BTDC-1_09152009_FM	RBP-TURB	Clear	9/15/2009	19:20:00	MDT
BVD-BTDC-2_09122008_FM	RBP-TURB	Slight Turb.	9/12/2008	11:00:00	MDT
BVD-BTDC-2_09152009_FM	RBP-TURB	Clear	9/15/2009	13:40:00	MDT
BVD-BTDC-3_06042009_FM	RBP-TURB	Slight Turb.	6/4/2009	14:45:00	MDT
BVD-BTDC-3_09152009_FM	RBP-TURB	Slight Turb.	9/15/2009	17:00:00	MDT
BVD-BTDC-3_09172008_FM	RBP-TURB	Clear	9/17/2008	08:30:00	MDT
BVD-BVHR-1_06032009_FM	RBP-TURB	Clear	6/3/2009	18:15:00	MDT
BVD-BVHR-1_09172008_FM	RBP-TURB	Clear	9/17/2008	11:30:00	MDT
BVD-BVHR-1_09242009_FM	RBP-TURB	Clear	9/24/2009	09:15:00	MDT
BVD-BVHR-2_06032009_FM	RBP-TURB	Clear	6/3/2009	19:30:00	MDT
BVD-BVHR-2_09172008_FM	RBP-TURB	Clear	9/17/2008	14:00:00	MDT
BVD-BVHR-2_09242009_FM	RBP-TURB	Clear	9/24/2009	10:30:00	MDT

Table D-3. HSI - Beaverhead TPA - Turbidity- 2008/2009

Activity ID	Characteristic ID	Result Value	Date	Time	Time Zone
BVD-BVHR-3_06032009_FM	RBP-TURB	Turbid	6/3/2009	20:45:00	MDT
BVD-BVHR-3_09162008_FM	RBP-TURB	Clear	9/16/2008	18:00:00	MDT
BVD-BVHR-3_09212009_FM	RBP-TURB	Clear	9/21/2009	13:45:00	MDT
BVD-BVHR-3A_09212009_FM	RBP-TURB	Clear	9/21/2009	15:30:00	MDT
BVD-BVHR-4_06042009_FM	RBP-TURB	Turbid	6/4/2009	13:50:00	MDT
BVD-BVHR-4_09122008_FM	RBP-TURB	Clear	9/12/2008	09:30:00	MDT
BVD-BVHR-4_09152009_FM	RBP-TURB	Clear	9/15/2009	14:30:00	MDT
BVD-BVHR-5_06042009_FM	RBP-TURB	Turbid	6/4/2009	16:00:00	MDT
BVD-BVHR-5_09122008_FM	RBP-TURB	Clear	9/12/2008	13:00:00	MDT
BVD-BVHR-5_09152009_FM	RBP-TURB	Clear	9/15/2009	15:45:00	MDT
BVD-BVHR-5A_09232009_FM	RBP-TURB	Clear	9/23/2009	14:40:00	MDT
BVD-BVHR-6_06042009_FM	RBP-TURB	Turbid	6/4/2009	13:00:00	MDT
BVD-BVHR-6_09172008_FM	RBP-TURB	Clear	9/17/2008	16:00:00	MDT
BVD-BVHR-6_09232009_FM	RBP-TURB	Clear	9/23/2009	16:00:00	MDT
BVD-BVHR-6A_09232009_FM	RBP-TURB	Clear	9/23/2009	08:20:00	MDT
BVD-BVHR-7_06042009_FM	RBP-TURB	Turbid	6/4/2009	16:55:00	MDT
BVD-BVHR-7_09182008_FM	RBP-TURB	Clear	9/18/2008	11:00:00	MDT
BVD-BVHR-7_09182009_FM	RBP-TURB	Slight Turb.	9/18/2009	08:40:00	MDT
BVD-BVHR-8_06042009_FM	RBP-TURB	Turbid	6/4/2009	17:45:00	MDT
BVD-BVHR-8_09182008_FM	RBP-TURB	Clear	9/18/2008	09:00:00	MDT
BVD-BVHR-8_09182009_FM	RBP-TURB	Slight Turb.	9/18/2009	10:45:00	MDT
BVD-CCC-1_06032009_FM	RBP-TURB	Slight Turb.	6/3/2009	18:45:00	MDT
BVD-CCC-1_09242009_FM	RBP-TURB	Clear	9/24/2009	10:00:00	MDT
BVD-DYC-1_06022009_FM	RBP-TURB	Clear	6/2/2009	17:40:00	MDT
BVD-DYC-1_09222009_FM	RBP-TURB	Slight Turb.	9/22/2009	12:45:00	MDT
BVD-DYC-1A_09222009_FM	RBP-TURB	Clear	9/22/2009	15:50:00	MDT
BVD-EFBTDC-1_06012009_FM	RBP-TURB	Slight Turb.	6/1/2009	18:45:00	MDT
BVD-EFBTDC-1_09092008_FM	RBP-TURB	Clear	9/9/2008	16:00:00	MDT
BVD-EFBTDC-1_09152009_FM	RBP-TURB	Clear	9/15/2009	10:15:00	MDT
BVD-EFDC-1_06022009_FM	RBP-TURB	Clear	6/2/2009	16:45:00	MDT
BVD-EFDC-1_09162008_FM	RBP-TURB	Clear	9/16/2008	09:00:00	MDT
BVD-EFDC-1_09222009_FM	RBP-TURB	Clear	9/22/2009	13:50:00	MDT
BVD-FRL-1_06032009_FM	RBP-TURB	Clear	6/3/2009	10:05:00	MDT
BVD-FRL-1_09112008_FM	RBP-TURB	Clear	9/11/2008	10:00:00	MDT

Table D-3. HSI - Beaverhead TPA - Turbidity- 2008/2009

Activity ID	Characteristic ID	Result Value	Date	Time	Time Zone
BVD-FRL-1_09162009_FM	RBP-TURB	Clear	9/16/2009	11:30:00	MDT
BVD-FRNC-1_09232009_FM	RBP-TURB	Clear	9/23/2009	11:30:00	MDT
BVD-FRNC-106032009_FM	RBP-TURB	Clear	6/3/2009	16:15:00	MDT
BVD-GHC-1_06032009_FM	RBP-TURB	Slight Turb.	6/3/2009	09:10:00	MDT
BVD-GHC-1_09112008_FM	RBP-TURB	Clear	9/11/2008	09:10:00	MDT
BVD-GHC-1_09162009_FM	RBP-TURB	Clear	9/16/2009	09:00:00	MDT
BVD-GHC-2_06032009_FM	RBP-TURB	Slight Turb.	6/3/2009	13:15:00	MDT
BVD-GHC-2_09112008_FM	RBP-TURB	Clear	9/11/2008	14:15:00	MDT
BVD-GHC-2_09162009_FM	RBP-TURB	Clear	9/16/2009	13:55:00	MDT
BVD-GHC-3_06022009_FM	RBP-TURB	Slight Turb.	6/2/2009	12:20:00	MDT
BVD-GHC-3_09102008_FM	RBP-TURB	Clear	9/10/2008	12:30:00	MDT
BVD-GHC-3_09162009_FM	RBP-TURB	Clear	9/16/2009	16:15:00	MDT
BVD-GHC-4_06022009_FM	RBP-TURB	Turbid	6/2/2009	13:40:00	MDT
BVD-GHC-4_09102008_FM	RBP-TURB	Clear	9/10/2008	15:00:00	MDT
BVD-GHC-5_06032009_FM	RBP-TURB	Turbid	6/3/2009	20:00:00	MDT
BVD-GHC-5_09162008_FM	RBP-TURB	Clear	9/16/2008	16:30:00	MDT
BVD-GHC-5_09212009_FM	RBP-TURB	Clear	9/21/2009	15:00:00	MDT
BVD-RSC-1_06032009_FM	RBP-TURB	Clear	6/3/2009	15:25:00	MDT
BVD-RSC-1_09232009_FM	RBP-TURB	Clear	9/23/2009	10:30:00	MDT
BVD-RSC-2_06032009_FM	RBP-TURB	Clear	6/3/2009	17:00:00	MDT
BVD-RSC-2_09162008_FM	RBP-TURB	Clear	9/16/2008	13:00:00	MDT
BVD-RSC-2A_09232009_FM	RBP-TURB	Clear	9/23/2009	13:10:00	MDT
BVD-RSC-2B_09232009_FM	RBP-TURB	Clear	9/23/2009	12:30:00	MDT
BVD-RSC-3_06022009_FM	RBP-TURB	Slight Turb.	6/2/2009	18:30:00	MDT
BVD-RSC-3_09162008_FM	RBP-TURB	Clear	9/16/2008	14:30:00	MDT
BVD-RSC-3_09232009_FM	RBP-TURB	Clear	9/23/2009	13:50:00	MDT
BVD-RSVRC-1_09102008_FM	RBP-TURB	Clear	9/10/2008	11:00:00	MDT
BVD-RSVRC1_09162009_FM	RBP-TURB	Clear	9/16/2009	15:00:00	MDT
BVD-RSVRC-2_06022009_FM	RBP-TURB	Clear	6/2/2009	11:20:00	MDT
BVD-SCDR-1_09112008_FM	RBP-TURB	Clear	9/11/2008	11:30:00	MDT
BVD-SCDR-1A_09162009_FM	RBP-TURB	Clear	9/16/2009	12:40:00	MDT
BVD-SCDR-2_06032009_FM	RBP-TURB	Slight Turb.	6/3/2009	12:45:00	MDT
BVD-SCDR-2_09162009_FM	RBP-TURB	Clear	9/16/2009	13:25:00	MDT
BVD-SPRGC-1_09172009_FM	RBP-TURB	Clear	9/17/2009	16:15:00	MDT

Table D-3. HSI - Beaverhead TPA - Turbidity- 2008/2009

Activity ID	Characteristic ID	Result Value	Date	Time	Time Zone
BVD-SPRGC-2_06042009_FM	RBP-TURB	Slight Turb.	6/4/2009	09:30:00	MDT
BVD-SPRGC-2_09172009_FM	RBP-TURB	Clear	9/17/2009	15:30:00	MDT
BVD-SPRGC-2_09182008_FM	RBP-TURB	Clear	9/18/2008	18:15:00	MDT
BVD-SPRGC-3_09172009_FM	RBP-TURB	Slight Turb.	9/17/2009	14:20:00	MDT
BVD-SPRGC-3_09182008_FM	RBP-TURB	Slight Turb.	9/18/2008	17:15:00	MDT
BVD-SPRGC-4_06042009_FM	RBP-TURB	Slight Turb.	6/4/2009	07:30:00	MDT
BVD-SPRGC-4_09172009_FM	RBP-TURB	Clear	9/17/2009	08:30:00	MDT
BVD-SPRGC-4_09182008_FM	RBP-TURB	Clear	9/18/2008	13:00:00	MDT
BVD-STNC-1_06042009_FM	RBP-TURB	Clear	6/4/2009	12:15:00	MDT
BVD-STNC-1_09172009_FM	RBP-TURB	Slight Turb.	9/17/2009	13:20:00	MDT
BVD-STNC-1_09182008_FM	RBP-TURB	Turbid	9/18/2008	16:15:00	MDT
BVD-STNC-1A_09172009_FM	RBP-TURB	Turbid	9/17/2009	13:20:00	MDT
BVD-STNC-2_06042009_FM	RBP-TURB	Slight Turb.	6/4/2009	11:15:00	MDT
BVD-STNC-2_09182008_FM	RBP-TURB	Clear	9/18/2008	15:15:00	MDT
BVD-STNC-4_06042009_FM	RBP-TURB	Clear	6/4/2009	08:20:00	MDT
BVD-STNC-4_09172008_FM	RBP-TURB	Clear	9/17/2008	17:45:00	MDT
BVD-STNC-4_09172009_FM	RBP-TURB	Clear	9/17/2009	10:30:00	MDT
BVD-TYLC-1_09102008_FM	RBP-TURB	Clear	9/10/2008	16:00:00	MDT
BVD-TYLC-1_09222009_FM	RBP-TURB	Clear	9/22/2009	10:15:00	MDT
BVD-TYLC-1A_09222009_FM	RBP-TURB	Clear	9/22/2009	11:45:00	MDT
BVD-TYLC-2_06022009_FM	RBP-TURB	Clear	6/2/2009	09:55:00	MDT
BVD-TYLC-2_09102008_FM	RBP-TURB	Clear	9/10/2008	08:45:00	MDT
BVD-TYLC-2_09222009_FM	RBP-TURB	Clear	9/22/2009	08:45:00	MDT
BVD-WFBTDC-1_06012009_FM	RBP-TURB	Turbid	6/1/2009	16:45:00	MDT
BVD-WFBTDC-1_09152008_FM	RBP-TURB	Clear	9/15/2008	14:20:00	MDT
BVD-WFBTDC-1_09152009_FM	RBP-TURB	Clear	9/15/2009	08:50:00	MDT
BVD-WFBTDC-2_06012009_FM	RBP-TURB	Turbid	6/1/2009	17:45:00	MDT
BVD-WFBTDC-2_09152008_FM	RBP-TURB	Clear	9/15/2008	16:00:00	MDT
BVD-WFBTDC-2_09152009_FM	RBP-TURB	Clear	9/15/2009	09:30:00	MDT
BVD-WFDC-1_06022009_FM	RBP-TURB	Clear	6/2/2009	15:15:00	MDT
BVD-WFDC-1_09222009_FM	RBP-TURB	Clear	9/22/2009	14:35:00	MDT
BVD-WFDC-2_06022009_FM	RBP-TURB	Clear	6/2/2009	16:00:00	MDT
BVD-WFDC-2_09112008_FM	RBP-TURB	Slight Turb.	9/11/2008	16:30:00	MDT
BVD-WFDC-2_09222009_FM	RBP-TURB	Clear	9/22/2009	15:20:00	MDT

Table D-4. HSI - Beaverhead TPA - TSS - 2008/2009

Activity ID	Characteristic ID	Result Detection Condition	Result Value	Result Value Unit	Result Qualifier	Date	Time	Time Zone
BVD-BTDC-1_09092008_WS	TSS		6	mg/l		9/16/2008		
BVD-BTDC-1_09152009_WS	TSS		5	mg/l		9/21/2009	11:30:00	MDT
BVD-BTDC-2_06022009_WS	TSS		12.7	mg/l		6/9/2009	10:18:00	MST
BVD-BTDC-2_09122008_WS	TSS		17	mg/l		9/16/2008		
BVD-BTDC-2_09152009_WS	TSS		7	mg/l		9/21/2009	13:40:00	MDT
BVD-BTDC-3_06042009_WS	TSS		19.8	mg/l		6/11/2009	17:50:00	MST
BVD-BTDC-3_ 09122008_QCFB	TSS	ND				9/22/2008		
BVD-BTDC-3_ 09122008_QCFR	TSS		5	mg/l		9/23/2008		
BVD-BTDC-3_ 09152009_WS	TSS		7	mg/l		9/21/2009	17:00:00	MDT
BVD-BTDC-3_ 09172008_WS	TSS	ND				9/23/2008		
BVD-BVHR-1_06032009_WS	TSS		1.6	mg/l		6/9/2009	10:18:00	MST
BVD-BVHR-1_09172008_WS	TSS	ND				9/22/2008		
BVD-BVHR-1_ 09242009_QCFB	TSS	ND				9/25/2009	09:15:00	MDT
BVD-BVHR-1_ 09242009_QCFR	TSS		3	mg/l		9/25/2009	09:15:00	MDT
BVD-BVHR-1_09242009_WS	TSS		1	mg/l		9/25/2009	09:15:00	MDT
BVD-BVHR-2_06032009_WS	TSS		3	mg/l		6/10/2009	12:26:00	MST
BVD-BVHR-2_09172008_WS	TSS	ND				9/23/2008		
BVD-BVHR-2_ 09242009_QCFB	TSS		1	mg/l	B	9/25/2009	10:30:00	MDT
BVD-BVHR-2_ 09242009_QCFR	TSS		4	mg/l		9/25/2009	10:30:00	MDT
BVD-BVHR-2_09242009_WS	TSS		3	mg/l		9/25/2009	10:30:00	MDT
BVD-BVHR-3_06032009_WS	TSS		26	mg/l		6/10/2009	12:26:00	MST
BVD-BVHR-3_09162008_WS	TSS		4	mg/l		9/22/2008		
BVD-BVHR-3_09212009_WS	TSS		3	mg/l		9/25/2009	13:45:00	MDT
BVD-BVHR-3A_09212009_WS	TSS		5	mg/l		9/25/2009	15:30:00	MDT
BVD-BVHR-4_06042009_WS	TSS		39	mg/l		6/11/2009	17:50:00	MST
BVD-BVHR-4_09122008_WS	TSS	ND				9/16/2008		
BVD-BVHR-4_09152009_WS	TSS		3	mg/l		9/21/2009	14:30:00	MDT
BVD-BVHR-5_06042009_WS	TSS		31	mg/l		6/11/2009	17:50:00	MST
BVD-BVHR-5_09122008_WS	TSS	ND				9/16/2008		

Table D-4. HSI - Beaverhead TPA - TSS - 2008/2009

Activity ID	Characteristic ID	Result Detection Condition	Result Value	Result Value Unit	Result Qualifier	Date	Time	Time Zone
BVD-BVHR-5_09152009_WS	TSS		3	mg/l		9/21/2009	15:45:00	MDT
BVD-BVHR-5A_09232009_WS	TSS		2	mg/l		9/25/2009	14:40:00	MDT
BVD-BVHR-6_ 06042009_QCFB	TSS		1	mg/l	B	6/11/2009	10:43:00	MST
BVD-BVHR-6_ 06042009_QCFR	TSS		38	mg/l		6/11/2009	10:43:00	MST
BVD-BVHR-6_ 06042009_WS	TSS		35	mg/l		6/11/2009	10:43:00	MST
BVD-BVHR-6_ 09172008_WS	TSS	ND				9/23/2008		
BVD-BVHR-6_ 09232009_QCFB	TSS	ND				9/25/2009	16:00:00	MDT
BVD-BVHR-6_ 09232009_QCFR	TSS	ND				9/25/2009	16:00:00	MDT
BVD-BVHR-6_09232009_WS	TSS		2	mg/l		9/25/2009	16:00:00	MDT
BVD-BVHR-6A_09232009_WS	TSS	ND				9/25/2009	08:20:00	MDT
BVD-BVHR-7_06042009_WS	TSS		9	mg/l	B	6/11/2009	17:50:00	MST
BVD-BVHR-7_09182008_WS	TSS	ND				9/23/2008		
BVD-BVHR-7_09182009_WS	TSS		7	mg/l		9/21/2009	08:40:00	MDT
BVD-BVHR-8_06112009_WS	TSS		12.1	mg/l		6/17/2009	16:22:00	MST
BVD-BVHR-8_ 09182008_QCFB	TSS	ND				9/23/2008		
BVD-BVHR-8_ 09182008_QCFR	TSS	ND				9/23/2008		
BVD-BVHR-8_09182008_WS	TSS	ND				9/22/2008		
BVD-BVHR-8_09182009_WS	TSS		9	mg/l		9/21/2009	10:45:00	MDT
BVD-CCC-1_06032009_WS	TSS		14	mg/l		6/10/2009	12:26:00	MST
BVD-CCC-1_09172008_WS	TSS	ND				9/23/2008		
BVD-CCC-1_09242009_WS	TSS		9	mg/l		9/25/2009	10:00:00	MDT
BVD-DYC-1_06022009_WS	TSS		12	mg/l		6/9/2009	10:18:00	MST
BVD-DYC-1_09112008_WS	TSS		13	mg/l		9/16/2008		
BVD-DYC-1_09222009_WS	TSS		46	mg/l		9/25/2009	12:45:00	MDT
BVD-DYC-1A_ 09222009_QCFB	TSS	ND				9/25/2009	15:50:00	MDT
BVD-DYC-1A_ 09222009_QCFR	TSS		4	mg/l		9/25/2009	15:50:00	MDT
BVD-DYC-1A_ 09222009_WS	TSS		6	mg/l		9/25/2009	15:50:00	MDT
BVD-EFBTDC-1_ 06012009_WS	TSS		13	mg/l		6/8/2009	13:27:00	MST
BVD-EFBTDC-1_09092008_WS	TSS	ND				9/16/2008		
BVD-EFBTDC-1_09152009_WS	TSS		1	mg/l		9/21/2009	10:15:00	MDT

Table D-4. HSI - Beaverhead TPA - TSS - 2008/2009

Activity ID	Characteristic ID	Result Detection Condition	Result Value	Result Value Unit	Result Qualifier	Date	Time	Time Zone
BVD-EFDC-1_06022009_WS	TSS		23	mg/l		6/8/2009	18:29:00	MST
BVD-EFDC-1_ 09162008_QCFB	TSS	ND				9/22/2008		
BVD-EFDC-1_ 09162008_QCFR	TSS	ND				9/22/2008		
BVD-EFDC-1_ 09162008_WS	TSS	ND				9/22/2008		
BVD-EFDC-1_ 09222009_WS	TSS		4	mg/l		9/25/2009	13:50:00	MDT
BVD-FRL-1_ 06032009_WS	TSS		15	mg/l		6/9/2009	10:18:00	MST
BVD-FRL-1_09112008_WS	TSS		7	mg/l		9/16/2008		
BVD-FRL-1_09162009_WS	TSS		5	mg/l		9/21/2009	11:30:00	MDT
BVD-FRNC-1_06032009_WS	TSS		8	mg/l		6/9/2009	10:18:00	MST
BVD-FRNC-1_09232009_WS	TSS		1	mg/l		9/25/2009	11:30:00	MDT
BVD-GHC-1_06032009_WS	TSS		6	mg/l		6/9/2009	10:18:00	MST
BVD-GHC-1_09112008_WS	TSS	ND				9/16/2008		
BVD-GHC-1_09162009_WS	TSS	ND				9/21/2009	09:00:00	MDT
BVD-GHC-2_06032009_WS	TSS		6	mg/l		6/9/2009	10:18:00	MST
BVD-GHC-2_09112008_WS	TSS	ND				9/16/2008		
BVD-GHC-2_09162009_WS	TSS		1	mg/l		9/21/2009	13:55:00	MDT
BVD-GHC-3_ 06022009_QCFB	TSS	ND				6/8/2009	18:29:00	MST
BVD-GHC-3_ 06022009_QCFR	TSS		24	mg/l		6/8/2009	18:29:00	MST
BVD-GHC-3_06022009_WS	TSS		24	mg/l		6/8/2009	18:29:00	MST
BVD-GHC-3_09102008_WS	TSS	ND				9/16/2008		
BVD-GHC-3_09162009_WS	TSS		6	mg/l		9/21/2009	16:15:00	MDT
BVD-GHC-4_06022009_WS	TSS		35	mg/l		6/8/2009	18:29:00	MST
BVD-GHC-4_09102008_WS	TSS	ND				9/16/2008		
BVD-GHC-5_06032009_WS	TSS		87.9	mg/l		6/10/2009	12:26:00	MST
BVD-GHC-5_09162008_WS	TSS	ND				9/23/2008		
BVD-GHC-5_09212009_WS	TSS		4	mg/l		9/25/2009	15:00:00	MDT
BVD-RSC-1_ 06032009_QCFB	TSS	ND				6/9/2009	10:18:00	MST
BVD-RSC-1_ 06032009_QCFR	TSS		3	mg/l		6/9/2009	10:18:00	MST
BVD-RSC-1_06032009_WS	TSS		2.8	mg/l		6/9/2009	10:18:00	MST
BVD-RSC-1_09162008_WS	TSS	ND				9/23/2008		

Table D-4. HSI - Beaverhead TPA - TSS - 2008/2009

Activity ID	Characteristic ID	Result Detection Condition	Result Value	Result Value Unit	Result Qualifier	Date	Time	Time Zone
BVD-RSC-1_ 09232009_QCFB	TSS	ND				9/25/2009	10:30:00	MDT
BVD-RSC-1_ 09232009_QCFR	TSS	ND				9/25/2009	10:30:00	MDT
BVD-RSC-1_09232009_WS	TSS	ND				9/25/2009	10:30:00	MDT
BVD-RSC-2_06022009_WS	TSS		7	mg/l		6/9/2009	10:18:00	MST
BVD-RSC-2_09162008_WS	TSS	ND				9/22/2008		
BVD-RSC-2A_09232009_WS	TSS		3	mg/l		9/25/2009	13:10:00	MDT
BVD-RSC-2B_09232009_WS	TSS		2	mg/l		9/25/2009	12:30:00	MDT
BVD-RSC-3_06022009_WS	TSS		22	mg/l		6/9/2009	10:18:00	MST
BVD-RSC-3_09162008_WS	TSS		12	mg/l		9/22/2008		
BVD-RSC-3_09232009_WS	TSS		1	mg/l		9/25/2009	13:50:00	MDT
BVD-RSVRC-1_09102008_WS	TSS	ND				9/16/2008		
BVD-RSVRC1_ 09162009_WS	TSS		6	mg/l		9/21/2009	15:00:00	MDT
BVD-RSVRC-2_06022009_WS	TSS		2	mg/l		6/8/2009	18:29:00	MST
BVD-SCDR-1_09112008_WS	TSS		21	mg/l		9/16/2008		
BVD-SCDR-1A_09162009_WS	TSS		45	mg/l		9/21/2009	12:40:00	MDT
BVD-SCDR-2_06022009_WS	TSS		86.6	mg/l		6/9/2009	10:18:00	MST
BVD-SCDR-2_09162009_WS	TSS		51	mg/l		9/21/2009	13:25:00	MDT
BVD-SPRGC-1_09172009_WS	TSS		12	mg/l		9/21/2009	16:15:00	MDT
BVD-SPRGC-1_09182008_WS	TSS		9	mg/l		9/23/2008		
BVD-SPRGC-2_06042009_WS	TSS		109	mg/l		6/11/2009	10:43:00	MST
BVD-SPRGC-2_09172009_WS	TSS		20	mg/l		9/21/2009	15:30:00	MDT
BVD-SPRGC-2_ 09182008_QCFB	TSS	ND				9/23/2008		
BVD-SPRGC-2_ 09182008_QCFR	TSS		7	mg/l		9/23/2008		
BVD-SPRGC-2_09182008_WS	TSS		6	mg/l		9/23/2008		
BVD-SPRGC-3_09172009_WS	TSS		21	mg/l		9/21/2009	14:20:00	MDT
BVD-SPRGC-3_09182008_WS	TSS		27	mg/l		9/23/2008		
BVD-SPRGC-4_06042009_WS	TSS		33	mg/l		6/11/2009	10:43:00	MST
BVD-SPRGC-4_09172009_WS	TSS		14	mg/l		9/21/2009	08:30:00	MDT
BVD-SPRGC-4_09182008_WS	TSS		6	mg/l		9/23/2008		
BVD-STL-1_06042009_WS	TSS		38.2	mg/l		6/9/2009	10:18:00	MST

Table D-4. HSI - Beaverhead TPA - TSS - 2008/2009

Activity ID	Characteristic ID	Result Detection Condition	Result Value	Result Value Unit	Result Qualifier	Date	Time	Time Zone
BVD-STNC-1_06042009_WS	TSS		22	mg/l		6/11/2009	10:43:00	MST
BVD-STNC-1_09172009_WS	TSS		31	mg/l		9/21/2009	13:20:00	MDT
BVD-STNC-1_09182008_WS	TSS		50	mg/l		9/23/2008		
BVD-STNC-1A_09172009_WS	TSS		80	mg/l		9/21/2009	12:30:00	MDT
BVD-STNC-2_06042009_WS	TSS		48	mg/l		6/11/2009	10:43:00	MST
BVD-STNC-2_09182008_WS	TSS	ND				9/23/2008		
BVD-STNC-4_06042009_WS	TSS		9	mg/l	B	6/11/2009	10:43:00	MST
BVD-STNC-4_09172008_WS	TSS	ND				9/23/2008		
BVD-STNC-4_09172009_WS	TSS		3	mg/l		9/21/2009	10:30:00	MDT
BVD-TYLC-1_09102008_WS	TSS		7	mg/l		9/16/2008		
BVD-TYLC-1_09222009_WS	TSS	ND				9/25/2009	10:15:00	MDT
BVD-TYLC-1A_09222009_WS	TSS	ND				9/25/2009	11:45:00	MDT
BVD-TYLC-2_06022009_WS	TSS		4	mg/l		6/8/2009	18:29:00	MST
BVD-TYLC-2_09102008_WS	TSS	ND				9/16/2008		
BVD-TYLC-2_ 09222009_QCFB	TSS	ND				9/25/2009	08:45:00	MDT
BVD-TYLC-2_ 09222009_QCFR	TSS		4	mg/l		9/25/2009	08:45:00	MDT
BVD-TYLC-2_09222009_WS	TSS		5	mg/l		9/25/2009	08:45:00	MDT
BVD-WFBTDC-1_06012009_WS	TSS		51	mg/l		6/8/2009	13:27:00	MST
BVD-WFBTDC-1_09152008_WS	TSS	ND				9/22/2008		
BVD-WFBTDC-1_09152009_WS	TSS		6	mg/l		9/21/2009	08:50:00	MDT
BVD-WFBTDC-2_06012009_WS	TSS		88.5	mg/l		6/8/2009	13:27:00	MST
BVD-WFBTDC-2_09152008_WS	TSS	ND				9/22/2008		
BVD-WFBTDC-2_09152009_WS	TSS		4	mg/l		9/21/2009	09:30:00	MDT
BVD-WFDC-1_06022009_WS	TSS		10	mg/l		6/8/2009	18:29:00	MST
BVD-WFDC-1_09112008_WS	TSS		5	mg/l		9/16/2008		
BVD-WFDC-1_09222009_WS	TSS		2	mg/l		9/25/2009	14:35:00	MDT
BVD-WFDC-2_06022009_WS	TSS		17	mg/l		6/8/2009	18:29:00	MST
BVD-WFDC-2_09112008_WS	TSS		19	mg/l		9/16/2008		
BVD-WFDC-2_09222009_WS	TSS		107	mg/l		9/25/2009	15:20:00	MDT

Table D-5. KirK Morphology Assessment 2003

Site Name/Reach	Mainstem BDC (03-U384)	Upper Spring Creek (03-U375)	Lower Spring Creek (03-U376)	Upper Stone Creek (03-U378)	Lower Stone Creek (03-U377)	Lower West Fork BDC (03-U382)	Upper West Fork BDC (03-U379)
Party	SD/SM	SD,SM, DK	SD,SM, SP,RH	SD/SM/SP/RH	SD/SM/SP/RH	SD/SM	SD/SM
Date	9/11/2003	9/8/2003	9/9/2003	9/9/2003	9/9/2003	9/11/2003	9/10/2003
State	MT	MT	MT	MT	MT	MT	MT
County	Beaverhead	Madison	Madison	Beaverhead	Beaverhead	Beaverhead	Beaverhead
Stream Name	Blacktail Deer Creek	Spring Creek	Spring Creek	Stone Creek	Stone Creek	West Fork Blacktail Deer Creek	West Fork Blacktail Deer Creek
UTM Easting	372781	389492	386773	393979	380338	393238	396277
UTM Northing	4999245	5016236	5026053	5007237	5019971	4968879	4959724
Bankfull Width	16.5	8.7	7.9	4.7	11	15.5	10.1
Bankfull Depth	1.45	2.02	1.8	1.6	1.5	1.19	1.9
W/D ratio	11.4	4.3	4.4	2.9	7.3	13	5.2
Stream Length	325	99	324	164	324	376	288
Valley Slope	0.6	2.6	0.3	4.8	0.3	1.5	2.3
Valley Length	291	84	302		302	320	200
Sinuosity (SL/VL)	1.1	1.18	1.07		1.07	1.18	1.1
Sinuosity (VS/CS)	1	1.6	0.75	1.17	0.75	1.9	2.88
Bankfull Width	16.5	8.7	7.9	4.7	11	15.5	10.1
Floodprone Width	20.2	20.5	23	10	16	35.3	41.7
Entrenchment Ratio	1.2	2.3	2.9	2.1	1.45	2.3	4.1
Bed Material	gravel/ cobbles	80% sand w/some cobbles	Fine Sand, silt, gravel, few cobbles	Boulders/cobbles/some gravel and sand	Sand/gravel/ some large rocks	Gravel/cobbles/ some sand	Mostly cobbles in sandy matrix, some boulders
Left Bank lds	silt/sand/ gravel	sand	sand & silt	boulders/cobbles	vegetated	sand	sand/cobble
Right Bank lds	sand/gravel/cobbles	sand	sand & silt	boulders/cobbles	vegetated	sand/cobbles	sand/cobbles
Left Bank Slope	12.8	16.19%	18.90%	32.2	32.2	67%	68%
Right Bank Slope	13.7	11.16%	5.40%	84.35	84.33	22%	2.50%
Pebble d50	33	1.8	1.5	35	10	21	16
Pebble d10	silt	1	0.4	2	silt	0.36	silt
Pebble d90	105	90	89	260	40	90	120
Rootwad Upper Reach		13		1		none	4
Rootwad Lower Reach		32		1		none	4
Logs 10-30cm Upper Reach	2	1	1	4	1	1	4
Logs 10-30cm Lower Reach	3	0		3		0	0

Table D-5. KirK Morphology Assessment 2003

Site Name/Reach	Mainstem BDC (03-U384)	Upper Spring Creek (03-U375)	Lower Spring Creek (03-U376)	Upper Stone Creek (03-U378)	Lower Stone Creek (03-U377)	Lower West Fork BDC (03-U382)	Upper West Fork BDC (03-U379)
Logs 30-50cm Upper Reach				2			
Distance					100 m		
LWD Importance	low	low	Fairly high	Fairly high for habitat but less so than substrate	relatively low	low	low- most root wads where stream is further from road
Debris Jam 1		1		17			1
Debris Jam 2				15			
Beaver Activity	none	none	none		none	none	none
Riparian % Cover	85	95	90	90	100	60	90
Riparian % Shade	60	50	10	20		25	10
Left Bank Veg	willows/ cottonwood/red osier dogwood/ grasses/ sedges	willows/grass	willows/grass	grass/woodies/ shrubs	grass	bare/grasses/some willows	grass w/ 20% willow, some sedges
Right Bank Veg	cottonwood/willow / grasses/ rushes	willows/grass	grass/weeds	grass/some woodies/shrubs	grass	willows/sedges/ grasses	grass w/ 5% willow
Mid-channel Bar Veg	none	NA	NA	NA	NA	NA	NA
Channel Class							
% Pool	10	15	10	10	5		0
% Riffle	70	70	20	80	40	20	25
% Pocket Water		<1		10			5
% Run	20	15	70		55	80	70
# Pools	3	15	2	3	1		
# Riffles	9		3		5	2	2
Distance			100	100 m	100 m		25
Total Length Pools	20 m		10 meters	10 m	2 m		
Total Length Riffles	120 m		20 meters	80 m	40 m		25

Table D-5. KirK Morphology Assessment 2003

Site Name/Reach	Mainstem BDC (03-U384)	Upper Spring Creek (03-U375)	Lower Spring Creek (03-U376)	Upper Stone Creek (03-U378)	Lower Stone Creek (03-U377)	Lower West Fork BDC (03-U382)	Upper West Fork BDC (03-U379)
Distance	140 m		100 meters	100 m	100 m		
% Reach Pools			10	10	5		
% Reach Riffles			20	80	40	20	25
Max Depth Pool #1	3 ft	All 15 pools max. depth of 8" and residual depth of 2"	25-50	<25	25-50		25-50
Max Depth Pool #2	3 ft		25-50	<25			25-50
Max Depth Pool #3	2 ft						
Out Dpth Pool #1	6 in		<25	<25	<25		<25
Out Dpth Pool #2	6 in		<25	<25			<25
Out Dpth Pool #3	6 in						
Max Dpth <25cm				2			
Max Dpth 25-50cm			2		1		
Res Dpth <25cm			2	2	1		
% Pocket LWD			0	25	1		
% Pocket Rocks			0	5	0		
Ave Pocket Dpth			NA	20 cm	20 cm		
Dep Features	side bars, lots of silt deposition in pools	side bars	mid bars, side bars and diagonal bars	mid bars/diagonal bars	mid bars/ diagonal bars/ side bars	mid bars/side bars	Minimal deposition on sides and in heavy algal areas.
Channel Stability	stable/static	stable/static	Fairly stable	stable/static	stable/static	stable	
Percent undercut	5	15	0	10	0	<2	5
Sediment Supply	silt/sand/ grave/ cobble	sand	silt/sand	silt/sand/grave/ cobble	sand/grave/cobble	silt/sand/gravel/ cobble	san
Sediment Source	immediate banks	immediate banks	upstream	immediate banks and upstream	upstream (natural)	immediate banks and upstream	immediate banks
Magnitude	low		Fairly high			failing high banks during flood years	

Table D-6. Cross Section Data from the BDNF Integrated Riparian Monitoring Hydrology Report 2010

USFS French Creek Stream Morphology 2010	X-Sec. 1 2010	X-Sec. 2 2010	X-Sec. 3 2010
Calculated Floodprone Width	39.61	52.70	49.38
Entrenchment Ratio (Floodprone)	5.87	9.18	6.76
Geomorphic Floodplain Width	9.70	8.40	48.60
Entrenchment Ratio (Floodplain)	1.43	1.50	6.65
Bankfull Width	6.75	5.74	7.30
Mean Bankfull Depth at X-Section	0.88	0.83	0.80
Width/Depth Ratio (W/D)	7.67	6.92	9.13
Bank Erosion Hazard Index Avg	27.70	27.70	27.70
Stream Type	E4a	E4a	E4a
D50 – Mean Particle Size (mm)	38.50	38.50	38.50
Valley Bottom Width (VBW) (feet)	240.00	240.00	240.00
Valley Bottom Gradient (%)	5.04	5.04	5.04
Sinuosity	1.2	1.20	1.20
Stream Slope (%)	4.2	4.20	4.20

Table D-7. Cross Section Data from the BDNF Integrated Riparian Monitoring Hydrology Report 2010

Grasshopper Creek Stream Morphology 2010	X-Sec. 1 2010	X-Sec. 2 2010	X-Sec. 3 2010
Calculated Floodprone Width	76.37	17.05	32.09
Entrenchment Ratio (Floodprone)	15.82	2.55	4.23
Geomorphic Floodplain Width	15.40	12.80	27.10
Entrenchment Ratio (Floodplain)	3.18	1.91	3.57
Bankfull Width	4.83	6.69	7.59
Mean Bankfull Depth at X-Section	1.59	1.08	1.13
Width/Depth Ratio (W/D)	3.04	6.19	6.72
Bank Erosion Hazard Index Avg	33.30	33.30	33.30
Stream Type	E4	E4	E4
D50 – Mean Particle Size (mm)	48.80	48.80	48.80
Valley Bottom Width (VBW) (feet)	110.00	110.00	110.00
Valley Bottom Gradient (%)	2.62	2.62	2.62
Sinuosity	1.40	1.40	1.40
Stream Slope (%)	1.87	1.87	1.87

Table D-8. DEQ Reference Site Data 2004/2005

Site ID	Stream	Latitude	Longitude	Date	Mean BkfW (ft)	Channel Type	PBLCnt %<6mm	PBLCnt %<2mm	Grid Pool %<6 mm	Residual Pool Depth (ft)
MO2CTWDO1	Cottonwood Creek	44.5633	-112.2546	9/13/04	8.5	C	9	6		
EFKBlack_298_C	East Fork Blacktail Deer Creek	44.86584	-112.2188	7/14/05	40.7	C	6	4	3	1.9

APPENDIX E – STREAMBANK EROSION SOURCE ASSESSMENT – BEAVERHEAD TPA

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E1.0 INTRODUCTION

This appendix includes a summary of the field protocols and results from sediment loading due to streambank erosion along several stream segments in the Beaverhead TMDL Planning Area (TPA). It is an excerpt from the Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA (Watershed Consulting, Inc., unpublished 2011), which is on file at the DEQ. Sediment loads due to streambank erosion were calculated based on field data collected in 2010/2011. Streambank erosion assessments were conducted over two monitoring timeframes, with 28 monitoring sites assessed during September 2011 and 1 monitoring site assessed during April 2011. Streambank erosion data collected at field monitoring sites was extrapolated to the stream reach and stream segment scales based on information in the Aerial Assessment Database, which was compiled in GIS prior to field data collection. Streambank erosion data collected in the field was also used to estimate sediment loading at the watershed scale and to assess the potential to decrease sediment inputs due to streambank erosion.

E1.1 SEDIMENT IMPAIRMENTS

In the Beaverhead TPA, seventeen stream segments are listed on the 2010 303(d) List for sediment impairments including: the Beaverhead River (lower segment), Blacktail Deer Creek, Clark Canyon Creek, Dyce Creek, Farlin Creek, French Creek, Rattlesnake Creek (upper and lower segments), Reservoir Creek, Scudder Creek, Spring Creek, Steel Creek, Stone Creek (upper and lower segments), Taylor Creek, West Fork Blacktail Deer Creek, and West Fork Dyce Creek.

E2.0 METHODS

Streambank erosion data were collected at 29 monitoring sites in the Beaverhead TPA. At each of the sites, eroding streambanks were assessed for erosion severity and categorized as either "actively/visually eroding" or "slowly eroding/vegetated/undercut." **Bank Erosion Hazard Index (BEHI)** measurements were performed and **Near Bank Stress (NBS)** was evaluated at each eroding bank (Rosgen, 1996; Rosgen, 2006). Bank erosion severity was rated from "very low" to "extreme" based on the BEHI score, which was determined based on the following six variables: bank height, bankfull height, root depth, root density, bank angle, and surface protection. Near Bank Stress was also rated from "very low" to "extreme" depending on the shape of the channel at the toe of the bank and the force of the water (i.e. "stream power") along the bank. In addition, the source, or underlying cause, of streambank erosion was evaluated based on observed anthropogenic disturbances within the riparian corridor, as well as current and historic land-use practices observed within the surrounding landscape. Source of streambank instability was identified based on the following near-stream source categories: natural, historic, residential/urban, irrigation, timber, mining, cropland and "other," for sources not included in the other categories. Sources of erosion in the "historic" or "other" categories included historic mining activities, historic beaver removal, and channel straightening in the Beaverhead TPA. Natural sources of streambank erosion included natural channel scour or wildlife trails. If multiple sources were observed, then a percent of the total influence was estimated for each source.

Streambank erosion data collected at **monitoring sites** were extrapolated to the **stream reach**, **stream segment**, and **sub-watershed** scales based on similar reach type characteristics as identified in the Aerial

Assessment Database. Sediment load calculations were performed for monitoring sites, stream reaches, stream segments, and sub-watersheds which are distinguished as follows:

Monitoring Site	*- A 500, 1000, or 2000 foot section of a stream reach where field monitoring was conducted*
Stream Reach	*-Subdivision of the stream segment based on ecoregion, stream order, gradient and confinement as evaluated in GIS*
Stream Segment	*-assessed segment*
Sub-watershed	*-assessed segment and tributary streams based on 1:100,000 NHD data layer*

The annual sediment load was estimated for each assessed bank based on the streambank length, mean height, and the annual retreat rate for each eroding streambank. The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between the BEHI and NBS ratings. Annual retreat rates for the Beaverhead TPA were estimated based on retreat rates from the Lamar River in Yellowstone National Park (Rosgen, 1996) (**Table E-1**). The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material, which was assumed to average 1.3 tons/yard^3 as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (Rosgen, 2006; United States Environmental Protection Agency, 2006). This process resulted in a sediment load for each eroding bank expressed in tons per year.

Table E-1. Annual Streambank Retreat Rates (Feet/Year), Lamar River, Yellowstone National Park (adapted from Rosgen 1996).

BEHI	Near Bank Stress					
	very low	low	moderate	high	very high	extreme
very Low	0.002	0.004	0.009	0.021	0.050	0.12
low	0.02	0.04	0.10	0.24	0.57	1.37
moderate	0.10	0.17	0.28	0.47	0.79	1.33
high - very high	0.37	0.53	0.76	1.09	1.57	2.26
extreme	0.98	1.21	1.49	1.83	2.25	2.76

E2.1 Streambank Erosion Sediment Load Extrapolation Method

Monitoring site sediment loads were extrapolated to the stream reach, stream segment and sub-watershed scales based on the aerial assessment reach type analysis and field-verified reach types for assessment sites. Streambank erosion data were extrapolated using the following procedure:

1. Monitoring site sediment loads were extrapolated directly to the stream reach in which the monitoring site was located, based on total loading per 1000/ft.

2. Existing streambank erosion sediment loads were extrapolated to unassesed reaches based on average sediment loading/1000 ft from assessed sites for each reach type. Field data were collected within ten individual reach types that were delineated by confinement, stream order and gradient. Un-assessed reach types were assigned loads from the most applicable and appropriate assessed reach type based on similarities with stream slope, stream order, and best professional judgment **(Table E-2)**.

Table E-2. Measured Reach Types and Average Sediment Loads Applied to Unassessed Reach Types

Measured Reach Type	Number of Monitoring Sites	Measured Reach Type Avg. Sediment Load/1000 ft (tons/yr)	Unassessed Reach Types
MR-2-1-U	1	22.9	MR-2-1-U, MR-2-1-C
MR-4-1-U	2	19.3	MR-4-1-U, MR-4-1-C, MR-10-1-C, MR-10-1-U
MR-0-2-U	7	75.6	MR-0-2-U, MR-0-2-C, MR-0-1-U
MR-2-2-C	1	27.6	MR-2-2-C, MR-2-3-C
MR-2-2-U	5	39.8	MR-2-2-U, MR-2-3-U
MR-4-2-U	1	31.2	MR-4-2-U, MR-4-2-C, MR-10-2-C, MR-10-2-U, MR-4-3-C, MR-4-3-U, MR-10-3-C
MR-0-3-U	2	19.8	MR-0-3-U
MR-0-4-U	2	20.1	MR-0-4-U, MR-0-4-C, MR-2-4-C
MR-0-5-U	3	34.7	MR-0-5-U
MR-0-7-U	5	82.9	MR-0-7-U, MR-0-7-C

E2.2 Streambank Erosion Sediment Load Reduction Analysis Methods

The narrative water quality standards that apply to sediment relate to the naturally occurring condition, which is defined as conditions that occur if all reasonable land, soil, and water conservation practices are applied. To assist with TMDL development, the streambank erosion assessment includes an estimation of sediment loading reductions that could be achieved if implementation of Best Management Practices (BMPs) were applied to achieve naturally occurring condition. Streambank erosion sediment load reductions were evaluated based on field collected data and streambank erosion sources identified in the Aerial Assessment Database through the following process:

1. Anthropogenic activities that remove streamside vegetation or alter channel form tend to de-stabilize streambanks and increase the amount of active streambank erosion. The sediment assessment includes estimating the extent of bank erosion from human and natural influences on a given reach.

2. Therefore, for each reach, a reduction in sediment load can be considered using the proportion of the sediment load attributable to various influences, and the corresponding potential load decrease can be the reduction from existing loading to the load under naturally occurring conditions.

3. To account for uncertainty and allow for reasonable land use, the load reduction calculation entails reducing the human load by 75% for all human loading that is less than 50% of the total load and 100% of the human load above 50%. This approach recognizes that erosion is inevitable and allowable under naturally occurring conditions as defined above.

   As an example of the reduction calculation, in the case of a reach with 100% of the load attributable to human loading, the reduced load would be 12.5% of the total:
   Reduced load = Total load - (((Total load*0.5)*1) + ((Total load* 0.5)*0.75))

   In the case of a reach with less than 50% of the load attributable to human loading, the following calculation was used:
   Reduced load = Total load - ((Total load* % anthropogenic load)*0.75)

4. Because they are assumed to be achieving the naturally occurring condition, no sediment load reductions were applied to reaches with >70% natural sources of erosion. In addition, no load reduction was applied to the natural load in reaches with >70% natural sources.

5. No sediment load reductions were applied to unassessed tributaries of the assessed stream segments.

E3.0 Streambank Erosion Results

E3.1 Streambank Erosion Sediment Load Extrapolation

A total annual sediment load of 1,416.5 tons/year was attributed to the 259 assessed eroding streambanks within the 29 sites monitored for streambank erosion in the Beaverhead TPA. Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison and extrapolation. Sediment loads per 1000 feet are presented in **Table E-3** for each monitoring site. Sediment loads per 1,000 feet ranged from 2.5 tons/yr at site TAYL 27-01 to 427.1 tons/yr at site SPRG 31-01. **Table E-3** also lists monitoring sites for each reach type, with load totals by reach and reach type.

Table E-3. Loads for Assessment Sites and Reach Types

Reach Type	Site ID	% Natural Erosion	% Anthro. Erosion	SedLoad per 1000 ft (tons/yr)	Assessed Site Bank Erosion Sediment Load
MR-2-1-U	SCUD 11-01	0	100	22.9	11.4
MR-4-1-U	WFDY 17-01	13.3	86.7	15.1	11.9
	STEL 05-01	0	100	23.55	11.8
	Avg/Total	**6.7**	**93.4**	**19.3**	**23.7**
MR -0-2-U	CLKC 32-01	54.2	45.8	33.2	16.6
	DYCE 02-02	0.0	100.0	6.2	3.1
	SPRG 31-01	0.0	100.0	427.1	213.5
	DYCE 02-02	0.0	100.0	6.2	3.1
	STON 20-02	9.6	90.4	16.0	8.0
	STON 22-02	10.0	90.0	3.4	3.4
	STON 22-02B	20.0	80.0	7.7	3.9
	TAYL 32-01	51.9	48.1	35.6	17.8
	Avg/Total	**18.2**	**81.8**	**66.9**	**269.4**
MR-2-2-C	FREN 23-01	60.0	40.0	27.6	13.8
MR-2-2-U	CLKC 19-02	33.3	66.7	95.7	47.9
	FARL 28-01	0.0	100.0	44.9	22.5
	RESR 11-01	51.0	49.0	4.9	2.5
	STON 05-01	11.8	93.6	51.2	25.6
	TAYL 27-01	45.0	55.0	2.5	1.2
	Avg/Total	**28.2**	**72.9**	**39.8**	**99.7**
MR-4-2-U	CLKC 18-02	61.3	38.8	31.2	15.6
MR-0-3-U	RATT 54-04	21.2	78.8	27.6	27.6
	WFBK 08-04	30.4	69.6	11.9	11.9
	Avg/Total	**25.8**	**74.2**	**19.8**	**39.5**

Table E-3. Loads for Assessment Sites and Reach Types

Reach Type	Site ID	% Natural Erosion	% Anthro. Erosion	SedLoad per 1000 ft (tons/yr)	Assessed Site Bank Erosion Sediment Load
MR-0-4-U	GRAS 12-01	27.3	72.7	22.0	22.0
	GRAS 20-11	75.7	24.3	18.1	18.1
	Avg/Total	**51.5**	**48.5**	**20.1**	**40.1**
MR-0-5-U	BLKD 02-08	80.0	20.0	50.1	50.1
	BLKD 02-14	43.3	56.7	28.4	28.4
	BLKD 02-30	59.5	40.5	25.6	25.6
	Avg/Total	**60.9**	**39.1**	**34.7**	**104.1**
MR-0-7-U	BEAV 09-04	0.0	100.0	6.8	10.2
	BEAV 09-06	32.5	67.5	316.8	633.5
	BEAV 09-11	82.0	18.0	37.1	55.6
	BEAV 09-14	48.3	51.7	5.9	11.8
	BEAV 09-15	56.7	43.3	47.8	95.6
	Avg/Total	**43.9**	**56.1**	**82.9**	**806.7**

Field-based assessments identified dominant land uses affecting each eroding bank and included estimating the proportion of sediment loading due to natural and various anthropogenic sources. Historic uses (including historic clearing, mining, grazing, and trapping) and current riparian grazing are the greatest anthropogenic contributors of sediment loads due to streambank erosion for most assessed sites in the Beaverhead TPA (**Figure E-1**). Irrigation is a major contributor to Stone Creek but is not a primary source throughout the TPA.

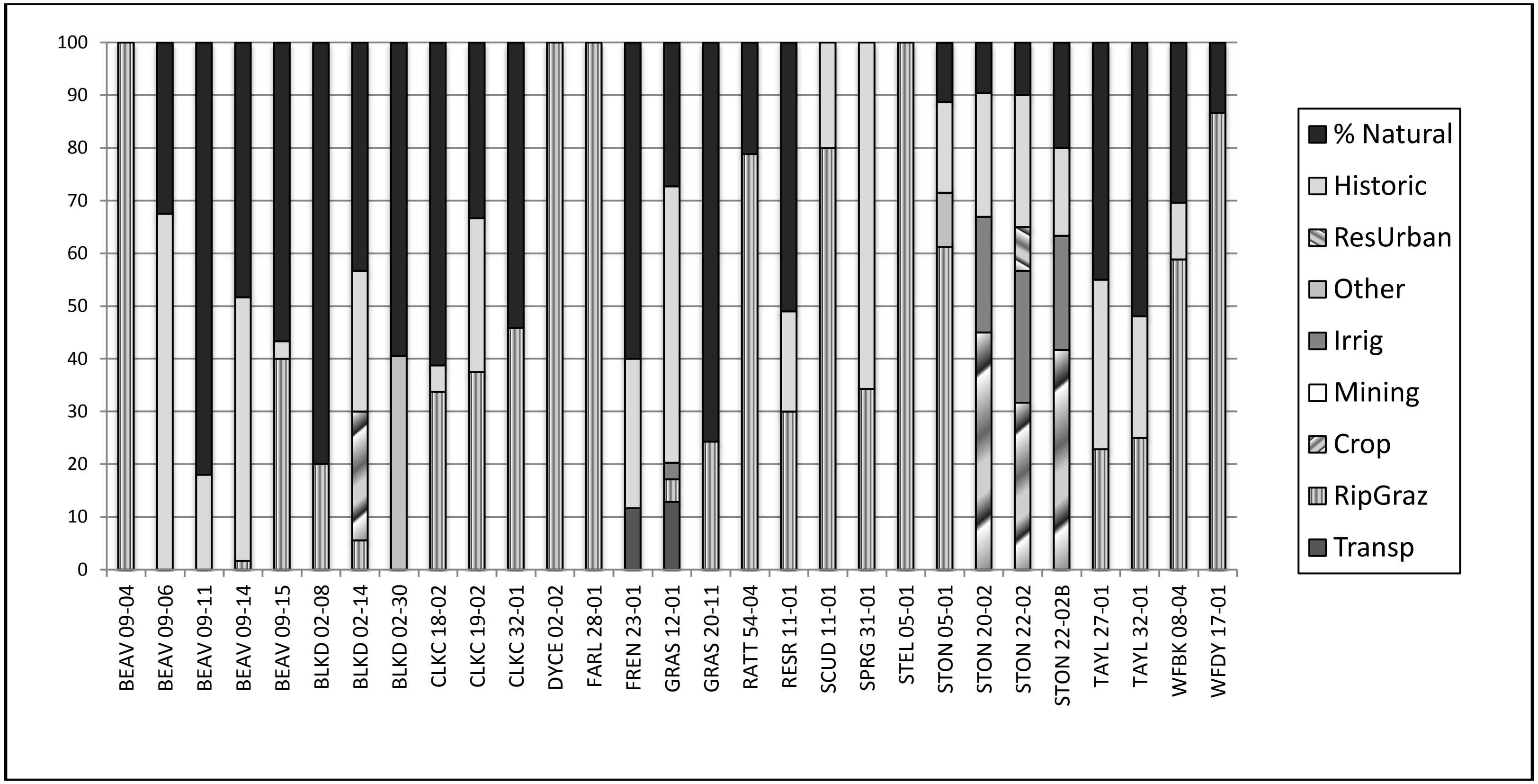

Figure E-1. Streambank Erosion Sources by Reach

Sources of sediment loading are likely to affect different reach types in different ways due to variations in stream energy and landscape controls on access to the stream. For example, low gradient, large streams typically occur in open valley bottoms affected by grazing and agricultural production, whereas higher in the watersheds, erosion is often influenced by roads, timber harvest, or historic mining, as well as riparian grazing where side slopes allow access to the stream.

Sediment loads from assessed sites were averaged by reach type to facilitate sediment load extrapolation to assessed segments and subbasins.

E3.1.1 Load Reductions by Reach Type

As described above, reductions for unassessed reach types are estimated based on erosion rates from assessed reach types, following the reach type groupings listed in **Table E-2**. Extrapolated average streambank erosion sediment load reductions for all reach types on assessed streams in the Beaverhead TPA are presented in **Table E-4**.

Table E-4. Reach Type Streambank Sediment Load Reductions with BMPs

Reach Type	Total Load (tons/yr)	Target Load (tons/yr)	Reduction (tons/yr)	% Reduction
MR-0-1-U	190.25	71.95	118.31	45.00
MR-0-2-C	382.53	176.72	205.81	53.50
MR-0-2-U	10608.69	2998.01	7610.68	65.66
MR-0-3-U	6567.9	2591.2	3976.7	60.5
MR-0-4-C	652.6	229.6	423.0	64.8
MR-0-4-U	2515.1	847.0	1668.1	66.3
MR-0-5-U	6208.3	2313.8	3894.5	62.7
MR-0-7-C	303.9	144.3	159.6	52.5
MR-0-7-U	32251.2	7888.2	24363.0	75.5
MR-10-1-C	316.4	193.6	122.8	38.8
MR-10-1-U	174.8	132.3	42.5	24.3
MR-10-2-C	108.1	74.6	33.5	31.0
MR-10-2-U	54.6	54.6	0.0	0.0
MR-10-3-C	13.9	13.9	0.0	0.0
MR-2-1-C	225.6	72.1	153.5	68.0
MR-2-1-U	466.9	168.9	298.0	63.8
MR-2-2-C	1271.8	614.8	657.0	51.7
MR-2-2-U	3369.59	1341.80	2027.80	54.12
MR-2-3-C	269.99	120.20	149.79	58.00
MR-2-3-U	1012.38	506.87	505.51	44.57
MR-2-4-C	22.3	7.3	15.1	67.5
MR-4-1-C	1100.4	540.2	560.2	50.9
MR-4-1-U	939.6	435.4	504.2	53.7
MR-4-2-C	1006.8	515.8	491.0	48.8
MR-4-2-U	857.3	434.2	423.1	49.4
MR-4-3-C	58.7	50.5	8.2	14.0
MR-4-3-U	249.6	178.8	70.7	28.3

E3.1.2 Extrapolated Loads and Reductions per Assessed Segment

Monitoring site sediment loads were extrapolated to the stream segment scale based on the reach type groups listed in **Table E-2**. Stream segment sediment loads were estimated for all reaches of assessed stream segments included in the Aerial Assessment Database(Watershed Consulting, Inc., unpublished 2011). Average annual streambank erosion sediment loads were estimated for the assessed stream segments in the Beaverhead TPA based on the total length of the stream segment and loading per 1000 foot by reach type.

Segment length, average loading rates (load/mile), and total sediment loads for each listed stream segment are presented in **Table E-5**. In the Beaverhead TPA, streambank erosion sediment loads per assessed segment ranged from 396.3 tons/year in West Fork Dyce Creek to 27,504.5 tons/year in the lower Beaverhead River. The lower and upper segments of the Beaverhead River have the highest sediment load per mile of stream. West Fork Dyce Creek has the lowest streambank erosion estimated sediment load per mile of stream.

The loading reductions listed in **Table E-5** were calculated as the average of load reductions from each reach within the segment. Percent load reduction for each segment is calculated as the total load reduction for reaches within the segment divided by the total load of all reaches within the segment, multiplied by 100 to convert to percent. Reductions represent achievable reductions in loading to the assessed waterbody segments; additional reductions may also be possible from the tributaries to the assessed waterbodies.

Table E-5. Loads and Reductions for Assessed Segments

Assessed Segment	Stream miles	Total Existing Load (tons/yr)	Sediment Load per mile	Load from Anthro. Sources (tons/yr)	Load from Natural Sources (tons/yr)	Target Load (tons/yr)	Reduction (tons/yr)	Avg. % Reduction
Beaverhead River - Lower	62.8	27,504.5	437.7	24552.4	2952.1	6390.1	21114.3	76.8
Beaverhead River -Upper	11.5	5050.6	437.7	4039.6	1011.0	1642.3	3408.3	67.5
Blacktail Deer Creek	39.9	6841.1	171.7	5104.8	1736.2	2591.3	4249.7	62.1
Clark Canyon Creek	8.4	1083.1	129.2	806.7	276.5	409.2	674.0	62.2
Dyce Creek	4.1	1102.4	268.9	805.9	296.4	434.2	668.1	60.6
Farlin Creek	6.0	731.0	122.2	499.7	231.3	318.8	412.2	56.4
French Creek	6.5	853.4	132.1	676.5	176.9	282.7	570.7	66.9
Grasshopper Creek	47.5	5128.9	108.0	3949.3	1179.5	1820.6	3308.3	64.5
Rattlesnake Creek -Lower	8.8	932.4	106.4	773.2	159.2	275.7	656.7	70.4
Rattlesnake Creek -Upper	18.3	2726.8	149.2	1664.0	1062.8	1378.4	1348.4	49.4
Reservoir Creek	12.2	2611.5	213.5	1982.0	629.5	952.2	1659.3	63.5
Scudder Creek	4.7	776.6	167.0	538.8	237.8	331.6	445.0	57.3
Spring Creek	14.9	4037.8	270.8	3398.9	638.9	1143.6	2894.2	71.7
Steel Creek	3.8	413.8	109.8	307.2	106.6	156.6	257.2	62.2
Stone Creek Lower	3.4	1368.4	399.0	1195.1	173.3	344.3	1024.1	74.8
Stone Creek Upper	10.0	2937.5	294.6	2560.0	377.5	744.7	2192.8	74.6
Taylor Creek	11.4	2298.3	201.1	1610.9	687.4	973.6	1324.7	57.6
West Fork Blacktail Deer Creek	15.9	1730.4	109.1	1161.3	569.2	784.2	946.2	54.7
West Fork Dyce Creek	4.6	396.3	86.5	298.1	98.2	147.8	248.6	62.7

E3.1.3 Extrapolated Loads and Reductions per Subbasin

Subbasins and assessed segments were assigned to all reaches in the aerial assessment database in GIS. Subbasin sediment loads were estimated from the sum of the average annual streambank erosion sediment loads on assessed stream segments as calculated in the extrapolation process described in **Section E2.1**.

Subbasins include all assessed segments and associated subwatersheds draining to the pour point (downstream end) of the subbasin. For example, Lower Rattlesnake Creek subbasin includes the segments Upper Rattlesnake Creek and French Creek as well as Lower Rattlesnake Creek. **Table E-6** lists contributing segments, drainage area, and length of assessed streams within each subbasin.

Table E-6. Subbasin Area and Assessed Segments

Subbasin Name	Assessed Segments/ subwatersheds included in Subbasin	Total Drainage Area (acres)	Total Assessed Stream Length (mi)
Clark Canyon Creek	Clark Canyon Creek	11,084	8.4
Beaverhead River -Upper	Beaverhead River –Upper Clark Canyon Creek	37,126	19.9
West Fork Dyce Creek	West Fork Dyce Creek	2,339	4.6
Dyce Creek	Dyce Creek West Fork Dyce Creek	8,733	8.7
Farlin Creek	Farlin Creek	3,615	6.0
Reservoir Creek	Reservoir Creek	8,950	12.2
Scudder Creek	Scudder Creek Steel Creek	4298	8.5
Steel Creek	Scudder Creek	2,370	3.8
Taylor Creek	Taylor Creek	13,614	11.4
Grasshopper Creek	Grasshopper Creek Dyce Creek West Fork Dyce Creek Steel Creek Scudder Creek Farlin Creek Reservoir Creek Taylor Creek	224,603	94.3
French Creek	French Creek	6,769	6.5
Rattlesnake Creek -Upper	Rattlesnake Creek -Upper French Creek	35,318	24.7
Rattlesnake Creek -Lower	Rattlesnake Creek -Lower Rattlesnake Creek –Upper French Creek	92,105	33.5
West Fork Blacktail Deer Creek	West Fork Blacktail Deer Creek	32,879	15.9
Blacktail Deer Creek	Blacktail Deer Creek West Fork Blacktail Deer Creek	202,349	55.8
Stone Creek Upper	Stone Creek Upper	15,975	10.0
Stone Creek Lower	Stone Creek Lower Stone Creek Upper	26,020	13.4
Spring Creek	Spring Creek	32,394	14.9
Beaverhead River - Lower	Entire TPA	905,848	294.5

Streambank erosion sediment load reductions for each subbasin are provided in **Table E-7** to facilitate use with other sub-basin scale analyses, such as upland erosion modeling. Potential reductions in anthropogenic loading as a result of the application of BMPs range from approximately 54% for Upper Rattlesnake Creek to 75% for both subbasins of Stone Creek, with a 69% reduction identified to the entire Beaverhead TPA.

Subbasin totals include only assessed stream segments within the Beaverhead TPA. Average rates of erosion applied to segments may not be applicable to unassessed streams in the subwatersheds, and therefore unassessed tributaries were not included in the load extrapolation. The same BMPs and approach to reducing sediment loading used to achieve reductions on assessed segments apply to unassessed streams, which are influenced by similar land uses.

Table E-7. Subbasin Loads and Reductions

Subbasin	Acres in Drainage	Assessed Stream Miles in Subbasin	Total Existing Load (tons/yr)	Sediment Load per mile	Load from Anthro. Sources (tons/yr)	Load from Natural Sources (tons/yr)	Target Load (tons/yr)	Reduction (tons/yr)	Avg. % Reduction
Beaverhead River - Lower	905,848	294.5	68,524.8	232.7	55,924.4	12,600.3	21,121.9	47,402.8	69.1
Beaverhead River -Upper	37,126	19.9	6133.7	307.9	4846.3	1287.5	2051.5	4082.3	66.6
Blacktail Deer Creek	202,349	55.8	8571.5	153.6	6266.1	2305.4	3375.5	5195.9	60.6
Clark Canyon Creek	11,084	8.4	1083.1	129.2	806.7	276.5	409.2	674	62.2
Dyce Creek	8733	8.7	1498.7	172.7	1104.0	394.6	582.0	916.7	61.2
Farlin Creek	3615	6.0	731	122.2	499.7	231.3	318.8	412.2	56.4
French Creek	6769	6.5	853.4	132.1	676.5	176.9	282.7	570.7	66.9
Grasshopper Creek	224,603	94.3	13,458.8	142.8	9991.9	3466.7	5135.4	8323.4	61.8
Rattlesnake Creek -Lower	92,105	33.5	4512.6	134.7	3113.7	1398.9	1936.8	2575.8	57.1
Rattlesnake Creek -Upper	35,318	24.7	3580.2	144.7	2340.5	1239.7	1661.1	1919.1	53.6
Reservoir Creek	8950	12.2	2611.5	213.5	1982.0	629.5	952.2	1659.3	63.5
Scudder Creek	4298	8.5	1190.4	140.0	846.0	344.4	488.2	702.2	58.9
Spring Creek	32,394	14.9	4037.8	270.8	3398.9	638.9	1143.6	2894.2	71.7
Steel Creek	2370	3.8	413.8	108.9	307.2	106.6	156.6	257.2	62.2
Stone Creek Lower	26,020	13.4	4305.9	321.3	3755.1	550.8	1089.0	3216.9	74.7
Stone Creek Upper	15,975	10.0	2937.5	294.6	2560.0	377.5	744.7	2192.8	74.6
Taylor Creek	13,614	11.4	2298.3	201.1	1610.9	687.4	973.6	1324.7	57.6
West Fork Blacktail Deer Creek	32,879	15.9	1730.4	109.1	1161.3	569.2	784.2	946.2	54.7
West Fork Dyce Creek	2339	4.6	396.3	86.5	298.1	98.2	147.8	248.6	62.7

E4.0 Assumptions and Uncertainty

This assessment assumes that different streams with similar reach type characteristics will have similar physical attributes and sediment loads due to streambank erosion.

The analysis contains several potential sources of uncertainty:

- Since budget and time constraints dictate that only a portion of the streams within the Beaverhead TPA could be assessed in the field, a degree of uncertainty is unavoidable when extrapolating data from assessed sites to un-assessed sites.
- Calculating segment and reach lengths from GIS layers also may a create uncertainty, since layers are digitized based on topographic maps and generally underestimate stream lengths.
- Some degree of uncertainty is inherent in the BEHI methods and categorization of sediment loading by erosion source, as the index values for the BEHI ratings are based on studies conducted in a similar region but different geographic location, and percent loading due to different erosion sources must be estimated using best professional judgment.
- The identification of sediment as a pollutant in many streams in the Beaverhead TPA relate to the fine sediment fraction found on the stream bottom, while streambank erosion sediment modeling examined all sediment sizes.
- Since sediment source modeling may under-estimate or over-estimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate calculation of sediment production within each sub-watershed. Instead, the streambank erosion assessment model results should be considered an instrument for estimating sediment loads and making general comparisons of sediment loads from various sources.

E5.0 Summary

The 2011 sediment and habitat assessment in the Beaverhead TPA provides a broad-scale analysis of existing sediment conditions within impaired stream segments and estimated streambank erosion sediment loads for use in TMDL development. A total of 612 reaches were delineated during the aerial assessment reach stratification process covering approximately 321 miles of stream. A total of 27 distinct reach types were assigned within the one Level III ecoregion (Middle Rockies) in the Beaverhead TPA based on stream and landscape characteristics. Sediment and habitat variables were assessed at 32 monitoring sites, 29 of which were assessed for streambank erosion. Statistical analysis of the sediment and habitat data from the monitoring sites will aid in developing sediment TMDL targets that are specific for the Beaverhead TPA, while streambank erosion data and calculated load reductions will be utilized in the sediment TMDL. A total annual sediment load of 1,416.5 tons/year was attributed to the 259 assessed eroding streambanks within the 29 sites monitored for streambank erosion in the Beaverhead TPA. A total average annual sediment load of 68,525 tons/year was estimated for the assessed stream segments through the extrapolation process. It is estimated that this sediment load can be reduced to 21,122 tons/year, which is a 69% reduction in sediment load from streambank erosion.

E6.0 REFERENCES

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APPENDIX F – UPLAND SEDIMENT SOURCE ASSESSMENT – BEAVERHEAD TPA

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F1.0 INTRODUCTION

The Beaverhead TMDL Planning Area (TPA) is located in Beaverhead County, with a small portion in Madison County and includes the towns of Dillon and Twin Bridges. The Beaverhead TPA encompasses the entire Beaverhead River watershed, which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The TPA coincides with the 10020002 fourth-code hydrologic unit code (HUC), and is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south. This report provides an upland source assessment that will be used for TMDL development.

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE) and sediment delivery to the stream was predicted using a sediment delivery ratio. This model provided an assessment of existing sediment loading from upland sources and an assessment of potential sediment loading through the application of Best Management Practices (BMPs). The BMPs evaluated assumed modifications in upland management practices as well as improvements within the riparian buffer zone. When reviewing the results of the upland sediment load model, it is important to note that a significant portion of the sediment load is the "natural upland load" and not affected by the application of BMPs to the upland management practices.

The general form of the USLE has been widely used for erosion prediction in the U.S. and is presented in the National Engineering Handbook (1983) as:

(1) $A = RK(LS)CP$ (in tons per acre per year)

where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P) (Wischmeier and Smith 1978, Renard et al. 1997). USLE was selected for the Beaverhead TPA due to its relative simplicity and ease in parameterization and the fact that it has been integrated into a number of other erosion prediction models. These include: (1) the Agricultural Nonpoint Source Model (AGNPS), (2) Areal Nonpoint Source Watershed Environment Response Simulation Model (ANSWERS), (3) Erosion Productivity Impact Calculator (EPIC), (4) Generalized Watershed Loading Functions (GWLF), and (5) the Soil Water Assessment Tool (SWAT) (Doe, 1999). A detailed description of the general USLE model parameters is presented below.

The **R-factor** is an index that characterizes the effect of raindrop impact and rate of runoff associated with a rainstorm. It is a summation of the individual storm products of the kinetic energy in rainfall (hundreds of ft-tons per acre per year) and the maximum 30-minute rainfall intensity (inches per hour). The total kinetic energy of a storm is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period.

The **K-factor** or soil erodibility factor indicates the susceptibility of soil to resist erosion. It is a measure of the average soil loss (tons per acre per hundreds of ft-tons per acre of rainfall intensity) from a particular soil in continuous fallow. The K-factor is based on experimental data from the standard SCS erosion plot that is 72.6 ft long with uniform slope of 9%.

The **LS-factor** is a function of the slope and overland flow length of the eroding slope or cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. According to McCuen (1998), flow lengths are seldom greater than 400 ft or shorter than 20 ft.

The **C-factor** or crop management factor is the ratio of the soil eroded from a specific type of cover to that from a clean-tilled fallow under identical slope and rainfall. It integrates a number of factors that affect erosion including vegetative cover, plant litter, soil surface, and land management. The original C-factor of the USLE was experimentally determined for agricultural crops and has since been modified to include rangeland and forested cover. It is now referred to as the vegetation management factor (VM) for non-agricultural settings (Brooks, 1997).

Three different kinds of effects are considered in determination of the VM-factor. These include: (1) canopy cover effects, (2) effects of low-growing vegetal cover, mulch, and litter, and (3) rooting structure. A set of metrics has been published by the Soil Conservation Service (SCS) for estimation of the VM-factors for grazed and undisturbed woodlands, permanent pasture, rangeland, and idle land. Although these are quite helpful for the Beaverhead setting, Brooks (1997) cautions that more work has been carried out in determining the agriculturally based C-factors than rangeland/forest VM-factors. Because of this, the results of the interpretation should be used with discretion.

The **P-factor** or conservation practice factor is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row (up-slope down-slope) farming practices with that of certain agriculturally based conservation practices.

F2.0 Modeling Approach

Sediment delivery from hillslope erosion was estimated using a Universal Soil Loss Equation (USLE) based model to predict soil loss along with a distance and riparian health based sediment delivery ratio (SDR) to predict sediment delivered to the stream. This USLE based model is implemented as a watershed scale, grid format, GIS model using ArcView v 9.2 GIS software.

Desired results from the modeling effort include the following: (1) annual sediment load from each of the water quality limited segments on the state's 303(d) list, (2) the mean annual source distribution from each land category type, (3) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of riparian buffer zone management BMPs, (4) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of upland management BMPs, and (5) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of riparian buffer zone management BMPs and upland management BMPs. Based on these considerations, a GIS - modeling approach (USLE) was formulated to facilitate database development and manipulation, provide spatially explicit output, and supply output display for the modeling effort.

F3.0 MODELING SCENARIOS

Four management scenarios were evaluated for the Beaverhead TPA. They include: (1) an existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) an upland BMP conditions scenario that considers improved grazing and cover management; (3) a riparian health BMP conditions scenario that considers improved riparian buffer zones; and (4) a riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management.

Erosion was differentiated into two source categories for each scenario: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. A similar classification is presented as part of the National Engineering Handbook Chapter 3 – Sedimentation (USDA, 1983). Differentiation is necessary for TMDL planning. Land cover categories considered to be affected by human-caused activity and therefore affected by BMPs within the Beaverhead TPA were developed (open space), developed (low intensity), developed (medium intensity), developed (high intensity), pasture/hay, grasslands/herbaceous, shrub/scrub, cultivated crops, and transitional (logging). All other land cover categories were considered to have "natural erosion."

Well vegetated riparian buffers have been shown to act as filters that help to remove sediment from overland flow. In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. A riparian health assessment was completed by the Montana Department of Environmental Quality (DEQ) for the Beaverhead TPA. The DEQ riparian health assessment is used here to estimate further reduction in the quantity of eroded sediment that is ultimately delivered to the streams. These riparian areas are also considered to be affected by human-caused activity and are therefore subject to improved riparian health management.

F4.0 DATA SOURCES

The USLE model was parameterized using a number of published data sources. These include information from: (1) U.S. Geological Survey (USGS), (2) Spatial Climate Analysis Service (SCAS), and (3) Soil Conservation Service (SCS). Additionally, local information regarding specific land cover was acquired from the U.S. Forest Service (USFS) and the Natural Resource Conservation Service (NRCS). Specific GIS data used in the modeling effort included the following:

Grid data of the **R-factor** was obtained from the NRCS, and is based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. PRISM precipitation data is derived from weather station precipitation records, interpolated to a gridded landscape coverage by a method (developed by the Spatial Climate Analysis Service of Oregon State University) which accounts for the effects of elevation on precipitation patterns.

Polygon data of the **K-factor** were obtained from the NRCS General Soil Map (STATSGO) database and the NRCS Soil Survey Geographic (SSURGO) database. The USLE K factor is a standard component of the STATSGO soil survey, but has not been included for all polygons in the SSURGO soil survey. SSURGO data has higher resolution and is more current than the STATSGO dataset, however, the SSURGO data for the

Beaverhead TPA did not contain the required K-factor for the entire watershed. STATSGO data was used to fill in the blanks. Soils polygon data were summarized and interpolated to grid format.

The **LS-factor** was derived from 30m USGS digital elevation model (DEM) grid data, interpolated to a 10m pixel. This factor is calculated within the model.

The **C-factor** was estimated using the National Land Cover (NLCD) dataset and using C-factor interpretations provided by the NRCS with input from Montana Department of Environmental Quality (DEQ). C-factors are intended to be conservatively representative of conditions in the Beaverhead TPA.

The **P-factor** was set to one, as per previous communication with the NRCS State Agronomist who suggested that this value is the most appropriate representation of current management practices in the Beaverhead TPA.

The **sediment delivery ratio** was derived by the model for each grid cell based on the observed relationship between the distance from the delivery point to the stream and the percent of eroded sediment delivered to the stream. This relationship was established by Megehan and Ketcheson (1996).

The **riparian health factor** was derived from a riparian health assessment completed by DEQ. Riparian health ratings of good, moderately good, fair, moderately fair, and poor were assigned according to the professional judgment of the assessment team. The percent of each sub-basin's area falling in each category was reported.

F5.0 Modeling Methods

An appropriate grid for each data source was created, giving full and appropriate consideration to proper stream network delineation, grid cell resolution, etc. A computer model was built using ArcView Model Builder to derive the five factors from model inputs, multiply the five factors and arrive at a predicted sediment production for each grid cell. The model also derived a sediment delivery ratio for each cell, and reduced the predicted sediment production by that factor to estimate sediment delivered to the stream network.

Specific parameterization of the USLE factors were preformed as follows (**Section 1.5.1** through **Section 1.5.12**).

F5.1 Sub-basins

The Beaverhead TPA boundary and the sub-basin boundaries were defined using the USGS 6th code Hydrologic Unit Codes (HUC) (**Figure F1-1**). Farlin Creek, Steel Creek, Scudder Creek, West Fork Dyce Creek, Dyce Creek, Taylor Creek, Reservoir Creek, and French Creek are 303(d) listed streams that were not represented in the 6th code HUCs. These sub-basins were cut from the larger HUC sub-basins using USGS topography as a guide to drainage divides. Additionally, the Rattlesnake Creek, Stone Creek, and Beaverhead River sub-basins were divided into an upper and lower sub-basin also using USGS topography as a guide at locations defined by DEQ.

Figure F1-1. Sub-basin polygons for the Beaverhead TPA.

F5.2 BEAVERHEAD TPA DEM

The digital elevation model (DEM) for the Beaverhead TPA is the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area, and for delineating the area within the outer bounds of the analysis for which the USLE model is not valid (i.e. the concentrated flow channels of the stream network). The USGS 30m DEM (level 2) for the Beaverhead TPA was used for these analyses (**Figure F1-2**). The DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Beaverhead TPA streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m DEM was then subjected to standard hydrologic preprocessing, including the filling of sinks to create a positive drainage condition for all areas of the watershed.

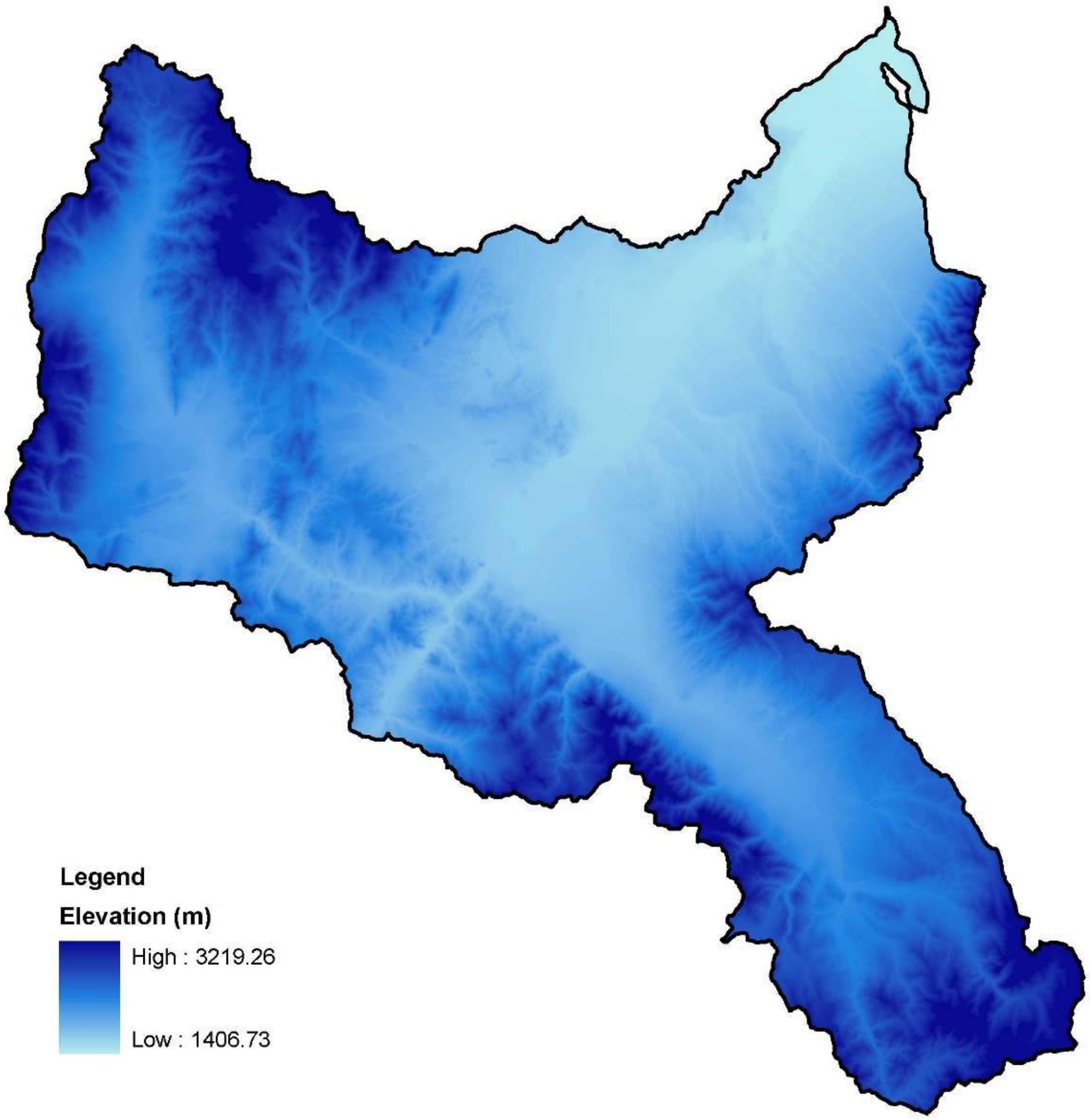

Figure F1-2. Digital Elevation Model (DEM) of the Beaverhead TPA Prepared for Hydrologic Analysis.

F5.3 Beaverhead TPA Flow Network

The stream network for the watershed was derived from the 10m DEM, using hydrologic analysis methods developed by the Utah State University Hydrology Research Group, and implemented in the TauDEM (Terrain Analysis Using Digital Elevation Models) software (**Figure F1-3**). These tools prepare a hydrologically correct surface from standard DEM data, filling errant sinks and ensuring positive drainage toward defined pour points. From this surface, a stream network is derived by calculating the watershed area for each pixel in the DEM, and assigning to the stream network those pixels that exceed a specified accumulation area threshold. The threshold is watershed specific, and is chosen in a manner whereby the resulting stream network satisfies the key elevation scaling laws (constant drop property and power law scaling of slope with area) that differentiate concentrated flow processes (channel erosion and transport) from the diffusive processes that characterize hillslope transport of sediment.

Figure F1-3. Flow network for the Beaverhead TPA.

F5.4 R-FACTOR

The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University, at 4 km grid cell resolution (**Figure F1-4**). For the purposes of this analysis, the SCAS R-factor grid was reprojected to Montana State Plane Coordinates (NAD83, meters), resampled to a 10m analytic cell size and clipped to the extent of the Beaverhead TPA, to match the project's standard grid definition.

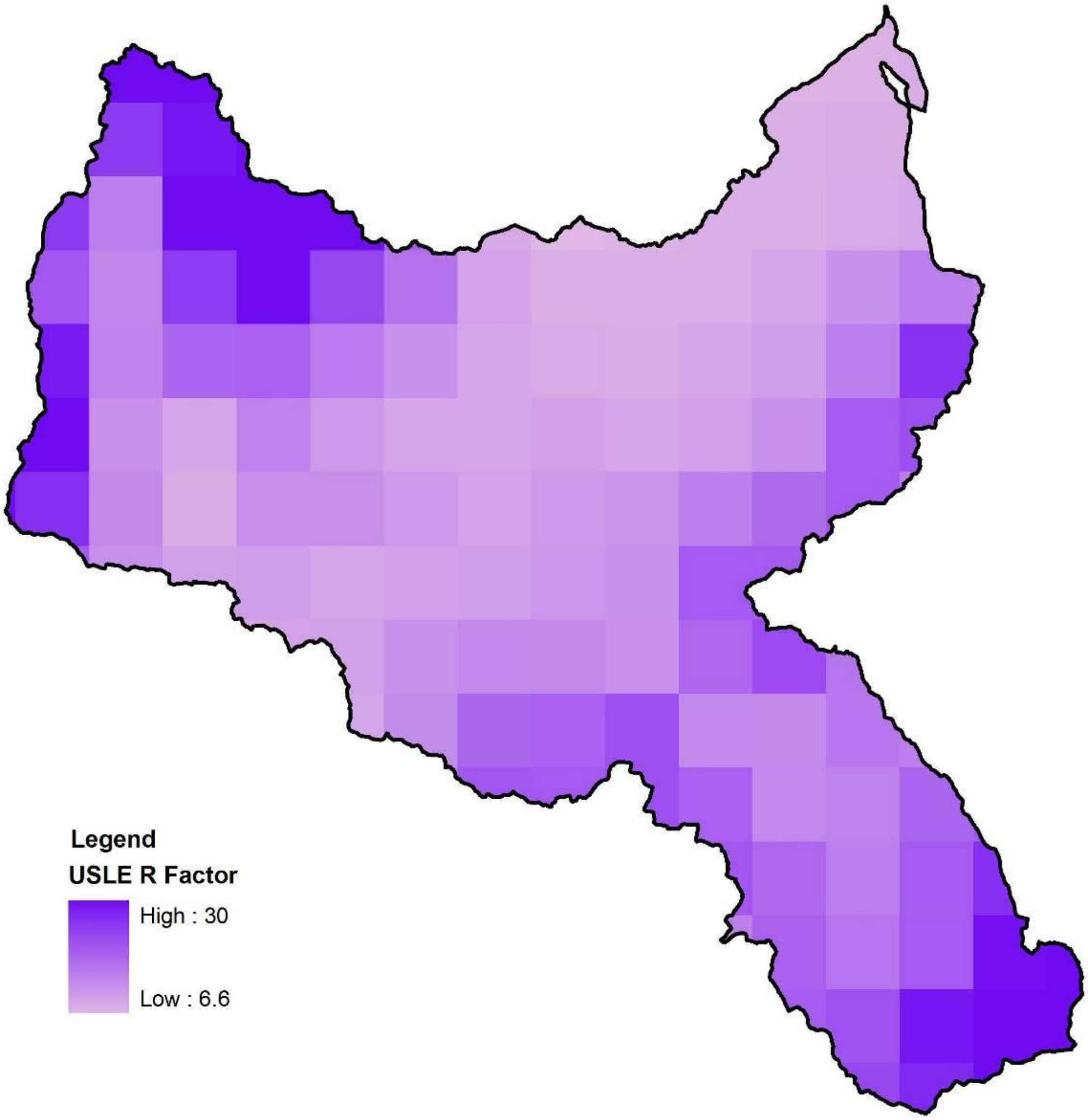

Figure F1-4. ULSE R-factor for the Beaverhead TPA.

F5.5 K-Factor

The soil erodibility factor grid was compiled from the 1:250K STATSGO and SSURGO data, as published by the NRCS. SSURGO data has higher resolution and is more current than the STATSGO data, however, the SSURGO data for the Beaverhead TPA did not contain the required K-factor for the entire watershed. STATSGO data was used to fill in the blanks (**Figure F1-5**). STATSGO and SSURGO database tables were queried to calculate a component weighted K value for all surface layers, which was then summarized by individual map unit. The map unit K values were then joined to a GIS polygon coverage of the map units, and the polygon coverage was converted to a 10m analytic grid for use in the model.

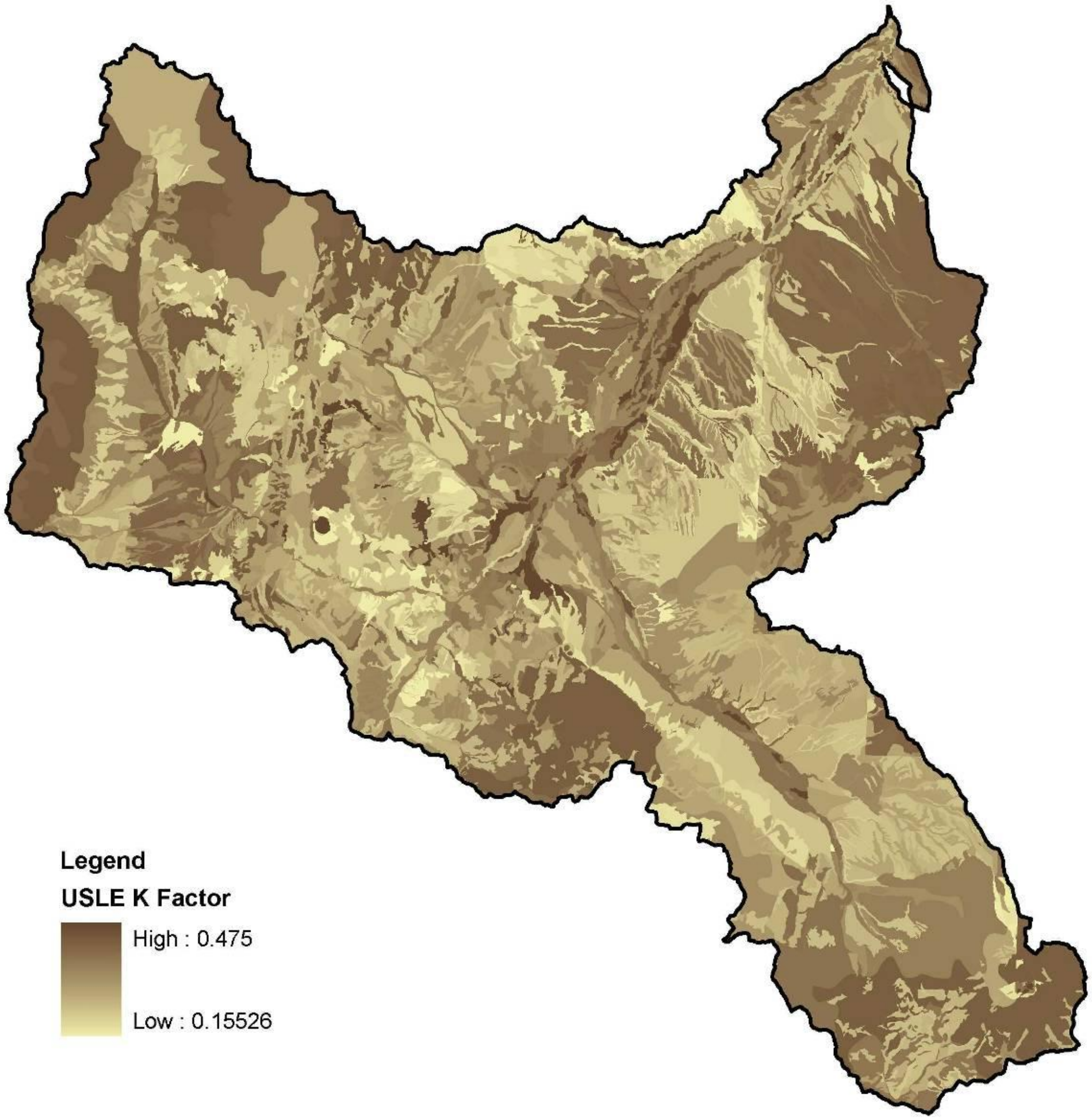

Figure F1-5. ULSE K-factor for the Beaverhead TPA

F5.6 LS-FACTOR

The equation used for calculating the slope length and slope factor was that given in the updated definition of RUSLE, as published in USDA handbook #703:

LS = Si (λim+1 - λi-1m+1) / (λI - λi-1) (72.6)m

Where:

λi = length in feet from top of slope to lower end of the segment. This value was determined by applying GIS based surface analysis procedures to the Beaverhead TPA DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters (**Figure F1-6**). In accordance with research that indicates that, in practice, the slope length rarely exceeds 400 ft, λ was limited to that maximum value.

Si = slope steepness factor for the ith segment.
= 10.8 sin θ + 0.03 for θ < 9%
= 16.8 sin θ - 0.50 for θ > 9%

m = a variable slope-length exponent.
= β / (1 + β)

and

B = ratio of rill to interrill erosion.
= (sin θ / 0.0896) / [3.0 (sin θ)0.8 + 0.56]

θ = slope angle as calculated by GIS based surface analysis procedures from the Beaverhead TPA DEM.

The LS factor grid was calculated from individual grids computed for each of these sub factors, using a simple ArcView Model Builder script.

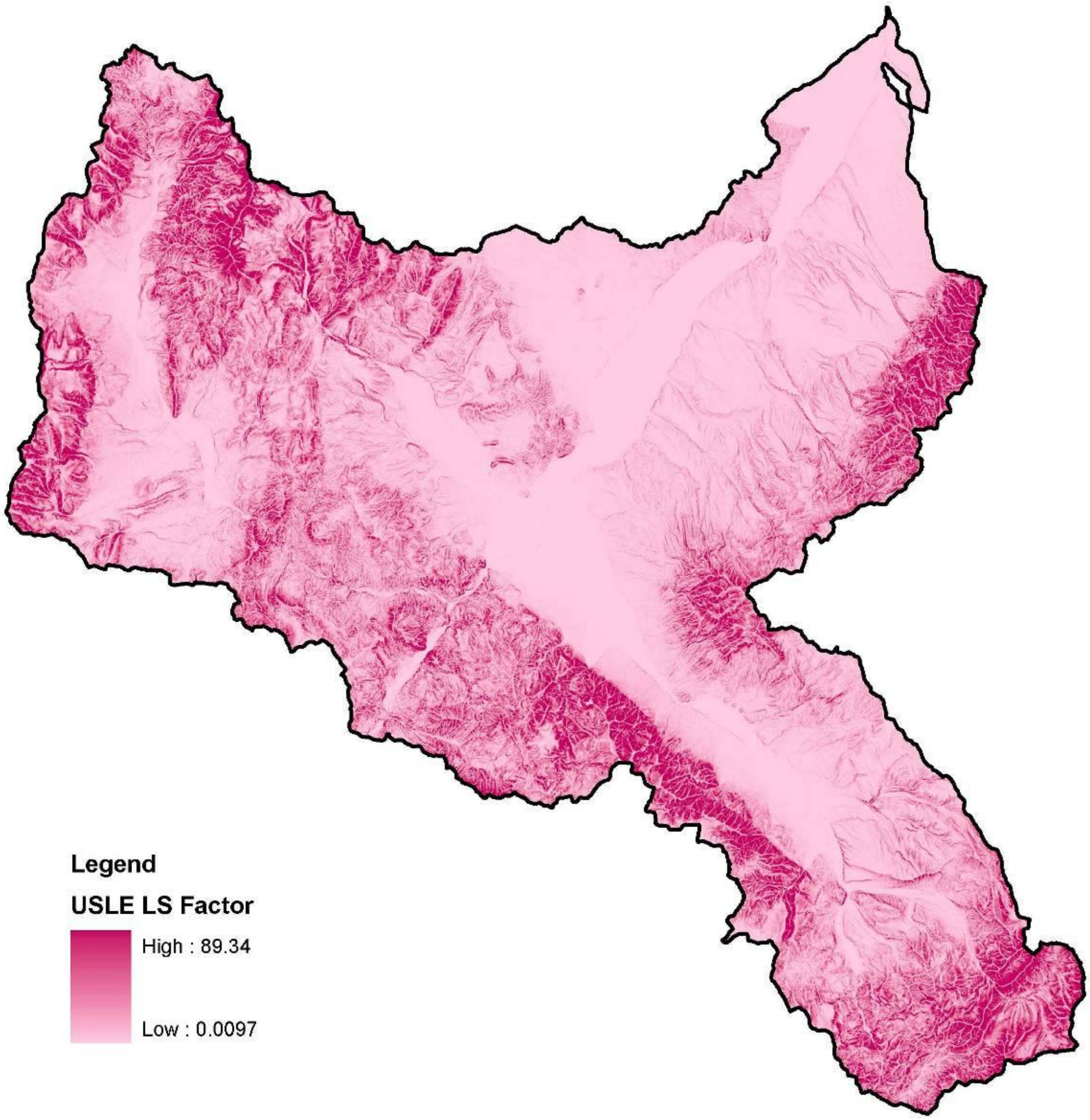

Figure F1-6. ULSE LS-factor for the Beaverhead TPA

F5.7 NLCD

The 2001 National Land Cover Dataset (NLCD) was obtained from USGS for use in establishing USLE C-factors for the Beaverhead TPA (**Figure F1-7**). The 2001 NLCD is the most current NLCD for the project are, and is a categorized 30 meter Landsat Thematic Mapper image shot in 2001. The NLCD image was reprojected to Montana State plane projection/coordinate system, and resampled to the project standard 10m grid. NLCD land cover classification codes for areas present in the Beaverhead TPA are described as follows:

11. Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

21. Developed, Open Space - Includes areas with a mixture of constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total

cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24. Developed, High Intensity – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.

41. Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grasslands/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

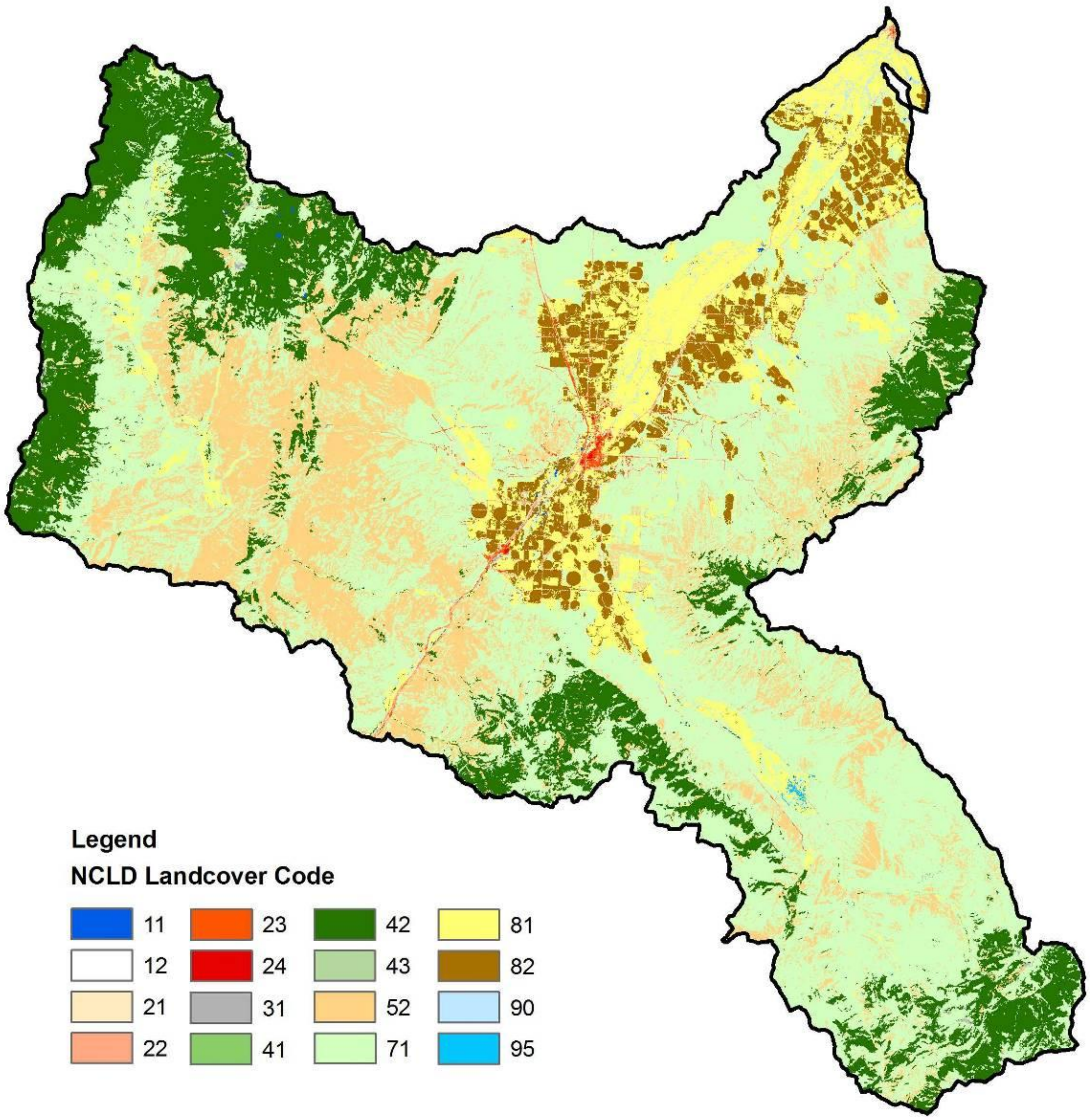

Figure F1-7. NLCD Landcover for the Beaverhead TPA.

F5.8 Logging and Fire Adjustment

In general, the land use classification of the NLCD was accepted as is, without ground truthing of original results or correction of changes that may have occurred since the NLCD image was shot. Given that we are looking for watershed and sub-watershed scale effects, the relative simplicity of the land use mix in the Beaverhead TPA, and the relative stability of that land use over the 10 years since the Landsat image that the NLCD is based on was taken, this was considered to be a reasonable assumption. One adjustment to the NLCD is necessary and appropriate, however. That is to quantify the amount of logging or fires that has occurred since 2001, and to also identify previously disturbed areas that are reforesting over that same period (**Figure F1-8**). As with other land uses in the valley, logging is a sustainable land use, but it is a land use that causes a land cover change that may affect sediment production.

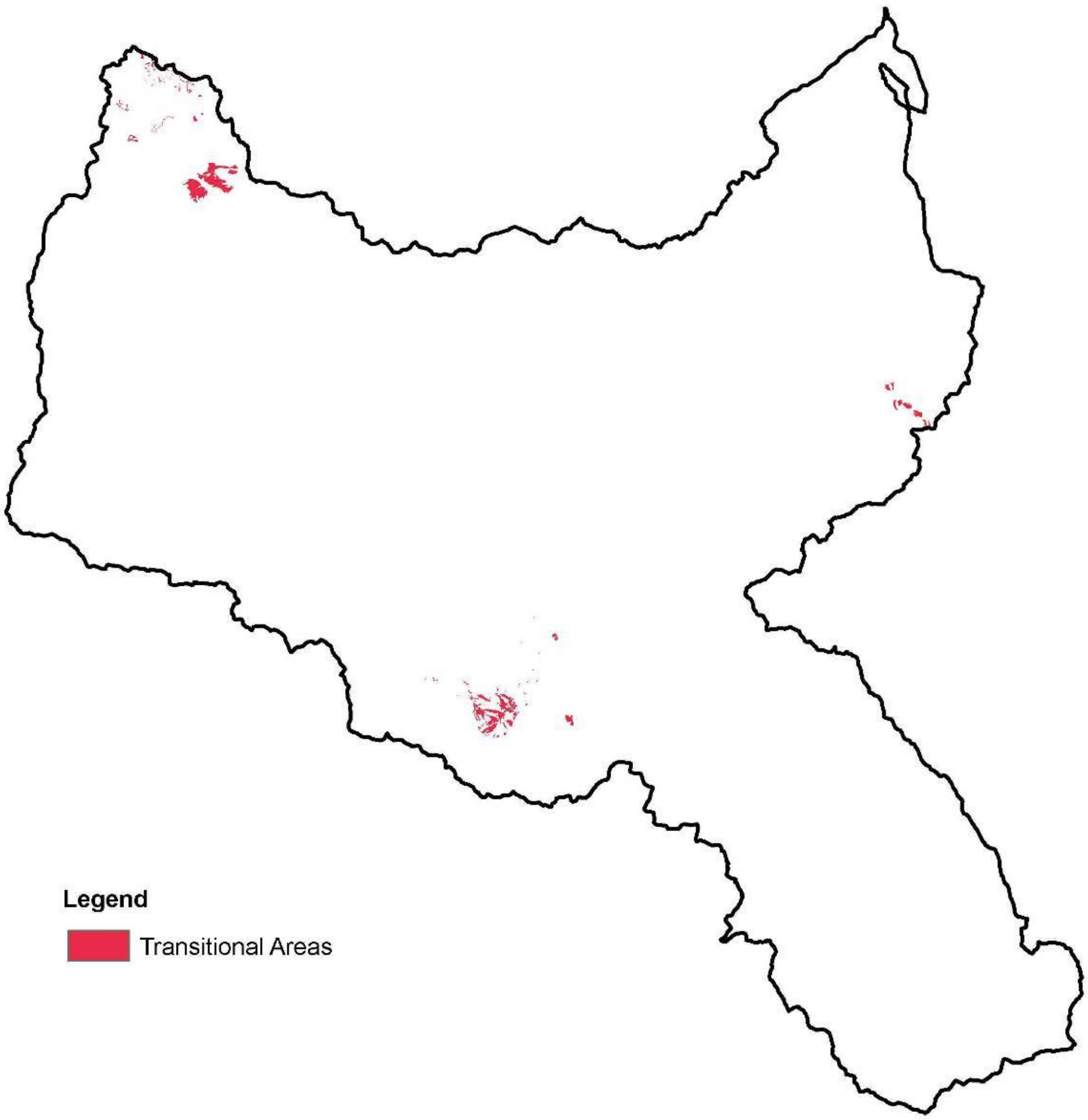

Figure F1-8. Logging and fire areas for the Beaverhead TPA.

Adjustment for logging was accomplished by using fire and harvest record polygons provided by the U.S. Forest Service. Polygons with a fire or harvest date of 2001 or later were selected. Adjustment for logging on non-USFS property was accomplished by comparing the 2001 NLCD grid for the Beaverhead TPA with the 2009 NAIP aerial photography. Areas which were coded as a forest type (41, 42 or 43) on the NLCD were digitized and coded as Type 1 (logged) if they appeared to be other than forested (typically bare ground, grassland, or shrubland) on the NAIP photos, if there were indications of logging activity (proximity to forest or logging roads, appearance of stands, etc), and if they were on non-USFS land. For the purposes of sediment generation estimation, Type 1 (logging) adjustment areas were treated as 'transitional' and classified with the corresponding C-factor.

Adjustment for reforestation was also accomplished by comparing the 2001 NLCD grid for the Beaverhead TPA with the 2009 NAIP aerial photography. Areas which were coded as something other than forest on the NLCD, but which appeared to be forested on the NAIP photos were digitized and coded as Type 2 (reforesting). However, no areas of reforestation were noted for the Beaverhead TPA.

F5.9 C-Factor Derivation

For purposes of the base (existing conditions) scenario, the following scheme of reclassification was used to derive annualized USLE C-factors from the NLCD land cover classes present in the Beaverhead TPA. This reclassification is based on the NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland" and was developed with the assistance and input of local NRCS employees. A narrative description of the professional judgment involved in the selection of these factors and the NRCS table are provided in **Attachment FA**.

To estimate the potential reduction in sediment production that might be accomplished under the desired conditions scenario (application of best management practices), the model was re-run using a different C-factor reclassification scheme. Relative to the existing conditions C-factor scheme, the BMP C-factor for the 'transitional' land classification was changed to reflect the forest cover that most such areas are transitioning to in the Beaverhead TPA. The 'grasslands/herbaceous', 'shrub/scrub', 'pasture/hay', and 'woody wetlands' BMP C-factors were conservatively changed to reflect a 10 percent increase in ground cover over existing conditions. The 'cultivated crops' BMP C-factor was changed to reflect a 20 percent increase in ground cover over existing conditions. No change was applied to the other land use types within the Beaverhead TPA from the existing conditions scenario.

The C-factors for the two scenarios are presented in **Table F1-1 and F1-2.**

Table F1-1. C-factors in the Beaverhead TPA.

NLCD Code	Description	C-Factor Existing Condition	C-Factor Desired Condition	Percent of Watershed
71	Grasslands/Herbaceous	0.020	0.010	48.2%
52	Shrub/Scrub	0.020	0.010	18.0%
42	Evergreen Forest	0.003	0.003	16.2%
81	Pasture/Hay	0.020	0.010	9.5%
82	Cultivated Crops	0.200	0.100	4.6%
21	Developed, Open Space	0.003	0.003	1.5%
22	Developed, Low Intensity	0.001	0.001	0.7%
90	Woody Wetlands	0.013	0.006	0.4%
N/A	Transitional	0.006	0.003	0.3%
23	Developed, Medium Intensity	0.001	0.001	0.3%
31	Barren Land	0.001	0.001	0.1%
95	Emergent Herbaceous Wetlands	0.003	0.003	0.03%
24	Developed, High Intensity	0.001	0.001	0.02%
43	Mixed Forest	0.003	0.003	0.02%
41	Deciduous Forest	0.003	0.003	0.004%

Table F1-2. Changes in percent ground cover for agricultural land cover types between existing and improved management conditions.

Land Cover	Existing % Ground Cover	Improved % Ground Cover
Shrub/scrub	75	85
Grasslands/Herbaceous	75	85
Pasture/Hay	75	85
Transitional	90	95-100
Woody Wetlands	80	90
Cultivated Crops	20	40

F5.10 RIPARIAN HEALTH ASSESSMENT

Well vegetated riparian buffers have been shown to act as filters that remove sediment from overland flow. Because of this ability, the influence of riparian corridors on water quality is proportionately much greater than the relatively small area in the landscape they occupy. In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. Thus, information regarding riparian zone health can be used to refine estimates of sediment delivery to streams from upstream sources. This section describes a Riparian Health Assessment of the Beaverhead TPA.

F5.10.1 DEQ Riparian Quality Assessment

The riparian corridor quality assessment was provided by DEQ. The assessment was based on the results of the DEQ aerial assessment and reach delineation. Reaches were delineated based on a combination of physical attributes (ecoregion, valley slope, valley confinement, and stream order) and the presence and degree of adjacent human activity. For each reach, a riparian corridor condition was estimated using aerial photos, field notes, and best professional judgment. DEQ designated riparian corridor as having poor, moderately poor, fair, moderately good, or good quality. These determinations were made with consideration of adjacent land use, streamside vegetation, and the presence or absence of human activities. The cumulative length of the reaches within each category was then tallied for each stream, and the percent of the length of stream in each category was calculated.

The results of the riparian corridor quality assessment from DEQ for the sub-basins are shown in **Table F1-3**.

Table F1-3. Percent of stream length in each riparian quality category.

Sub-basin	Existing Conditions					BMP Conditions				
	Good	Moderately Good	Fair	Moderately Fair	Poor	Good	Moderately Good	Fair	Moderately Fair	Poor
Beaverhead (upper)	0	94	0	0	6	94	0	6	0	0
Beaverhead (lower)	0	0	97	0	3	97	0	3	0	0
Blacktail Deer Creek	0	0	49	49	2	31.9	66.1	2	0	0
Clark Canyon Creek	27	70	0	0	3	97	0	3	0	0
Dyce Creek	19.2	0	80.8	0	0	100	0	0	0	0
East Fork Blacktail Deer Creek	24.1	75.6	0.2	0	0.1	99.9	0	0.1	0	0
Farlin Creek	31	0	0	62	7	93	0	7	0	0

Table F1-3. Percent of stream length in each riparian quality category.

Sub-basin	Existing Conditions					BMP Conditions				
	Good	Moderately Good	Fair	Moderately Fair	Poor	Good	Moderately Good	Fair	Moderately Fair	Poor
French Creek	24	76	0	0	0	100	0	0	0	0
Grasshopper Creek	7	0	93	0	0	100	0	0	0	0
Rattlesnake Creek (upper)	12	0	84	0	4	96	0	4	0	0
Rattlesnake Creek (lower)	0	0	50	50	0	32.5	67.5	0	0	0
Reservoir Creek	14	0	86	0	0	100	0	0	0	0
Scudder Creek	11	0	83	0	6	94	0	6	0	0
Spring Creek	2	0	0	94	4	2	94	4	0	0
Steel Creek	25	0	0	23	52	25	23	52	0	0
Stone Creek (upper)	2	0	98	0	0	100	0	0	0	0
Stone Creek (lower)	0	0	0	100	0	0	100	0	0	0
Taylor Creek	5	0	95	0	0	100	0	0	0	0
West Fork Blacktail Deer Creek	1	0	49.5	49.5	0	100	0	0	0	0
West Fork Dyce Creek	12	0	88	0	0	100	0	0	0	0

F5.10.2 Correcting for Differences in Sub-basin Delineation

The sub-basin division used for the DEQ riparian quality assessment varies slightly from the sub-basin division used for this TMDL assessment. Where the TMDL sub-basin encompassed more than one sub-basin in the DEQ riparian quality assessment, the TMDL riparian quality was taken to be the area weighted average of the contributing sub-basins.

For Dyce Creek and East Fork Blacktail Deer Creek, the TMDL sub-basin of interest for this report was defined by more than one sub-basin in the DEQ riparian quality assessment. The percent of the TMDL sub-basin in each riparian quality category for Dyce Creek is based on Lower Dyce Creek and East Fork Dyce Creek. The percent of the TMDL sub-basin in each riparian quality category for East Fork Blacktail Deer Creek is based on East Fork Blacktail Deer Creek less Indian Creek and Indian Creek. For these TMDL sub-basins, the riparian quality was weighted by the percent of sub-basin area. The calculations are shown in **Table F1-4**.

Table F1-4. Calculation of Area Weighted Riparian Quality for Dyce Creek and East Fork Blacktail Deer Creek.

Existing Riparian Quality	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Sub-Total Percent of TMDL Sub-basin
	Lower Dyce Creek (2,553 acres)		East Fork Dyce Creek (3,841 acres)		Dyce Creek (6,394 acres)
Good	0	0 * 0.4 = 0	32	32 * 0.6 = 19.2	0 + 19.2 = 19.2
Moderately Good	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Fair	100	100 * 0.4 = 40.0	68	68 * 0.6 = 40.8	40.0 + 40.8 = 80.8
Moderately Fair	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Poor	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Total	100		100		100
	East Fork Blacktail Deer Creek		Indian Creek (1,359 acres)		E.F. Blacktail Deer

Table F1-4. Calculation of Area Weighted Riparian Quality for Dyce Creek and East Fork Blacktail Deer Creek.

Existing Riparian Quality	**Percent of Stream Length**	**Weighted Percent of TMDL Sub-basin by Area**	**Percent of Stream Length**	**Weighted Percent of TMDL Sub-basin by Area**	**Sub-Total Percent of TMDL Sub-basin**
	less Indian Creek (37,598 acres)				Creek (38,957 acres)
Good	22	22 * 0.97 = 21.34	92	92 * 0.03 = 2.76	21.34 + 2.76 = 24.10
Moderately Good	78	78 * 0.97 = 75.66	0	0 * 0.03 = 0	75.66 + 0 = 75.66
Fair	0	0 * 0.97 = 0	5	5 * 0.03 = 0.15	0 + 0.15 = 0.15
Moderately Fair	0	0 * 0.97 = 0	0	0 * 0.03 = 0	0 + 0 = 0
Poor	0	0 * 0.97 = 0	3	3 * 0.03 = 0.09	0 + 0.09 = 0.09
Total	100		100		100

F5.11 Distance and Riparian Health Based Sediment Delivery Ratio

The USLE model (upon which this model is founded) is, as its name states, a soil loss (i.e. sediment production) model. Soil lost from one area due to erosive processes is typically re-deposited a short distance downslope, therefore not all of the sediment produced from a hillslope erosion event is delivered to a stream channel. As TMDL questions deal specifically with sediment delivered to the stream, a method of accounting for re-deposition and ultimate delivery to streams is required.

With USLE based models, this accounting of sediment re-deposition is typically achieved through the application of a sediment delivery ratio (SDR), a factor that estimates the percentage of sediment produced that is ultimately delivered to the stream. We apply a distance based sediment delivery ratio that reflects the relationship between downslope travel distance and ultimate sediment delivery.

Given that riparian zones can be effective sediment filters when wide and well vegetated, that riparian zone health is susceptible to anthropogenic impacts and thus to land management decisions, and that the effectiveness of riparian zones as sediment filters has been quantified in the literature (i.e. Wegner, 1999 and Knutson and Naef 1997), we incorporate riparian zone health and its effect on sediment delivery into our distance based sediment delivery ratio.

F5.11.1 Distance based SDR

Megahan and Ketcheson (1996) found that the relationship between the percentage (by volume) of a sediment mass that travels a given percentage of the maximum sediment travel distance of that sediment mass is as shown in **Figure F1-9**.

Megahan and Ketcheson

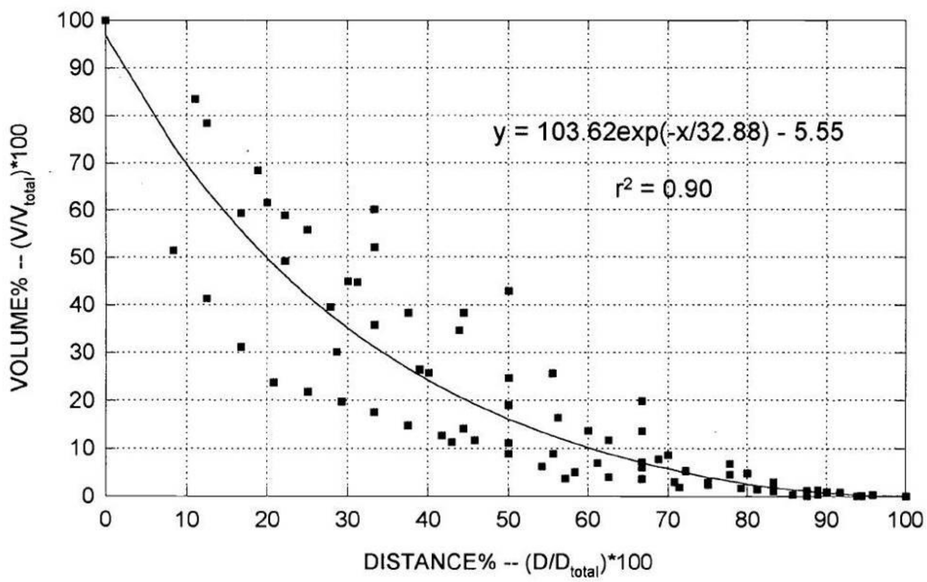

Figure 2. Dimensionless Plot of Sediment Volume Versus Travel Distance.

Figure F1-9. Figure 2 from Megahan and Ketcheson (1996), a dimensionless plot of sediment volume vs. travel distance.

This relationship was derived from a dataset of approximately 100 observations of sediment transport downslope from a known source (forest roads) that was not intercepted by a stream. It thus represents the 'typical' transport distribution along the maximum transport distance under a variety of field conditions.

Megahan and Ketcheson's logarithmic regression of the data permits this relationship to be expressed by the equation presented in **Figure F1-8**, which may be restated as a function of three variables:

Volume % = 103.62*EXP(-((D/Dtotal)/32.88))-5.55

where:

Volume% = the percentage of sediment mobilized from a source that travels at least distance D from that source

D = distance from the sediment source, and

Dtotal = the maximum distance that sediment travels from the source

As this equation is dimensionless, to serve as an SDR it must first be scaled to the field conditions of the study area. This is accomplished by evaluating the equation with site-specific values for D and Volume% at a single point, and solving for Dtotal. Having established a site-specific Dtotal, the M&K equation reduces to two unknowns, the two variables that define a distance based SDR: distance and percent sediment delivered beyond that distance. This SDR may be used to estimate sediment delivery at all points on the sediment delivery path, from streambank to a distance Dtotal.

The derivation of site-specific values of D and Volume % for use in scaling Megahan and Ketcheson's dimensionless equation is presented in **Section 1.5.10.2**

F5.11.2 Sub-basin specific Sediment Delivery Ratio scale factors.

Riparian zone sediment filtering capacity is typically expressed as a given percent reduction in delivery of sediment entering a riparian zone of a given width. This rating of a known percent delivery (Volume%) from a known distance from the stream (D) permits scaling of the Megahan and Ketcheson's dimensionless equation (**Section 1.5.11.1**) for use in predicting percent delivery from other distances.

Literature review (Wegner 1999, Knutson and Naef 1997) indicates that a 100 foot wide, well vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching its stream channel. Accordingly, this analysis conservatively assumes that a sediment reduction efficiency of 75% represents the performance of a 100 foot wide, high quality (good) vegetated riparian buffer in the Beaverhead TPA. Conversely, this analysis conservatively assumes that a 100 foot wide riparian zone without vegetation cover would only filter 10% of incoming sediment from reaching its stream. An approximately equal apportionment of the remaining range in sediment reduction efficiency between the 'poor', 'moderately fair', 'fair', and 'moderately good' riparian assessment categories results in the riparian health/sediment delivery relationship shown in **Figure F1-10**.

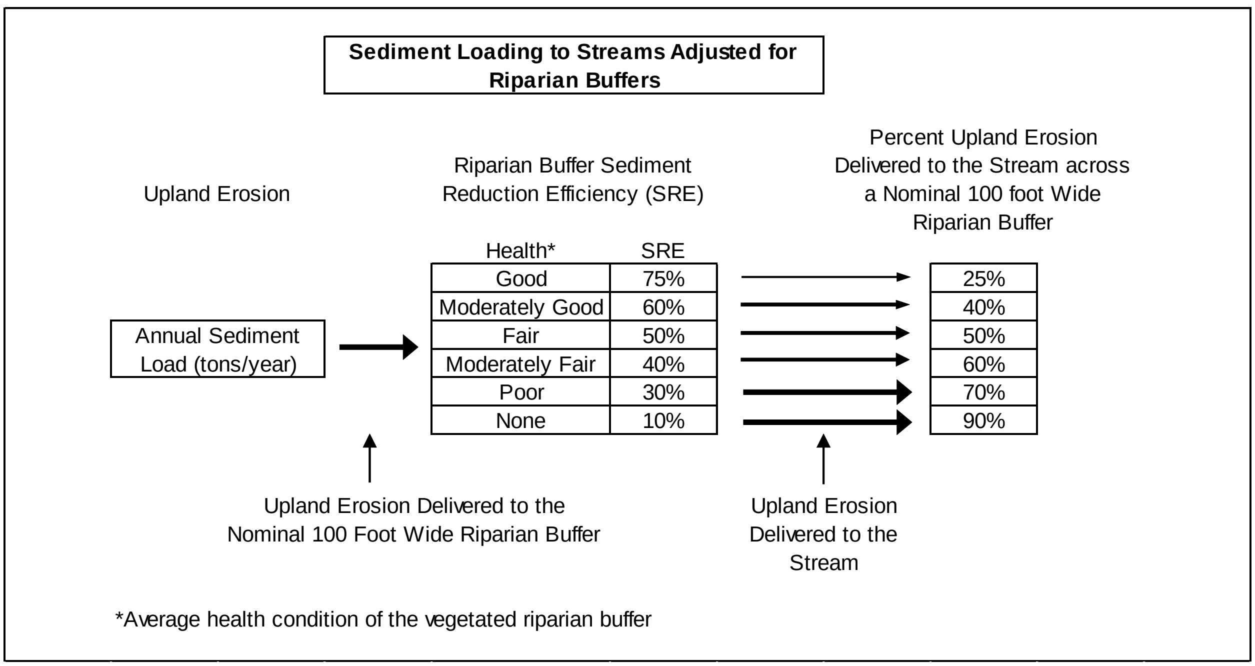

Figure F1-10. USLE Upland Sediment Load Delivery Adjusted for Riparian Buffer Capacity

Applying this relationship to the Beaverhead riparian assessment, we computed a riparian health score based sediment reduction percentage for each sub-basin of interest. This represents the percent reduction in delivery of sediment from a nominal 100 foot wide riparian zone. This was accomplished by taking the percentage of the stream length in each of the five riparian health classes, multiplying by the assumed sediment delivery efficiency reduction for each class (75% for good quality, 60% for moderately good quality, 50% for fair quality, 40% for moderately fair quality, and 30% for a poor quality) and summing for each stream.

The riparian health assessment based Sediment Reduction Percentage computed for each sub-basin of interest is presented in **Table F1-5**. Values are presented for both the existing conditions scenario and a BMP scenario. Under the BMP scenario, it is assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer will increase an area with poor quality riparian health to fair quality. The increase for areas with an existing riparian health quality of better than poor varies for each sub-basin depending on the potential for improvement as determined by DEQ.

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Farlin Creek	Good	31	23.3	93	69.8		-Mod. Fair to Good -Poor to Fair
	Mod. Good						
	Fair			7	3.5		
	Mod. Fair	62	24.8				
	Poor	7	2.1				
	Total		**50.2**		**73.3**	**23.1**	
Steel Creek	Good	25	18.8	25	18.8		-Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			23	13.8		
	Fair			52	26.0		
	Mod. Fair	23	9.2				
	Poor	52	15.6				
	Total		**43.6**				
Scudder Creek	Good	11	8.3	94	70.5		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	83	41.5	6	3.0		
	Mod. Fair						
	Poor	6	1.8				
	Total		**51.6**		**73.5**	**22.0**	
West Fork Dyce Creek	Good	12	9.0	100	75.0		-Fair to Good
	Mod. Good						
	Fair	88	44.0				
	Mod. Fair						
	Poor						
	Total		**53.0**		**75.0**		
Dyce Creek	Good	19.2	14.4	100	75.0		-Fair to Good
	Mod. Good						
	Fair	80.8	40.4				
	Mod. Fair						
	Poor						
	Total		**54.8**		**75.0**	**20.2**	

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Taylor Creek	Good	5	3.8	100	75.0		-Fair to Good
	Mod. Good						
	Fair	95	47.5				
	Mod. Fair						
	Poor						
	Total		**51.3**		**75.0**	**23.8**	
Reservoir Creek	Good	14	10.5	100	75.0		-Fair to Good
	Mod. Good						
	Fair	86	43.0				
	Mod. Fair						
	Poor						
	Total		**53.5**		**75.0**	**21.5**	
Grasshopper Creek	Good	7	5.3	100	75.0		-Fair to Good
	Mod. Good						
	Fair	93	46.5				
	Mod. Fair						
	Poor						
	Total		**51.8**		**75.0**	**23.3**	
Clark Canyon Creek	Good	27	20.3	97	72.8		-Mod. Good to Good -Poor to Fair
	Mod. Good	70	42.0				
	Fair			3	1.5		
	Mod. Fair						
	Poor	3	0.9				
	Total		**63.2**		**74.3**	**11.1**	
Beaverhead River Upper	Good			94	70.5		-Mod. Good to Good -Poor to Fair
	Mod. Good	94	56.4				
	Fair			6	3.0		
	Mod. Fair						
	Poor	6	1.8				
	Total		**58.2**		**73.5**	**15.3**	
French Creek	Good	24	18.0	100	75.0		-Mod. Good to Good
	Mod. Good	76	45.6				
	Fair						
	Mod. Fair						
	Poor						
	Total		**63.6**		**75.0**	**11.4**	
Rattlesnake Creek Upper	Good	12	9.0	96	72.0		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	84	42.0	4	2.0		
	Mod. Fair						
	Poor	4	1.2				
	Total		**52.2**		**74.0**	**21.8**	

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Rattlesnake Creek Lower	Good			32.5	24.4		-65% Fair to Good -35% Fair to Mod. Good -Mod. Fair to Mod. Good
	Mod. Good			67.5	40.5		
	Fair	50	25.0				
	Mod. Fair	50	20.0				
	Poor						
	Total		**45.0**		**64.9**	**19.9**	
West Fork Blacktail Deer Creek	Good	1	0.8	100	75.0		-Fair to Good -Mod. Fair to Good
	Mod. Good						
	Fair	49.5	24.8				
	Mod. Fair	49.5	19.8				
	Poor						
	Total		**45.3**		**75.0**	**29.7**	
East Fork Blacktail Deer Creek	Good	24.1	18.1	99.9	74.9		-Mod. Good to Good -Fair to Good -Poor to Fair
	Mod. Good	75.7	45.4				
	Fair	0.2	0.1	0.1	0.05		
	Mod. Fair						
	Poor	0.1	0.03				
	Total		**63.6**		**75.0**	**11.4**	
Blacktail Deer Creek	Good			31.9	23.9		-65% Fair to Good -35% Fair to Mod. Good -Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			66.1	39.7		
	Fair	49	24.5	2	1.0		
	Mod. Fair	49	19.6				
	Poor	2	0.6				
	Total		**44.7**		**64.6**	**19.9**	
Stone Creek Upper	Good	2	1.5	100	75.0		-Fair to Good
	Mod. Good						
	Fair	98	49.0				
	Mod. Fair						
	Poor						
	Total		**50.5**		**75.0**	**24.5**	
Stone Creek Lower	Good						-Mod. Fair to Mod. Good
	Mod. Good			100	60.0		
	Fair						
	Mod. Fair	100	40.0				
	Poor						
	Total		**40.0**		**60.0**	**20.0**	
Spring Creek	Good	2	1.5	2	1.5		-Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			94	56.4		
	Fair			4	2.0		
	Mod. Fair	94	37.6				
	Poor	4	1.2				
	Total		**40.3**		**59.9**		

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Beaverhead River Lower	Good			97	72.8		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	97	48.5	3	1.5		
	Mod. Fair						
	Poor	3	0.9				
	Total		**49.4**		**74.3**	**24.9**	

F5.11.3 Sediment Delivery Ratio - Example Calculation

To create a final, sub-basin specific SDR, Megahan and Ketcheson's dimensionless equation relating percent sediment volume to percent travel distance (**Figure F1-9**) was scaled to each sub-basin by using its riparian health assessment based 100 ft Sediment Reduction Percentage to derive a site-specific maximum sediment travel distance. For each sub-basin, the following method was applied:

1. From the sub-basin's Riparian Health Assessment, determine the expected % sediment delivery across a nominal 100 foot wide riparian zone.

   Example:
   Per **Table F1-5**, the Beaverhead River Lower sub-basin's expected existing sediment delivery across a **100** foot wide riparian zone is (100% - 49.4% reduction) = **50.6%** delivered.

2. Substitute the expected % sediment delivery across a 100 foot wide riparian zone into Megahan and Ketcheson's dimensionless sediment volume vs. travel distance equation.

   Example:
   Volume% = 103.62exp(-((D/Dtotal)*100)/32.88) - 5.55 =

   50.6% = 103.62exp(-((**100**/Dtotal)*100)/32.88) - 5.55

3. Solve the M&K equation for Dtotal to arrive at a representative maximum sediment travel distance for that sub-basin.

   Example:
   50.6% = 103.62exp(-((**100**/Dtotal)*100)/32.88) - 5.55

   Dtotal = **100**/(-0.3288*ln((**50.6** + 5.55)/103.62))

   Dtotal = **496** feet

4. Restate the M&K equation using the sub-basin's calculated maximum sediment travel distance (Dtotal) to arrive at an integrated Distance and Riparian Health based Sediment Deliver Ratio (SDR) for that sub-basin.

Example:
Within the Beaverhead River Lower sub-basin, the SDR for an analytical pixel with a drainage path to the nearest stream of length **D** would be given by:

Volume% = 103.62exp(-((D/**496**)*100)/32.88) - 5.55

By this method, the Sediment Delivery Ratio for each analytical pixel in a Beaverhead TPA sub-basin is obtained by evaluating this equation:

SDR = 103.62*EXP(-((D/**Dtotal**)/32.88))-5.55

Where:

SDR = the percentage of sediment generated from the pixel that is delivered to a stream;
D = the downslope distance from the pixel to the nearest stream channel; and
Dtotal = the sub-basin specific Riparian Health derived maximum sediment travel distance.

The results of the calculation for the Dtotal variable based on the DEQ riparian health assessment for the sub-basins are shown in **Table F1-6**.

Table F1-6. Results of D total calculations.

Sub-basin	Existing Conditions			BMP Conditions		
	Sediment Reduction Percentage	Sediment Delivery Percentage	Dtotal (feet)	Sediment Reduction Percentage	Sediment Delivery Percentage	Dtotal (feet)
Farlin Creek	50.2	49.8	486	73.3	26.7	261
Steel Creek	43.6	56.4	592	58.6	41.4	385
Scudder Creek	51.6	48.4	467	73.5	26.5	259
West Fork Dyce Creek	53.0	47.0	448	75.0	25.0	249
Dyce Creek	54.8	45.2	426	75.0	25.0	249
Taylor Creek	51.3	48.7	471	75.0	25.0	249
Reservoir Creek	53.5	46.5	442	75.0	25.0	249
Grasshopper Creek	51.8	48.2	464	75.0	25.0	249
Clark Canyon Creek	63.2	36.8	340	74.3	25.7	254
Beaverhead River Upper	58.2	41.8	388	73.5	26.5	259
French Creek	63.6	36.4	336	75.0	25.0	249
Rattlesnake Creek Upper	52.2	47.8	458	74.0	26.0	256
Rattlesnake Creek Lower	45.0	55.0	566	65.0	35.0	324
East Fork Blacktail Deer Creek	63.6	36.4	336	75.0	25.0	249
West Fork Blacktail Deer Creek	45.3	54.7	561	75.0	25.0	249
Blacktail Deer Creek	44.7	55.3	571	64.7	35.3	327
Stone Creek Upper	50.5	49.5	481	75.0	25.0	249
Stone Creek Lower	40.0	60.0	664	60.0	40.0	370
Spring Creek	40.3	59.7	658	59.9	40.1	371
Beaverhead River Lower	49.4	50.6	496	74.3	25.7	254

F5.12 MODEL ASSUMPTIONS

The following assumptions are made, concerning the applicability and accuracy of the model with respect to the intended use of the results:

1. That the USLE model is sufficiently accurate for TMDL purposes. Discussion: The USLE model has been in widespread use for more than thirty years, and has been found to be sufficient for natural resources management decision making at the field scale.
2. That it is appropriate to extend the field scale USLE model to watershed scale. Discussion: Many watershed scale implementations of the USLE model have been developed and presented in the peer reviewed literature. This model is a similar gridded USLE implementation, and it faithfully executes the methodology specified in USDA Agriculture Handbook No. 703. It operates in field scale on a 10 meter analytic pixel, and achieves watershed scale implementation through aggregation of field scale results.
3. That the data sources used are appropriate for USLE parameterization. Discussion: Data sources for USLE R and K factors were purpose built for that use. The USLE C factor is derived from Landsat thematic mapper imagery, classified by a rigorous process of peer reviewed methods into the NLCD landcover dataset. Specific assignment of C factors to landcover classes was performed under the guidance of natural resource professionals well versed in the application of USLE and USLE based sediment production models at the field scale. The USLE P factor was not used, as the best professional judgement of these same land managers is that the agricultural practices intended to be reflected by the USLE P factor are not in significant use in the Beaverhead TPA. The USLE L & S factors are mathematical constructs representing landform, and are derived here from Digital Terrain data. This analysis assumes that a 10 meter analytic pixel adequately describes the micro terrain slope and slope length at field scale. To the extent that this assumption is not met, results may deviate.
4. That the Riparian Health Assessment is of sufficient accuracy, resolution and coverage to serve as the basis for a sediment delivery ratio. Discussion: The Riparian Health Assessment only surveyed mainstem reaches. The condition of mainstem reaches is considered here to be broadly representative of overall watershed condition. To the extent that this assumption is not met, results may deviate proportionately.
5. That it is appropriate to use Megehan and Ketcheson's (1996) dimensionless equation relating sediment travel distance and delivered volume as the basis for a sediment delivery ratio. Discussion: Megehan and Ketcheson (1996) establishes that the purpose of the work is to provide an empirical alternative to process based modeling approaches for sediment delivery to streams. A decade later, Megehan and Ketcheson went on to produce the Washington Road Surface Erosion Model (WARSEM, 2004) which uses the Megehan and Ketcheson (1996) dimensionless equation as an SDR to account for delivery across fillslopes to streams. Here, we replicate Megehan and Ketcheson's use of the three variable dimensionless equation for the WARSEM SDR, evaluating that equation for a representative maximum sediment travel distance, and arriving at a scaled distance/sediment delivery relationship.

   A specific concern is that the Megehan and Ketcheson method, because it does not explicitly account for changes in vegetation as might be expected transitioning an upland/riparian zone boundary, may not adequately represent sediment delivery across a riparian zone. We note that whereas Megehan and Ketcheson used a single scaling of the dimensionless equation for all locations in an attempt to render the WARSEM model broadly applicable with minimum data collection needs, we take advantage of the available Beaverhead Riparian Health Assessment data to derive site-specific scalings of the dimensionless equation for Beaverhead sub-basins, based on riparian condition.

In this implementation, it is assumed that a significant difference in vegetation density between riparian and upland is unlikely to favor the upland, i.e. if there is a great difference, it is going to be a well vegetated near-stream zone paired with a sparsely vegetated upland. The most extreme instance of that would be reflected in this modeling approach as a ‘good’ riparian health category. For that category, we evaluate the dimensionless equation using the literature values of 75% sediment reduction at 100 feet, deriving a Dtotal value that may be used to estimate the percent sediment reduction at all distances. If failing to explicitly account for a significant change in vegetation produces a ‘bust’ in this procedure, it will be that it somewhat underestimates the sediment delivered from the upland portion of the delivery path. Given that:

- the maximum percent delivery for that portion of the path is 25%, declining to 0% at the outer bound, and
- that vegetation is only one component of the obstruction value, and
- that the obstruction value is only one of the factors predictive for sediment delivery,

we may conclude that the maximum effect of such a vegetation difference induced ‘bust’ is, in the most extreme case, some small fraction of 25%. Working down from that rare, most extreme case - if riparian condition and immediately adjacent upland condition are more similar, the potential magnitude of a ‘bust’ rooted in their difference becomes smaller as well. This places potential error in sediment due to the riparian transition well within the bounds of this effort.

6. That the uncalibrated watershed scale USLE model and sediment delivery ratio are sufficiently accurate for Beaverhead TMDL purposes. Discussion: The USLE is an empirical model developed initially for eastern US croplands, but has been extended via revised C factors and other means to be more broadly applicable. The C factors used for this effort were chosen to be as representative of Beaverhead conditions as professional judgement allows. The Megehan and Ketcheson dimensionless equation was similarly developed as an empirical method for sediment delivery accounting in watersheds similar to the Beaverhead. The implementation of that SDR method used here is further fit to the Beaverhead project area with the use of site-specific scaling factors. Both components of the model remain uncalibrated to local conditions however, in the sense that these attempts to better represent the Beaverhead TPA have not been tested empirically. Use of the results for relative comparison (as between sub-basins or alternative management scenarios) is well supported. Use of the results as predictors of absolute sediment load should be undertaken with care. Though both the USLE and the Megehan and Ketcheson SDR are currently in widespread use for absolute prediction of sediment load, local verification of predictive power is (as here) rarely undertaken.

F6.0 Results

F6.1 Management Scenarios

Figures F1-11 through **F1-14** present the USLE based hillslope model’s prediction of existing and potential conditions graphically. **Table F1-7** presents the prediction of existing and potential conditions numerically, broken out by 6th code HUC (as modified to represent the 303(d) listed streams) and existing land cover type. **Table F1-8** presents the delivered sediment load cumulative totals within the watershed. The cumulative totals for a sub-basin are a sum of the results for that sub-basin plus the sub-basins upstream of it. For example, Blacktail Deer Creek is a sum of the results for that sub-basin plus the results for West Fork Blacktail Deer Creek and East Fork Blacktail Deer Creek.

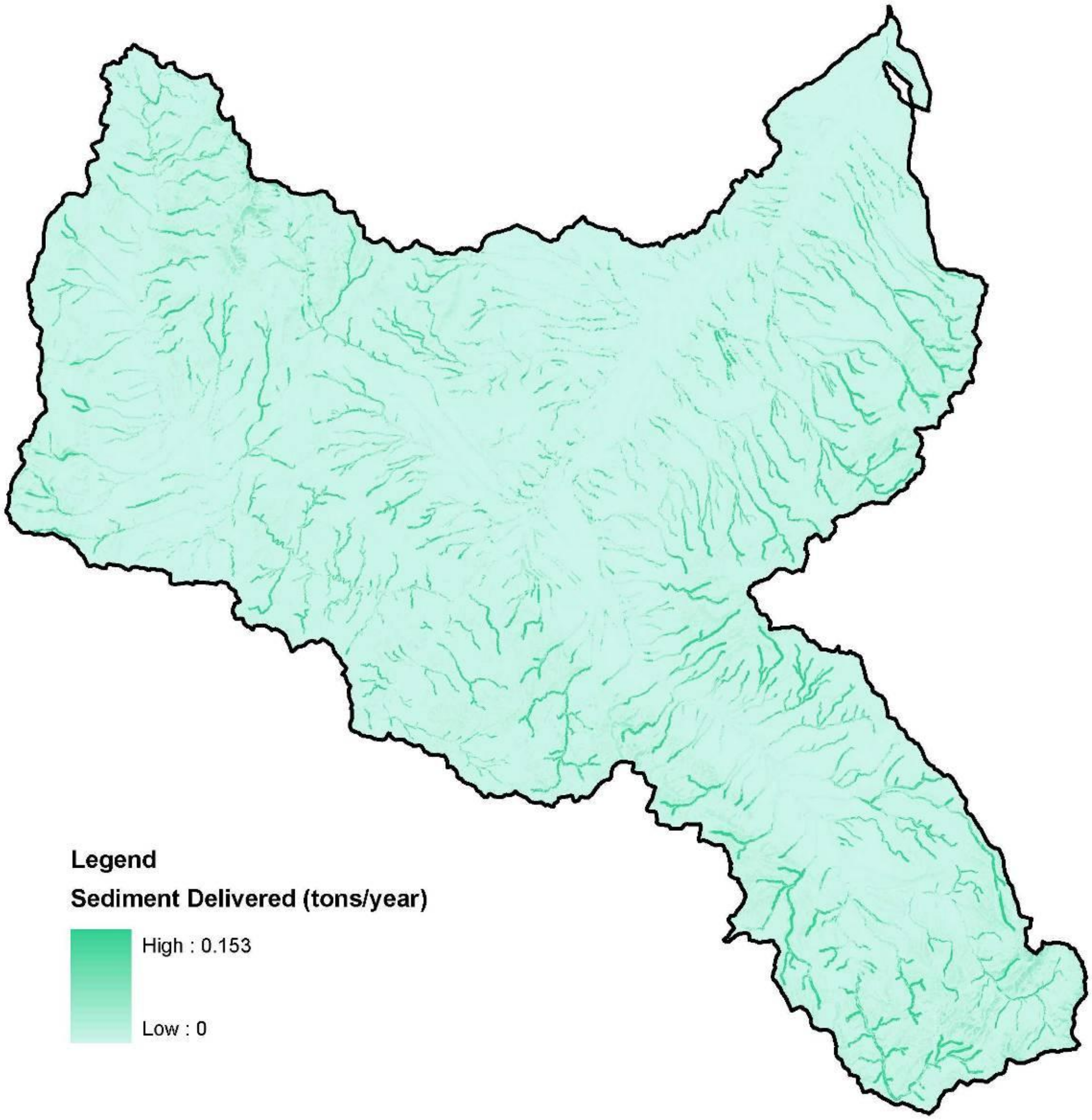

Figure F1-11. Upland Erosion Sediment Load for Existing Upland Conditions and Existing Riparian Health Conditions, Scenario 1.

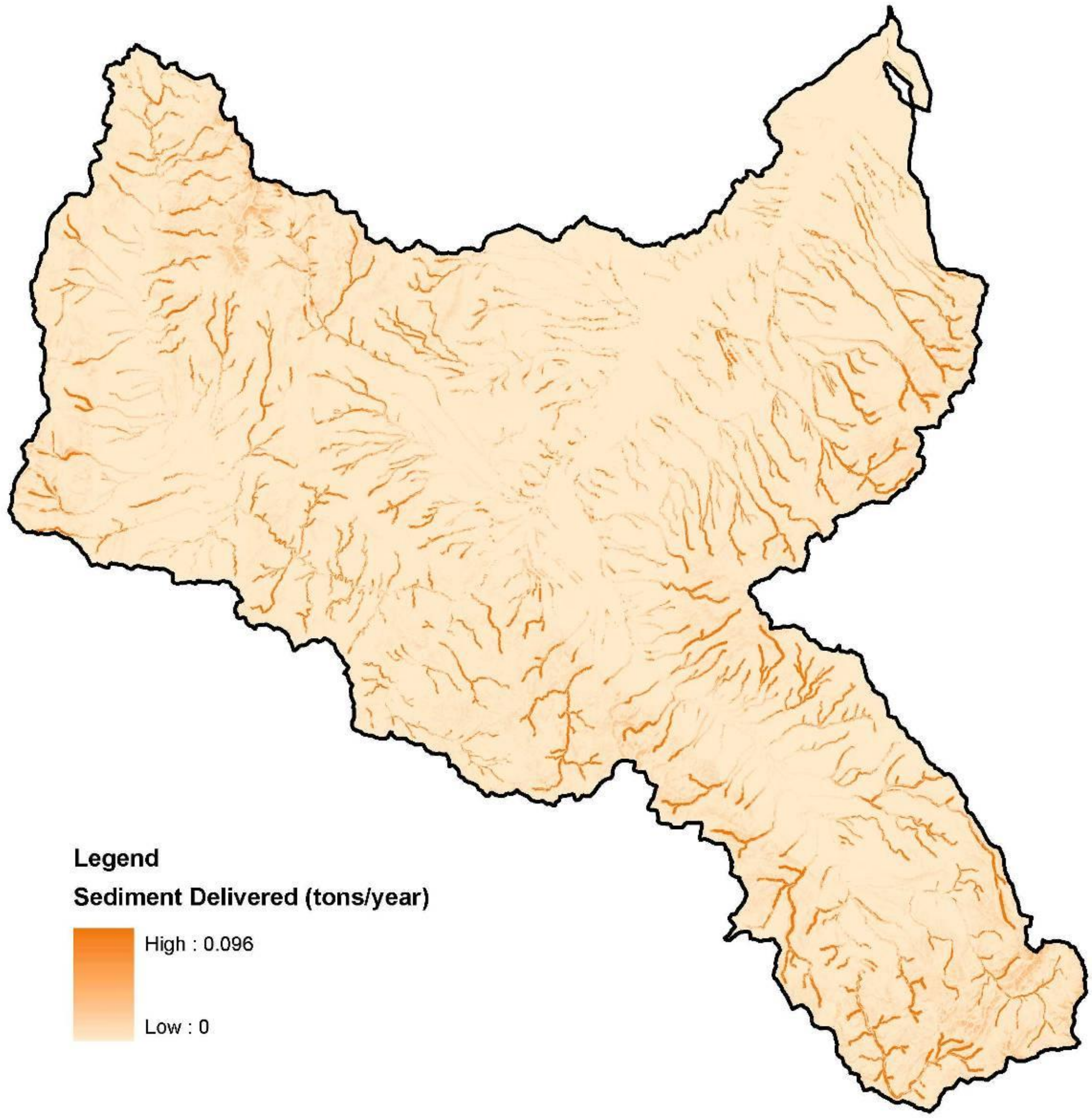

Figure F1-12. Upland Erosion Sediment Load for BMP Upland Conditions and Existing Riparian Health Conditions, Scenario 2.

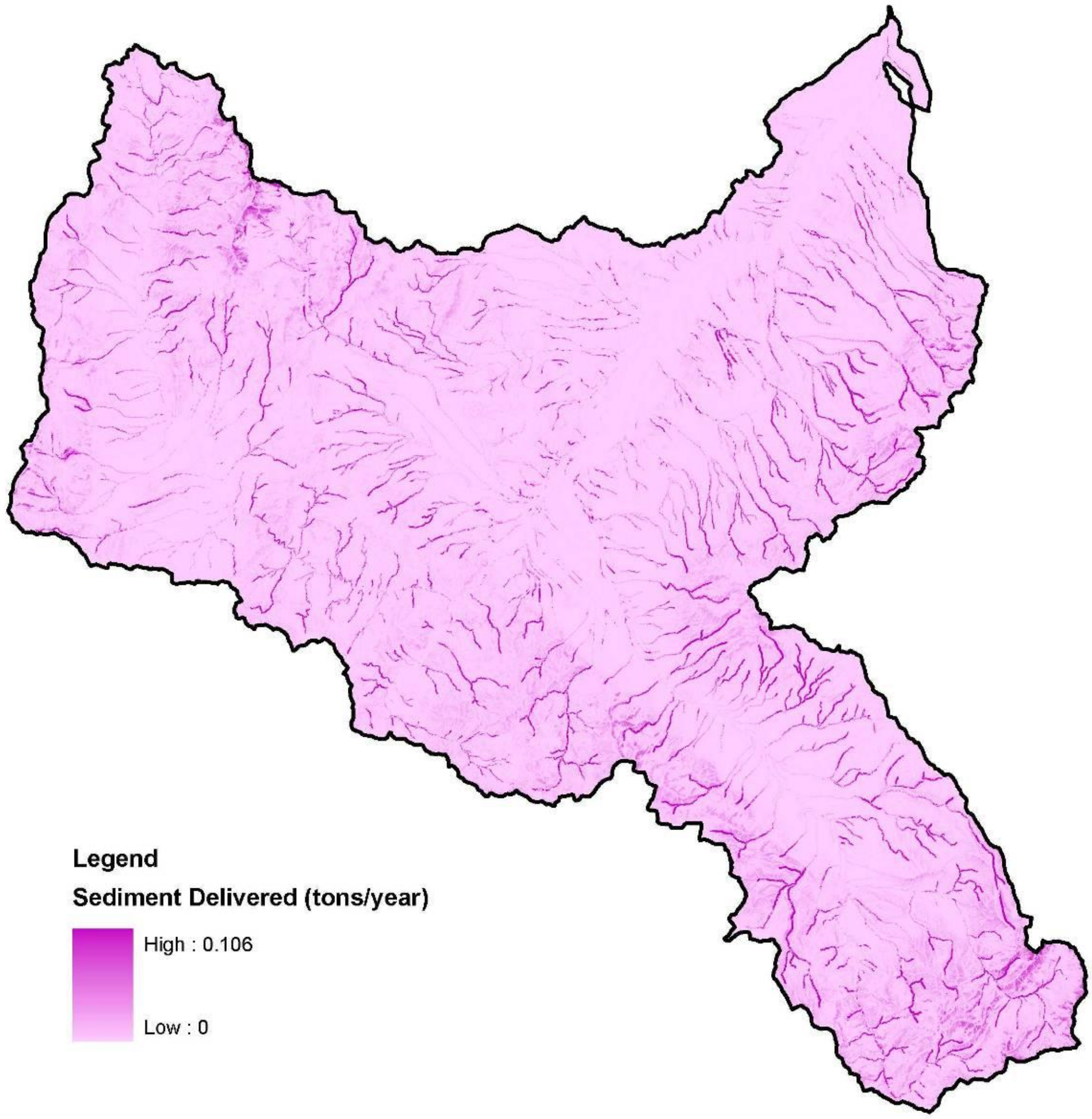

Figure F1-13. Upland Erosion Sediment Load for Existing Upland Conditions and BMP Riparian Health Conditions, Scenario 3.

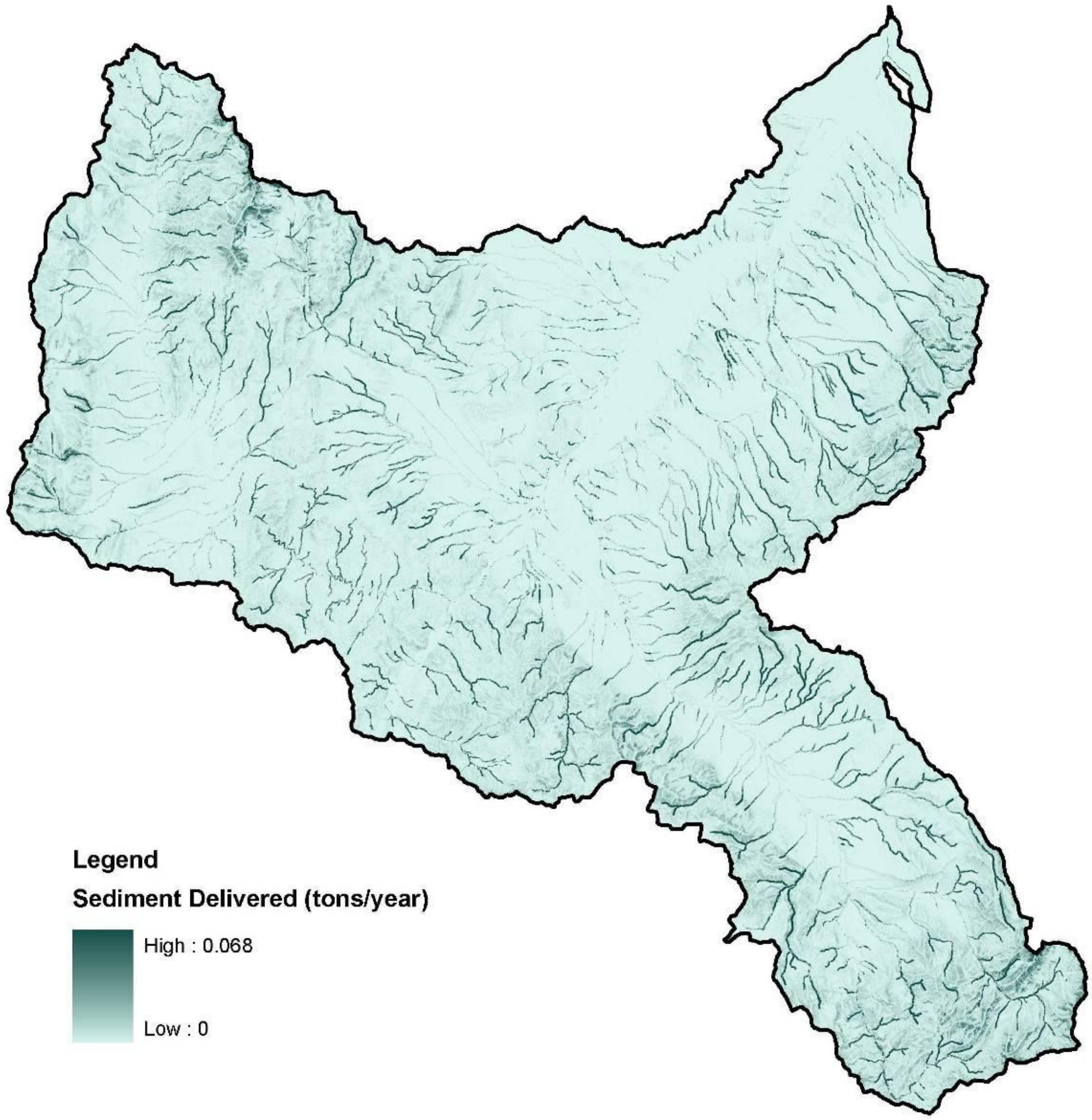

Figure F1-14. Upland Erosion Sediment Load for BMP Upland Conditions and BMP Riparian Health Conditions, Scenario 4.

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Farlin Creek	Grassland/herbaceous	905.2	46.5	23.3	50%	27.6	41%	13.8	70%
	Shrub/scrub	602.7	24.6	12.3	50%	17.8	28%	8.9	64%
	Evergreen forest	2,070.30	22.1	22.1	0%	12.9	42%	12.9	42%
	Pasture/Hay	28.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	8.9	<1	<1	0%	<1	0%	<1	0%
	Total	**3,615.50**	**93.5**	**57.8**	**38%**	**58.4**	**38%**	**35.6**	**62%**
Steel Creek	Grassland/herbaceous	920.2	34.4	17.2	50%	23	33%	11.5	67%
	Shrub/scrub	703	22.3	11.1	50%	13.4	40%	6.7	70%
	Evergreen forest	746.1	4.4	4.4	0%	3	32%	3	32%
	Pasture/Hay	0.2	<1	<1	0%	<1	0%	<1	0%
	Total	**2,369.60**	**61.1**	**32.7**	**46%**	**39.4**	**35%**	**21.2**	**65%**
Scudder Creek	Grassland/herbaceous	668.7	68.8	34.4	50%	36.3	47%	18.2	74%
	Shrub/scrub	433	28.4	14.2	50%	11.5	59%	5.8	80%
	Evergreen forest	799.3	5.6	5.6	0%	2.9	48%	2.9	48%
	Pasture/Hay	26.8	<1	<1	0%	<1	0%	<1	0%
	Barren land	0.7	<1	<1	0%	<1	0%	<1	0%
	Total	**1,928.60**	**103**	**54.3**	**47%**	**50.9**	**51%**	**26.9**	**74%**
West Fork Dyce Creek	Grassland/herbaceous	723.5	49.3	24.6	50%	27.7	44%	13.9	72%
	Shrub/scrub	508.5	29	14.5	50%	13	55%	6.5	78%
	Evergreen forest	1,106.20	10	10	0%	5.1	50%	5.1	50%
	Barren land	0.4	<1	<1	0%	<1	0%	<1	0%
	Total	**2,338.50**	**88.3**	**49.1**	**44%**	**45.8**	**48%**	**25.4**	**71%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Dyce Creek	Grassland/herbaceous	1,692.40	90.1	45.1	50%	52.7	42%	26.3	71%
	Shrub/scrub	2,612.00	50.2	25.1	50%	28	44%	14	72%
	Evergreen forest	1,970.10	17.9	17.9	0%	10.4	42%	10.4	42%
	Pasture/Hay	84.9	3.1	1.5	50%	1.7	45%	0.8	72%
	Developed, open space	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	19.9	<1	<1	0%	<1	0%	<1	0%
	Total	**6,393.80**	**161.4**	**89.7**	**44%**	**92.9**	**42%**	**51.7**	**68%**
Taylor Creek	Grassland/herbaceous	4,087.80	178.7	89.3	50%	90.3	49%	45.1	75%
	Shrub/scrub	7,362.00	153.7	76.9	50%	72.8	53%	36.4	76%
	Evergreen forest	1,993.80	8.1	8.1	0%	4.8	41%	4.8	41%
	Pasture/Hay	135.1	3.2	1.6	50%	1.6	49%	0.8	74%
	Developed, open space	27.3	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	6.6	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**13,613.70**	**343.7**	**175.9**	**49%**	**169.5**	**51%**	**87.1**	**75%**
Reservoir Creek	Grassland/herbaceous	4,589.90	76.5	38.2	50%	39	49%	19.5	74%
	Shrub/scrub	2,971.80	22.9	11.5	50%	12.9	44%	6.4	72%
	Evergreen forest	1,066.00	14.8	14.8	0%	8.6	42%	8.6	42%
	Pasture/Hay	282.8	2	1	50%	1.1	45%	0.5	73%
	Barren land	2.9	<1	<1	0%	<1	0%	<1	0%
	Total	**8,913.50**	**116.1**	**65.4**	**44%**	**61.5**	**47%**	**35**	**70%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Grasshopper Creek	Grassland/herbaceous	72,395.80	1,293.90	646.9	50%	727	44%	363.5	72%
	Shrub/scrub	49,785.70	1,015.70	507.9	50%	519.7	49%	259.9	74%
	Evergreen forest	54,946.30	525.1	525.1	0%	312.5	40%	312.5	40%
	Pasture/Hay	5,687.30	29.1	14.6	50%	15.6	47%	7.8	73%
	Developed, open space	160.2	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	77.5	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	67.6	<1	<1	0%	<1	0%	<1	0%
	Transitional	1,539.70	27.2	13.6	50%	16.8	38%	8.4	69%
	Developed, medium intensity	30.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	356.4	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	8.9	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	3.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	7.6	<1	<1	0%	<1	0%	<1	0%
	Total	**185,066.60**	**2,892.20**	**1,709.10**	**41%**	**1,592.50**	**45%**	**952.9**	**67%**
Clark Canyon Creek*	Grassland/herbaceous	4,159.10	64.6	48.5	25%	52.9	18%	39.8	38%
	Shrub/scrub	3,036.40	56.1	42.1	25%	42.8	24%	32	43%
	Evergreen forest	3,602.60	22.9	22.9	0%	18	21%	18	21%
	Pasture/Hay	67.8	1.8	0.9	50%	1.3	29%	0.6	65%
	Developed, open space	5.7	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	7.3	<1	<1	0%	<1	0%	<1	0%
	Transitional	163.5	1	0.5	50%	0.9	5%	0.5	53%
	Developed, medium intensity	5.5	<1	<1	0%	<1	0%	<1	0%
	Total	**11,047.80**	**146.3**	**114.9**	**21%**	**116**	**21%**	**90.9**	**38%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Beaverhead River Upper	Grassland/herbaceous	12,834.10	249.6	124.8	50%	171.1	31%	85.5	66%
	Shrub/scrub	9,811.30	184.4	92.2	50%	121.6	34%	60.8	67%
	Evergreen forest	240.3	2.2	2.2	0%	1.6	26%	1.6	26%
	Pasture/Hay	861	2.2	1.1	50%	1.4	36%	0.7	68%
	Developed, open space	580.2	2.3	2.3	0%	1.4	37%	1.4	37%
	Developed, low intensity	562	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	221.8	<1	<1	0%	<1	0%	<1	0%
	Transitional	778.1	8.1	4.1	50%	6.3	22%	3.2	61%
	Developed, medium intensity	112.7	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**26,002.60**	**449.7**	**227.4**	**49%**	**304**	**32%**	**153.7**	**66%**
French Creek	Grassland/herbaceous	1,796.80	160.7	80.3	50%	114.2	29%	57.1	64%
	Shrub/scrub	666.8	26.5	13.2	50%	19.7	25%	9.9	63%
	Evergreen forest	4,286.00	32.8	32.8	0%	25.3	23%	25.3	23%
	Pasture/Hay	0.9	<1	<1	0%	<1	0%	<1	0%
	Total	**6,750.60**	**219.9**	**126.3**	**43%**	**159.2**	**28%**	**92.2**	**58%**
Rattlesnake Creek Upper	Grassland/herbaceous	7,294.20	233.1	116.6	50%	175	25%	87.5	62%
	Shrub/scrub	6,846.50	145	72.5	50%	88.8	39%	44.4	69%
	Evergreen forest	13,932.40	109.4	109.4	0%	66.4	39%	66.4	39%
	Pasture/Hay	211.2	4.8	2.4	50%	2.7	44%	1.4	72%
	Developed, open space	6.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	125.7	<1	<1	0%	<1	0%	<1	0%
	Total	**28,421.50**	**492.8**	**301.3**	**39%**	**333.3**	**32%**	**200**	**59%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1: Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Scenario 2: Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Scenario 2: Percent Change from Existing	Scenario 3: Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Scenario 3: Percent Change from Existing	Scenario 4: Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Scenario 4: Percent Change from Existing
Rattlesnake Creek Lower	Grassland/herbaceous	26,358.20	337.2	168.6	50%	195.7	42%	97.9	71%
	Shrub/scrub	20,279.10	382.8	191.4	50%	212.1	45%	106.1	72%
	Evergreen forest	960	2.3	2.3	0%	1.8	21%	1.8	21%
	Pasture/Hay	4,884.10	11.3	5.7	50%	6.8	40%	3.4	70%
	Cultivated Crops	2,431.80	39.3	19.6	50%	22.5	43%	11.2	71%
	Developed, open space	1,049.30	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	518.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	268.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	13.7	<1	<1	0%	<1	0%	<1	0%
	Total	**56,767.90**	**773.5**	**388.2**	**50%**	**439.2**	**43%**	**220.7**	**71%**
West Fork Blacktail Deer Creek	Grassland/herbaceous	21,176.00	967.2	483.6	50%	434.5	55%	217.3	78%
	Shrub/scrub	3,027.00	98.1	49	50%	42.8	56%	21.4	78%
	Evergreen forest	8,282.40	138.5	138.5	0%	62.9	55%	62.9	55%
	Pasture/Hay	74.9	2.4	1.2	50%	1	58%	0.5	79%
	Developed, open space	216.2	5.7	5.7	0%	1.7	70%	1.7	70%
	Developed, low intensity	1.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	23.5	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	7.1	<1	<1	0%	<1	0%	<1	0%
	Total	**32,810.50**	**1,212.10**	**678.2**	**44%**	**543**	**55%**	**303.8**	**75%**
East Fork Blacktail Deer Creek	Grassland/herbaceous	22,892.10	714	357	50%	575	19%	287.5	60%
	Shrub/scrub	2,623.70	50	25	50%	41.5	17%	20.7	59%
	Evergreen forest	12,801.80	148.2	148.2	0%	115.6	22%	115.6	22%
	Pasture/Hay	143.4	1.9	1	50%	1.3	30%	0.7	65%
	Woody Wetlands	6.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	295.6	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	127.7	<1	<1	0%	<1	0%	<1	0%
	Total	**38,892.40**	**915.6**	**532.6**	**42%**	**734.7**	**20%**	**425.7**	**54%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Blacktail Deer Creek	Grassland/herbaceous	113,640.40	3,273.90	1,636.90	50%	1,872.40	43%	936.2	71%
	Shrub/scrub	23,916.20	744.9	372.5	50%	372.4	50%	186.2	75%
	Evergreen forest	14,372.50	224.3	224.3	0%	130.5	42%	130.5	42%
	Pasture/Hay	10,735.50	39.8	19.9	50%	23.1	42%	11.5	71%
	Cultivated Crops	2,628.80	57.5	28.7	50%	32.9	43%	16.5	71%
	Developed, open space	1,929.60	3	3	0%	1.7	43%	1.7	43%
	Developed, low intensity	667.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	458.6	1.4	0.6	54%	0.8	40%	0.4	72%
	Developed, medium intensity	354.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	79	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	303.6	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	55.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	14	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	23	<1	<1	0%	<1	0%	<1	0%
	Total	**169,178.80**	**4,345.10**	**2,286.30**	**47%**	**2,434.10**	**44%**	**1,283.20**	**70%**
Stone Creek Upper	Grassland/herbaceous	8,703.30	428.9	214.5	50%	221.1	48%	110.5	74%
	Shrub/scrub	5,394.40	255.1	127.5	50%	116.3	54%	58.2	77%
	Evergreen forest	1,356.90	23.2	23.2	0%	10.7	54%	10.7	54%
	Pasture/Hay	244.1	3.4	1.7	50%	1.9	46%	0.9	73%
	Cultivated Crops	105.1	4.8	2.4	50%	2.1	55%	1.1	78%
	Developed, open space	99.3	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	7.8	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.7	<1	<1	0%	<1	0%	<1	0%
	Barren land	18.6	<1	<1	0%	<1	0%	<1	0%
	Total	**15,932.10**	**715.9**	**369.8**	**48%**	**352.3**	**51%**	**181.6**	**75%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Stone Creek Lower	Grassland/herbaceous	4,179.40	68	34	50%	39.7	42%	19.9	71%
	Shrub/scrub	873.6	19.2	9.6	50%	10	48%	5	74%
	Pasture/Hay	2,508.70	12.8	6.4	50%	6.9	46%	3.5	73%
	Cultivated Crops	2,012.60	112.1	56	50%	63.2	44%	31.6	72%
	Developed, open space	289.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	135.2	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	47.1	<1	<1	0%	<1	0%	<1	0%
	Total	**10,046.20**	**212.7**	**106.7**	**50%**	**120.2**	**44%**	**60.3**	**72%**
Spring Creek	Grassland/herbaceous	16,555.20	441.9	221	50%	240.2	46%	120.1	73%
	Shrub/scrub	3,865.10	133	66.5	50%	75.6	43%	37.8	72%
	Evergreen forest	5,660.80	108.4	108.4	0%	61.6	43%	61.6	43%
	Pasture/Hay	3,112.30	15.2	7.6	50%	8.7	43%	4.4	71%
	Cultivated Crops	1,605.70	51.4	25.7	50%	27.8	46%	13.9	73%
	Developed, open space	1,001.30	1.5	1.5	0%	0.8	46%	0.8	46%
	Developed, low intensity	197.6	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	9.9	<1	<1	0%	<1	0%	<1	0%
	Transitional	293	11.5	5.7	50%	5.8	50%	2.9	75%
	Developed, medium intensity	63.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	6.9	<1	<1	0%	<1	0%	<1	0%
	Total	**32,371.60**	**763.1**	**436.5**	**43%**	**420.8**	**45%**	**241.6**	**68%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Beaverhead River Lower	Grassland/herbaceous	129,130.40	2,200.00	1,100.00	50%	1,103.50	50%	551.7	75%
	Shrub/scrub	24,982.10	723.3	361.6	50%	349.7	52%	174.9	76%
	Evergreen forest	22,443.50	316.4	316.4	0%	164.4	48%	164.4	48%
	Pasture/Hay	60,943.30	103.6	51.8	50%	56.9	45%	28.5	73%
	Cultivated Crops	34,814.20	485	242.5	50%	249.4	49%	124.7	74%
	Developed, open space	8,424.70	8.9	8.9	0%	3.7	59%	3.7	59%
	Developed, low intensity	4,031.70	1.1	1.1	0%	0.5	55%	0.5	55%
	Woody Wetlands	3,310.60	3.9	1.8	54%	2.6	32%	1.2	69%
	Transitional	274.7	3.6	1.8	50%	2.1	42%	1	71%
	Developed, medium intensity	2,119.90	<1	<1	0%	<1	0%	<1	0%
	Barren land	68.5	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	130.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	1.2	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	2.7	<1	<1	0%	<1	0%	<1	0%
	Total	**290,677.90**	**3,846.20**	**2,086.40**	**46%**	**1,933.00**	**50%**	**1,050.80**	**73%**

*C factors for the desired condition of Grassland/Herbaceous and Shrub/Scrub were adjusted from .010 to .015 in Clark Canyon Creek to account for sections of highly erodable upland areas, within those land cover types, where vegetative cover is unlikely to improve. Adjustments were made after recommendations from a memorandum to the FWP from Applied Geomorphology regarding a Clark Canyon Creek field visit by several local stakeholders.

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Scudder Creek Total (Steel Ck and Scudder Ck)	Grassland/herbaceous	1,588.9	103.2	51.6	50%	59.3	43%	29.6	71%
	Shrub/scrub	1,136.1	50.7	25.3	50%	25.0	51%	12.5	75%
	Evergreen forest	1,545.4	10.0	10.0	0%	5.9	41%	5.9	41%
	Pasture/Hay	27.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	0.7	<1	<1	0%	<1	0%	<1	0%
	Total	**4,298.2**	**164.0**	**87.0**	**47%**	**90.3**	**45%**	**48.1**	**71%**
Dyce Creek Total (West Fork Dyce Ck and Dyce Ck)	Grassland/herbaceous	2,415.8	139.4	69.7	50%	80.4	42%	40.2	71%
	Shrub/scrub	3,120.5	79.2	39.6	50%	41.1	48%	20.5	74%
	Evergreen forest	3,076.3	27.9	27.9	0%	15.5	45%	15.5	45%
	Pasture/Hay	84.9	3.1	1.5	50%	1.7	45%	0.8	72%
	Developed, open space	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	4.0	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	20.3	<1	<1	0%	<1	0%	<1	0%
	Total	**8,732.3**	**249.6**	**138.8**	**44%**	**138.7**	**44%**	**77.1**	**69%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Grasshopper Creek Total (Farlin Ck, Steel Ck, Scudder Ck, W.F. Dyce Ck, Dyce Ck, Taylor Ck, Reservoir Ck, and Grasshopper Ck)	Grassland/herbaceous	85,983.4	1,838.1	919.0	50%	1,023.5	44%	511.8	72%
	Shrub/scrub	64,978.7	1,346.8	673.4	50%	689.2	49%	344.6	74%
	Evergreen forest	64,698.1	607.9	607.9	0%	360.1	41%	360.1	41%
	Pasture/Hay	6,245.5	37.8	18.9	50%	20.2	47%	10.1	73%
	Developed, open space	192.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	88.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	68.7	<1	<1	0%	<1	0%	<1	0%
	Transitional	1,539.7	27.2	13.6	50%	16.8	38%	8.4	69%
	Developed, medium intensity	34.5	<1	<1	0%	<1	0%	<1	0%
	Barren land	390.2	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	8.9	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	3.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	7.6	<1	<1	0%	<1	0%	<1	0%
	Total	**224,239.6**	**3,859.2**	**2,234.1**	**42%**	**2,110.9**	**45%**	**1,235.9**	**68%**
Beaverhead River Upper Total (Clark Canyon C and Beaverhead River Upper)	Grassland/herbaceous	16,993.2	314.2	173.3	45%	224.00	29%	125.3	64%
	Shrub/scrub	12,847.7	240.4	134.3	44%	164.40	32%	92.8	66%
	Evergreen forest	3,842.9	25.1	25.1	0%	19.60	22%	19.6	22%
	Pasture/Hay	928.8	4.0	2	50%	2.70	33%	1.3	68%
	Developed, open space	585.9	2.3	2.3	0%	1.43	39%	1.4	39%
	Developed, low intensity	569.3	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	221.7	<1	<1	0%	<1	0%	<1	0%
	Transitional	941.6	9.1	4.5	51%	7.3	20%	3.6	60%
	Developed, medium intensity	118.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**37,050.4**	**596.0**	**342.2**	**43%**	**420.0**	**30%**	**244.6**	**59%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Rattlesnake Creek Upper Total (French Ck and Rattlesnake Ck Upper)	Grassland/herbaceous	9,091.0	393.8	196.9	50%	289.2	27%	144.6	63%
	Shrub/scrub	7,513.2	171.5	85.8	50%	108.5	37%	54.2	68%
	Evergreen forest	18,218.4	142.2	142.2	0%	91.7	36%	91.7	36%
	Pasture/Hay	212.1	4.8	2.4	50%	2.7	44%	1.4	72%
	Developed, open space	6.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	125.7	<1	<1	0%	<1	0%	<1	0%
	Total	**35,172.0**	**712.7**	**427.7**	**40%**	**492.4**	**31%**	**292.2**	**59%**
Rattlesnake Creek Total (Rattlesnake Ck Upper Total and Rattlesnake Ck Lower)	Grassland/herbaceous	35,449.2	731.0	365.5	50%	484.9	34%	242.4	67%
	Shrub/scrub	27,792.3	554.3	277.1	50%	320.6	42%	160.3	71%
	Evergreen forest	19,178.4	144.5	144.5	0%	93.5	35%	93.5	35%
	Pasture/Hay	5,096.2	16.2	8.1	50%	9.5	41%	4.7	71%
	Cultivated Crops	2,431.8	39.3	19.6	50%	22.5	43%	11.2	71%
	Developed, open space	1,055.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	518.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	6.2	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	272.3	<1	<1	0%	<1	0%	<1	0%
	Barren land	139.4	<1	<1	0%	<1	0%	<1	0%
	Total	**91,939.9**	**1,486.3**	**815.9**	**45%**	**931.7**	**37%**	**512.9**	**65%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Blacktail Deer Creek Total (W.F. Blacktail Deer Ck, E.F. Blacktail Deer Ck, and Blacktail Deer Ck)	Grassland/herbaceous	157,708.6	4,955.1	2,477.5	50%	2,881.9	42%	1,441.0	71%
	Shrub/scrub	29,566.9	893.1	446.5	50%	456.7	49%	228.3	74%
	Evergreen forest	35,456.7	511.0	511.0	0%	309.0	40%	309.0	40%
	Pasture/Hay	10,953.8	44.1	22.0	50%	25.4	42%	12.7	71%
	Cultivated Crops	2,628.8	57.5	28.7	50%	32.9	43%	16.5	71%
	Developed, open space	2,145.8	8.7	8.7	0%	3.4	61%	3.4	61%
	Developed, low intensity	668.2	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	467.7	1.6	0.7	54%	1.0	38%	0.4	72%
	Developed, medium intensity	354.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	398.0	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	304.7	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	55.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	148.8	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	23.0	<1	<1	0%	<1	0%	<1	0%
	Total	**240,881.6**	**6,472.8**	**3,497.1**	**46%**	**3,711.8**	**43%**	**2,012.8**	**69%**
Stone Creek Total (Stone Ck Upper and Stone Ck Lower)	Grassland/herbaceous	12,882.6	496.9	248.5	50%	260.8	48%	130.4	74%
	Shrub/scrub	6,268.0	274.3	137.1	50%	126.3	54%	63.1	77%
	Pasture/Hay	1,356.9	23.2	23.2	0%	10.7	54%	10.7	54%
	Cultivated Crops	2,752.7	16.3	8.1	50%	8.8	46%	4.4	73%
	Developed, open space	2,117.6	116.8	58.4	50%	65.3	44%	32.7	72%
	Developed, low intensity	388.9	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	143.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.7	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	47.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	18.6	<1	<1	0%	<1	0%	<1	0%
	Total	**25,978.3**	**928.7**	**476.4**	**49%**	**472.5**	**49%**	**241.9**	**74%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Beaverhead River Lower Total (Grasshopper Creek Total, Blacktail Deer Ck Total, Rattlesnake Ck Total, Stone Ck Total, Spring Ck, and Beaverhead River Lower)	Grassland/herbaceous	437,709.4	10,663.1	5,331.50	50%	5,994.8	44%	2,997.4	72%
	Shrub/scrub	157,453.0	3,924.7	1,962.40	50%	2,018.1	49%	1,009.1	74%
	Evergreen forest	148,794.3	1,711.3	1,711.20	0%	999.3	42%	999.3	42%
	Pasture/Hay	89,103.9	233.1	116.50	50%	129.5	44%	64.8	72%
	Cultivated Crops	43,598.1	750.0	375.00	50%	398.0	47%	199.0	73%
	Developed, open space	13,209.0	20.3	20.3	0%	8.5	58%	8.5	58%
	Developed, low intensity	5,647.1	1.5	1.5	0%	0.7	53%	0.7	53%
	Woody Wetlands	3,865.8	5.7	2.6	54%	3.7	35%	1.7	70%
	Transitional	2,107.4	42.3	21.20	50%	24.70	42%	12.3	71%
	Developed, medium intensity	2,892.6	<1	<1	0%	<1	0%	<1	0%
	Barren land	1,021.5	1.5	1.5	0%	1.4	7%	1.4	7%
	Emergent Herbaceous Wetlands	313.6	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	186.3	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	153.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	33.3	<1	<1	0%	<1	0%	<1	0%
	Total	**906,089.00**	**17,356.20**	**9,546.40**	**45%**	**9,580.70**	**45%**	**5,295.90**	**69%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Beaverhead River Total (Beaverhead River Upper Total and Beaverhead River Lower Total)	Grassland/herbaceous	454,702.6	10,977.3	5,504.8	50%	6,218.8	43%	3,122.7	72%
	Shrub/scrub	170,300.8	4,165.2	2096.7	50%	2,182.5	48%	1,101.9	74%
	Evergreen forest	152,637.2	1,736.3	1,736.3	0%	1,018.9	41%	1,018.9	41%
	Pasture/Hay	90,032.8	237.1	118.5	50%	132.2	44%	66.1	72%
	Cultivated Crops	43,598.1	750.0	375.0	50%	398.0	47%	199.0	73%
	Developed, open space	13,794.9	22.9	22.8	0%	10.1	56%	10.1	56%
	Developed, low intensity	6,216.4	2.1	2.1	0%	1.1	49%	1.1	49%
	Woody Wetlands	4,087.5	6.3	2.9	54%	4.1	35%	1.9	70%
	Transitional	3,049.0	51.4	25.7	50%	32.0	38%	16.0	69%
	Developed, medium intensity	3,010.8	<1	<1	0%	<1	0%	<1	0%
	Barren land	1,022.7	2.3	2.3	0%	2.1	6%	2.1	6%
	Emergent Herbaceous Wetlands	313.7	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	186.3	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	153.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	33.2	<1	<1	0%	<1	0%	<1	0%
	Total	**943,139.4**	**17,952.2**	**9,888.6**	**45%**	**10,000.6**	**44%**	**5,540.6**	**69%**

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ATTACHMENT FA. – ASSIGNMENT OF USLE C-FACTORS TO NLCD LANDCOVER VALUES

The NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland" (**Figure FA-1**) was used to develop C-factors for the various land use types as defined by the NLCD database within the Lower Clark Fork Tributaries watershed. This table uses four sub-factors: the vegetative canopy type and height, the vegetative canopy percent cover, the type of cover that contacts the soil surface, and the percent ground cover to derive a C-factor. The resulting C-factor is very sensitive to the type and percent of ground cover and less sensitive to the type and percent of canopy cover.

The type and percent of canopy cover were determined based on the NLCD land use definition. In some cases the minimum percent canopy cover specified in the land use definition was used and resulted in a conservative C-factor. The type of ground cover was considered to be G (cover is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep) for all of the land uses in the Beaverhead TPA. The percent ground cover not only includes the basal plant material, but also gravel and plant litter. The percent ground cover for each of the land uses within the Beaverhead TPA was estimated by Confluence.

Table FA-1 provides the C-factors for all land use types within the sub-basins of interest in the Beaverhead TPA for the existing conditions. The C-factors for the 'barren land', 'developed, low intensity', 'developed, medium intensity', and 'developed, high intensity' land uses are the same C-factors previously recommended by Richard Fasching, the former Montana State Agronomist, for other hillslope USLE modeling efforts.

Table FA-2 provides the C-factors for all land use types within the sub-basins of interest in the Beaverhead TPA for the desired well managed scenario. The percent ground cover was increased by 10% over the existing percentage for the 'grassland/herbaceous', 'shrub/scrub', 'pasture/hay', and 'woody wetlands' land uses to reflect a decrease in grazing. For the 'cultivated crops' land use, the percent ground cover was increased by 20% over the existing percentage to reflect improved agricultural practices. For the 'transitional' land use, the desired scenario assumed a return to a forest land use. The C-factors for the other land use types were not changed. This is similar to the methods used by the DEQ for the Shields River watershed TMDL and by Confluence for other hillslope USLE modeling efforts.

These tables were reviewed and approved by Kyle Tackett, an NRCS employee familiar with the Beaverhead TPA.

Exhibit MT510.03

"C" Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland 1/

Vegetal Canopy			Cover that Contacts the Surface (Vegetation, living and dead)					
Type and Height of Raised Canopy 2/	Canopy Cover 3/ %	Type 4/	Percent Ground Cover 0	20	40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall grass, weeds or brushes with average drop fall height of less than 3 feet 5/	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: 1) random distribution of mulch or vegetation, and 2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years. Also to be used for burned forest land and forest land that has been harvested less than three years ago.

For grazed woodland with high buildup of organic matter in the topsoil under permanent forest conditions, multiply the table values by 0.7.

2/ Average fall height of waterdrops from canopy to soil surface: m = meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff. W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface), and/or undecayed residue.

5/ The portion of a grass or weed cover that contacts the soil surface during a rainstorm and interferes with water flow over the soil surface is included in "cover at the surface." The remainder is included in canopy cover.

Figure FA-1. NRCS C-factor table

Table FA-1. C-factors for land cover types in the Beaverhead TPA for existing conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover	Type	Percent Ground Cover	C-factor
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003
22	Developed, low intensity	-	-	-	-	0.001
23	Developed, medium intensity	-	-	-	-	0.001
24	Developed, high intensity	-	-	-	-	0.001
31	Barren land	-	-	-	-	0.001
41	Deciduous forest	trees	75	G	95-100	0.003
42	Evergreen forest	trees	75	G	95-100	0.003
43	Mixed forest	trees	75	G	95-100	0.003
52	Shrub/scrub	appreciable brush	25	G	75	0.020
71	Grassland/herbaceous	no appreciable canopy	-	G	75	0.020
81	Pasture/Hay	no appreciable canopy	-	G	75	0.020
82	Cultivated Crops	no appreciable canopy	-	G	20	0.200
90	Woody Wetlands	trees	25	G	80	0.013
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003
99	Transitional	trees	25	G	90	0.006

Notes: Canopy cover percents were selected based on the land cover class definition.
Low, medium, and high intensity development land uses are assumed to be the same as barren land.
Deciduous and mixed forest land uses are assumed to be the same as evergreen forest.

Table FA-2. C-factors for land cover types in the Beaverhead TPA for BMP conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover	Type	Percent Ground Cover	C-factor
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003
22	Developed, low intensity	-	-	-	-	0.001
23	Developed, medium intensity	-	-	-	-	0.001
24	Developed, high intensity	-	-	-	-	0.001
31	Barren land	-	-	-	-	0.001
41	Deciduous forest	trees	75	G	95-100	0.003
42	Evergreen forest	trees	75	G	95-100	0.003
43	Mixed forest	trees	75	G	95-100	0.003
52	Shrub/scrub	appreciable brush	25	G	85	0.010
71	Grassland/herbaceous	no appreciable canopy	-	G	85	0.010
81	Pasture/Hay	no appreciable canopy	-	G	85	0.010
82	Cultivated Crops	no appreciable canopy	-	G	40	0.100
90	Woody Wetlands	trees	25	G	90	0.006
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003
99	Transitional	trees	75	G	95-100	0.003

Notes: Canopy cover percents were selected based on the land cover class definition.
Low, medium, and high intensity development land uses are assumed to be the same as barren land.
Deciduous and mixed forest land uses are assumed to be the same as evergreen forest.

APPENDIX G – UNPAVED ROAD ASSESSMENT – BEAVERHEAD TPA

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G1.0 INTRODUCTION

An assessment of the road network within the Beaverhead TMDL Planning Area (TPA) was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. This assessment employed GIS, field data collection, and sediment modeling to assess sediment inputs from the unpaved road network. In addition, sediment inputs from failed culverts and the application of traction sand was also evaluated, along with an evaluation of fish passage at assessed crossings.

G1.1 Sediment Impairments

The 2010 303(d) List includes the following stream segments for sediment / siltation impairment in the Beaverhead TPA: Spring Creek, Stone Creek, Blacktail Deer Creek, West Fork Blacktail Deer Creek, Clark Canyon Creek, Reservoir Creek, Taylor Creek, Dyce Creek, West Fork Dyce Creek, Scudder Creek, Steel Creek, Farlin Creek, French Creek, Rattlesnake Creek and the Beaverhead River.

G2.0 METHODS

Methods employed in this assessment are outlined in *Road Sediment Assessment & Modeling: Beaverhead TMDL Planning Area 303(d) Listed Tributary Streams – Road GIS Layers and Summary Statistics*, *July 30, 2010 (Montana Department of Environmental Quality, 2010a)* and *Road Sediment Assessment and Modeling Beaverhead TPA Sampling and Analysis Plan* (Montana Department of Environmental Quality, 2010b) and summarized below.

G2.1 Sediment Inputs from Unpaved Roads

Sediment inputs from unpaved roads were evaluated through a combination of GIS analysis, field data collection and computer modeling.

G2.1.1 GIS Analysis

Prior to field data collection, GIS data layers representing land ownership, road network, stream network, watersheds, and ecoregions were used to identify road crossings throughout the Beaverhead TPA. Land ownership data was divided into five categories: US Forest Service, US Bureau of Land Management, Montana Fish, Wildlife and Parks, Montana State Trust, and Private. The road network was derived from the State of Montana Base Map Service Center Transportation Framework Theme. The stream network was developed using the National Hydrography Dataset (NHD) mid-resolution (1:100,000) flowline layer. Flowlines were limited to streams/rivers and artificial paths; ditches and pipelines were not included. Watersheds were delineated on the basis of the 6th Hydrologic Unit Code layer and modified where necessary to delineate the subwatersheds of interest within the Beaverhead TPA. Landscapes were delineated according to EPA 2002 Level IV Ecoregions. These GIS layers were utilized to develop a database of stream crossings and parallel road segments that includes land ownership, road surface type, subwatershed, and ecoregion attributes in one attribute table. Through GIS analysis, 940 road crossings were identified within the Beaverhead TPA, 829 of which were identified as unpaved road crossings. Parallel road segments located within 150 feet of streams were also identified using GIS, totaling 177.30 miles, 171.27 of which were identified as unpaved road segments within 150 feet of a stream channel.

G2.1.2 Field Data Collection

A field assessment of unpaved roads was conducted by performing an inspection of road crossings and parallel road segments throughout the Beaverhead TPA in August of 2010.

G2.1.2.1 Crossing Assessment Sites

A total of 829 unpaved road crossings were identified in the Beaverhead TPA, 26 of which were assessed in the field. At each field assessed unpaved crossing, a series of measurements were performed to define road design, maintenance level, condition, culvert size, and sediment loading potential. Measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs). Information collected at each crossing was used to estimate sediment loading with the WEPP:Road model.

G2.1.2.2 Parallel Road Segment Assessment Sites

A total of 171.27 miles of unpaved parallel road segments were identified in the Beaverhead TPA and seven sites were assessed. Unpaved parallel road segments were assessed as they were encountered in the field, with an attempt to locate assessment sites near selected unpaved road crossing assessment sites. At each unpaved parallel road segment assessment site, a series of measurements were performed to define road design, maintenance level, condition, and sediment loading potential. Measurements included the length, gradient, and width of road contributing sediment. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any BMPs. Information collected at each parallel road segment was used to estimate sediment loading with the WEPP:Road model.

G2.1.3 WEPP Modeling

Sediment loading from unpaved road crossings and parallel road segments was estimated using the WEPP:Road soil erosion model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The WEPP:Road model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Field data collected from each field assessed site provided the following input data necessary to run the WEPP:Road model:

- Road design: insloped, bare ditch; insloped, vegetated or rocked ditch; outsloped, rutted; outsloped unrutted
- Road surface: native, graveled, paved
- Traffic level: high, low, none
- Soil texture: clay loam, silt loam, sandy loam, loam
- Rock content
- Gradient, length and width of the road, fill and buffer
- Climate data
- Years to simulate

G2.1.4 Potential Culvert Failures

A coarse assessment for each culvert was preformed on-site in order to measure and identify characteristics of the culvert. Characteristics evaluated included structure type, diameter and dimensions, gradient, bankfull width, fill height/length/width, outlet invert, and streambed materials.

This information was then used to estimate potential sediment loads from a culvert failure. At each culvert assessed in the field, the flood frequencies for the 2, 5, 10, 25, 50, and 100-year events were determined based on the bankfull width upstream of the culvert using United State Geological Survey Southwest Montana Region regression equations (Parrett and Johnson, 2004). The Urban Drainage and Flood Control District (UDFCD) Sewer and Culvert Hydraulics Version 2.0 (http://www.udfcd.org/) spreadsheet model was then utilized to establish the flow capacity of each field assessed culvert. The amount of sediment contributed during a culvert failure was calculated based on the volume of road fill overlaying the culvert with the assumption that culvert failure would erode sediment to a width equal to the bankfull width of the channel upstream of the culvert. For this analysis, an estimated soil weight of 1.66 tons/yard^3 was utilized based on the maximum unit weight for dry well-graded subangular sand presented in Table 1:4 of *Introductory Soil Mechanics and Foundations: Geotechnical Engineering Forth Edition (Sowers, 1979)*.

G2.2 Traction Sand Application

The application of traction sand to paved roads during winter maintenance activities is a potential source of sediment to streams within the Beaverhead TPA. There are six major paved travel routes within the Beaverhead TPA include the following:

- Interstate 15
- State Highway 278
- State Highway 41
- State Highway 91
- Pioneer Mountains National Scenic Byway
- Blacktail Road

Out of these six major paved travel routes, winter maintenance is managed by the Montana Department of Transportation along Interstate 15, State Highway 278, State Highway 41, and State Highway 91, while the Beaverhead Roads Department is responsible for maintaining the Pioneer Mountains National Scenic Byway and Blacktail Road, along with the city streets in Dillon. There are a total of 111 paved crossings in the Beaverhead TPA per GIS mapping, with the vast majority located on the six identified major travel routes. Data pertaining to traction sand application rates along these travel routes was obtained from the Montana Department of Transportation and the Beaverhead Roads Department.

G2.3 Fish Passage Analysis

At each field assessed unpaved road crossing site, an evaluation of the culvert was performed, including measurements of structure type, structure diameter, structure gradient, bankfull width upstream of the culvert, fill height, fill length, fill width, outlet invert, and presence of streambed materials in the culvert. These measurements were used to determine if the culvert represented a fish passage barrier at various flow conditions based on the United States Forest Service Region 10 Fish Passage Evaluation Criteria as described in *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska (U.S. Forest Service Alaska Region, 2002)*.

G3.0 RESULTS

The results of this assessment examining sediment loading from roads to streams within the Beaverhead TPA (**Figure G3-1**) are presented in the following sections. Results are presented by landownership

(**Figure G3-2**) and Level IV Ecoregion (**Figure 3-3**) for each of the 6th code subwatersheds (**Figure G3-4**) within the Beaverhead TPA.

G3.1 Sediment Inputs from Unpaved Roads

Sediment inputs from unpaved road crossings and parallel road segments were evaluated using the WEPP:Road model. The potential to reduce sediment loads from unpaved roads through the application of Best Management Practices (BMPs) was also assessed by reducing contributing road segment lengths to 100 feet. For unpaved road crossings, contributing road segment lengths exceeding 100 feet were reduced to 100 feet on either side of the crossing, while parallel road segment lengths greater than 100 were also reduced to 100 feet. In addition, sediment inputs from potential culvert failures were also evaluated.

G3.1.1 WEPP Model Input Parameters

Road condition data collected throughout the Beaverhead TPA in August of 2010 was input directly into the WEPP model following guidance outlined in *WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery Technical Documentation*, which is available on the Internet at http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html. In addition to field collected data, the WEPP:Road model requires the selection of site-specific climate data to provide an estimate of mean annual precipitation. The WEPP:Road model contains 55 custom climate stations for Montana. Out of these 55 custom climate stations, three were selected in southwest Montana to represent the range of precipitation conditions in the Beaverhead TPA (**Table G3-1**). Precipitation in the Beaverhead TPA ranges from 9-10" to 42-46" annually based on data collected from 1971 to 2000 and compiled by the PRISM Group at Oregon State University (http://nris.mt.gov/nsdi/nris/precip71_00.html) (**Figure G3-5**). Road crossing assessments in the Beaverhead TPA were conducted at sites located in precipitation zones ranging from 10-11" to 26-30". Mean annual sediment loads from unpaved road crossings and parallel road segments were estimated using field collected data and site-specific precipitation data in the WEPP:Road model.

Table G3-1. Precipitation Data Applied in the WEPP:Road Model.

Climate Station	Mean Precipitation (Inches)	PRISM Precipitation Zones (Inches)
Lima MT	11.21	9-10 to 13-14
Norris Madison PH MT	17.41	14-16 to 18-20
Mystic Lake	24.52	20-22 +

G3.1.2 Unpaved Road Crossings

Out of 829 unpaved road crossings delineated in GIS, a total of 26 were assessed in the field (**Figure G3-6**). From these 26 crossings, the estimated mean annual sediment load is 1.45 tons, with a mean annual sediment load of 0.056 tons contributed from each assessed unpaved road crossing (**Attachment G-1**). For extrapolation to the subwatershed scale, unpaved road crossings were grouped based on the Level IV Ecoregion, with the five mountain ecoregions grouped together as presented in **Table G3-2** and **Attachment G-2**. For the Beaverhead TPA, the estimated mean annual sediment load from unpaved road crossings is 45.14 tons (**Table G3-3**). Through the application of BMPs, it is estimated that this load can be reduced to 11.19 tons. A complete evaluation of sediment loads at the subwatershed scale is presented in **Attachment G-3**.

Table G3-2. Unpaved Road Crossing Mean Annual Sediment Loads for Level IV Ecoregions.

Level IV Ecoregion	Number of Sites Assessed	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)
Big Hole	2	0.004	0.003
Dry Intermontane Sagebrush Valleys	14	0.047	0.014
Dry Gneissic-Schistose-Volcanic Hills	6	0.059	0.016
Barren Mountains, Eastern Pioneer Sedimentary Mountains, Pioneer-Anaconda Ranges, Forested Beaverhead Mountains	4	0.106	0.013

Table G3-3. Unpaved Road Crossing Mean Annual Sediment Loads by Subwatershed.

Subwatershed	# of Crossings	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)
Beaverhead River	255	13.04	3.68
Blacktail Deer Creek	117	6.02	1.70
Clark Canyon Creek	3	0.18	0.05
Dyce Creek	11	0.87	0.15
East Fork Blacktail Deer Creek	42	3.46	0.57
Ermont Gulch	38	1.83	0.55
Farlin Creek	2	0.21	0.03
French Creek	8	0.79	0.10
Grasshopper Creek	156	7.60	1.65
Lower Rattlesnake Creek	16	0.76	0.23
Lower Stone Creek	5	0.24	0.07
Middle Fork Blacktail Deer Creek	8	0.46	0.12
Reservoir Creek	8	0.38	0.12
Scudder Creek	4	0.22	0.03
Spring Creek	40	2.08	0.57
Steel Creek	10	0.24	0.05
Taylor Creek	18	0.90	0.22
Upper Beaverhead River	16	0.94	0.26
Upper Rattlesnake Creek	23	1.44	0.32
Upper Stone Creek	15	0.84	0.24
West Fork Blacktail Deer Creek	31	2.40	0.44
West Fork Dyce Creek	3	0.26	0.04
BEAVERHEAD TPA	**829**	**45.14**	**11.19**

G3.1.3 Unpaved Parallel Road Segments

A total of seven unpaved parallel road segments were assessed in the field (**Figure G3-7**). From these seven unpaved parallel road segments, the estimated annual sediment load is 0.69 tons, with a mean annual sediment load of 0.099 tons contributed from each unpaved parallel road segment (**Table G3-4, Attachment G-4**). For extrapolation to the subwatershed scale, the mean annual sediment load per 100 feet was determined for the seven parallel road segments. In addition, contributing road segment lengths measured in the field were compared to GIS delineated lengths for the assessed parallel segments. Out of the seven field assessed parallel road segments, two did not correlate to parallel road segments in GIS, while erroneous GPS data from a third field assessed parallel road segment precluded correlation to a GIS delineated parallel road segment. For the remaining four parallel road segments, the contributing road length measured in the field averaged 7.2% of the overall road segment length measured in GIS (**Table G3-5**). Based on this, the mean annual load per 100 feet was multiplied by 0.072 to account for the portion of the parallel road segment not contributing sediment to the stream (**Table G3-4**). Thus, for unpaved parallel road segments, 0.0023 tons per year was extrapolated to every 100 feet of unpaved road within 150 feet of the stream channel as delineated in GIS. For the Beaverhead TPA, the estimated mean annual sediment load from unpaved parallel road segments is 21.21 tons (**Table G3-6**). Through the application of BMPs, it is estimated that this load can be reduced to 8.41 tons. A complete evaluation of sediment loads at the sub-watershed based scale is presented in **Attachment G-5.**

Table G3-4. Unpaved Parallel Segment Mean Annual Sediment Loads.

Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Mean Annual Load per 100 Feet (Tons)	Mean Annual Load per 100 Feet with BMPs (Tons)	Mean Annual Load per 100 Feet for 7.2% (Tons)	Mean Annual Load per 100 Feet for 7.2% with BMPs (Tons)
0.099	0.013	0.033	0.013	0.0023	0.0009

Table G3-5. Field Measured Lengths Compared to GIS Delineated Lengths for Parallel Segments.

Field Site ID	GIS Segment Length (Feet)	Field Contributing Length (Feet)	Field Contributing Length as a Percent of GIS Segment Length
P-1	1,964	261	13.3%
P-4	4,818	196	4.1%
P-7	8,299	200	2.4%
P-6	7,947	991	12.5%
TOTAL	**23,029**	**1,648**	**7.2%**

Table G3-6. Unpaved Parallel Road Segment Mean Annual Sediment Loads by Subwatershed.

Subwatershed	Parallel Segment Length (Miles)	Parallel Segment Length (Feet)	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)
Beaverhead River	49.02	258,808	6.07	2.41
Blacktail Deer Creek	27.98	147,723	3.46	1.37
Clark Canyon Creek	1.25	6,584	0.15	0.06
Dyce Creek	2.79	14,742	0.35	0.14
East Fork Blacktail Deer Creek	6.67	35,199	0.83	0.33
Ermont Gulch	7.09	37,451	0.88	0.35
Farlin Creek	1.50	7,936	0.19	0.07
French Creek	7.26	38,356	0.90	0.36
Grasshopper Creek	31.86	168,195	3.94	1.56
Lower Rattlesnake Creek	1.07	5,658	0.13	0.05
Lower Stone Creek	0.34	1,810	0.04	0.02
Middle Fork Blacktail Deer Creek	1.44	7,601	0.18	0.07
Reservoir Creek	1.06	5,613	0.13	0.05
Scudder Creek	1.47	7,770	0.18	0.07
Spring Creek	3.40	17,937	0.42	0.17
Steel Creek	3.78	19,959	0.47	0.19
Taylor Creek	1.26	6,635	0.16	0.06
Upper Beaverhead River	2.18	11,536	0.27	0.11
Upper Rattlesnake Creek	4.67	24,669	0.58	0.23
Upper Stone Creek	6.92	36,515	0.86	0.34
West Fork Blacktail Deer Creek	5.29	27,912	0.65	0.26
West Fork Dyce Creek	2.97	15,677	0.37	0.15
BEAVERHEAD TPA	**171.27**	**904,287**	**21.21**	**8.41**

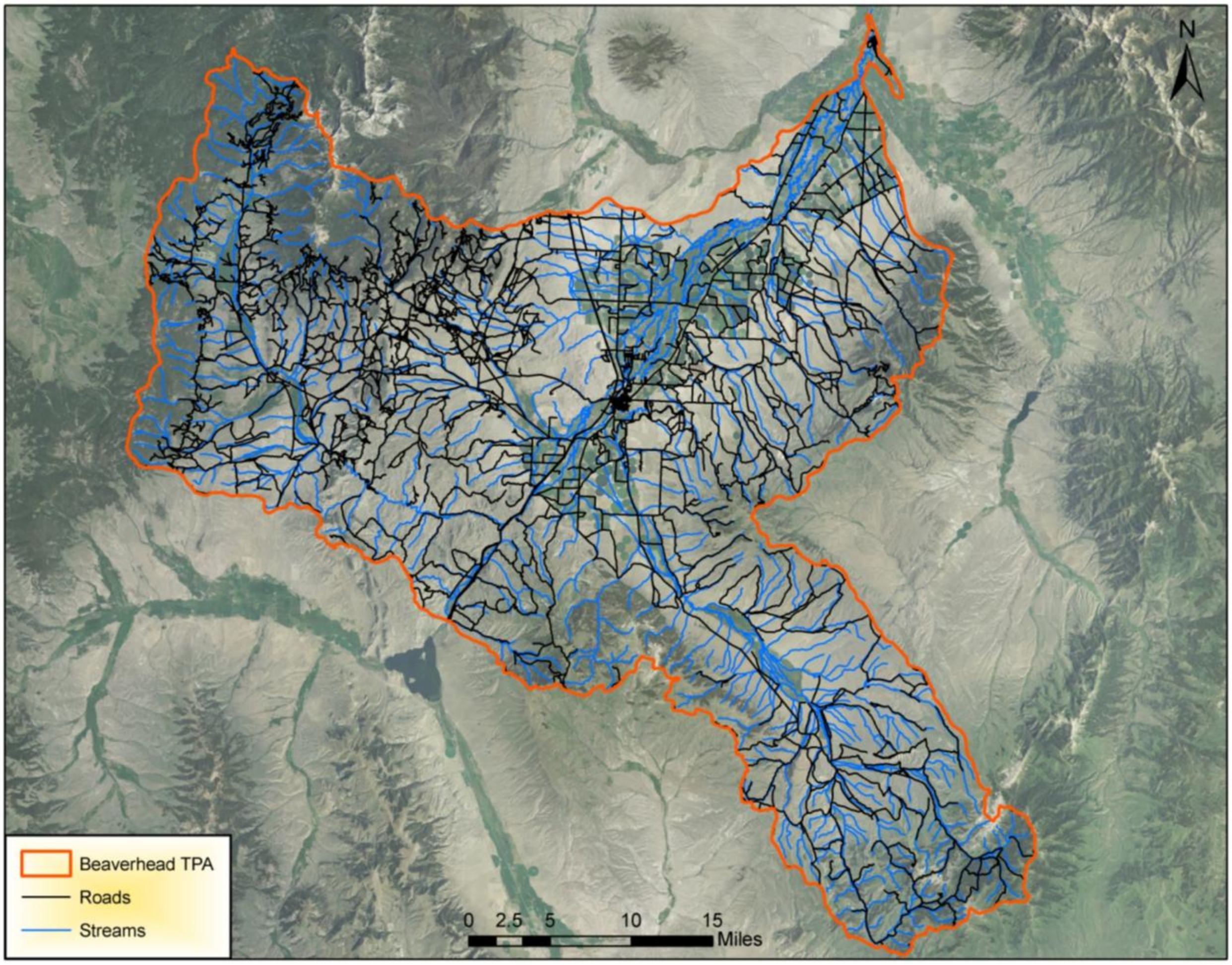

Figure G3-1. Road and Stream Networks in the Beaverhead TPA.

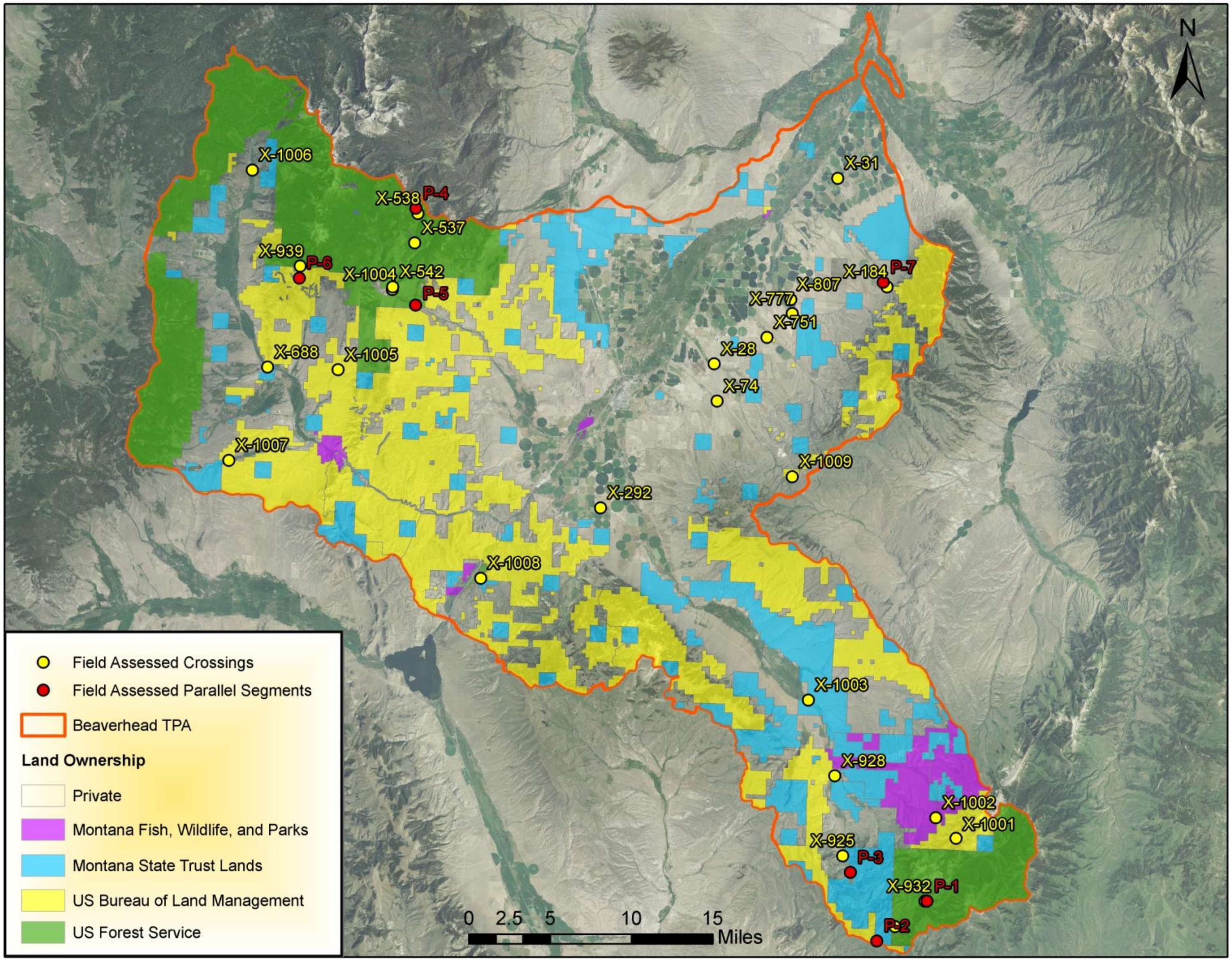

Figure G3-2. Landownership in the Beaverhead TPA.

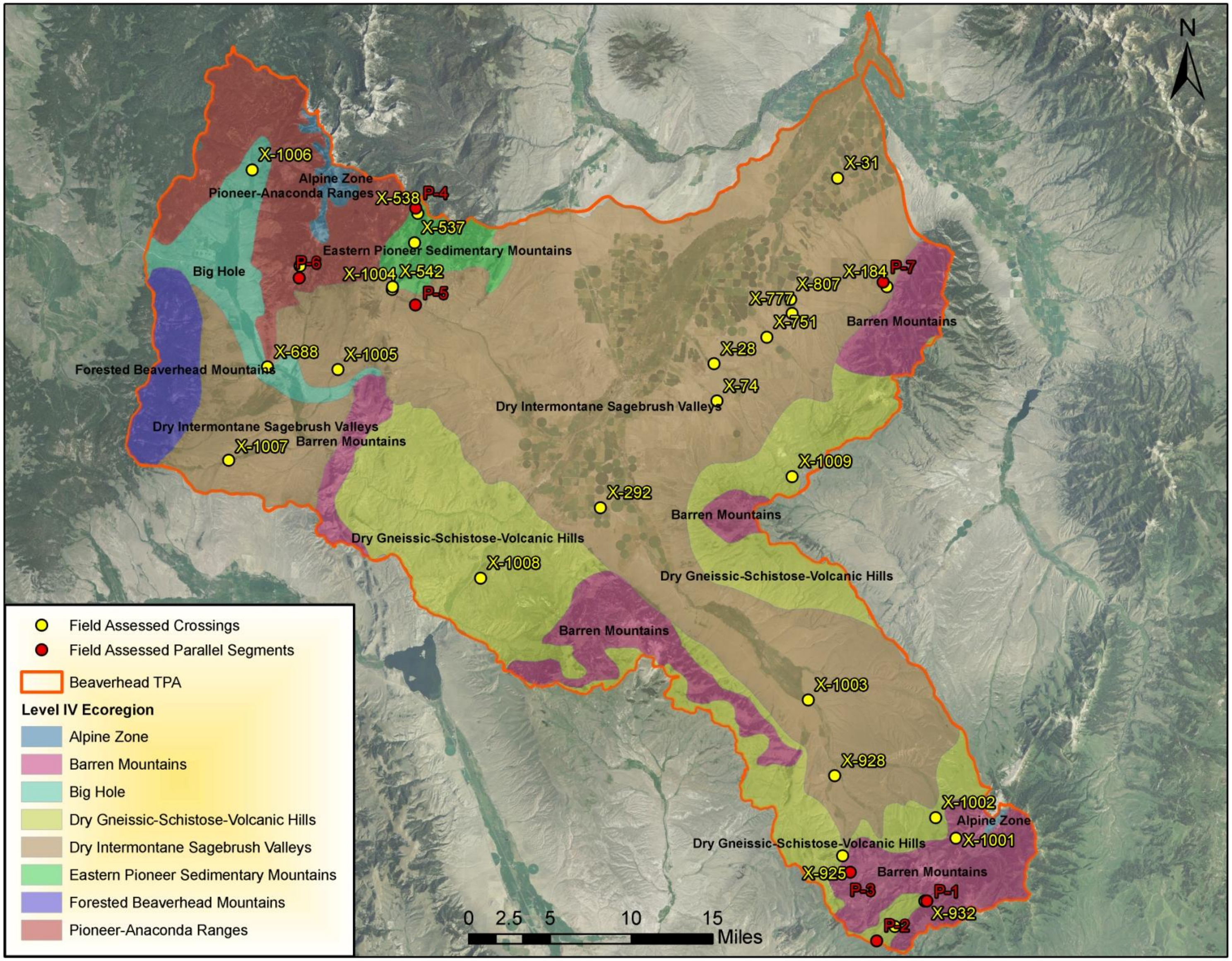

Figure G3-3. Level IV Ecoregions in the Beaverhead TPA.

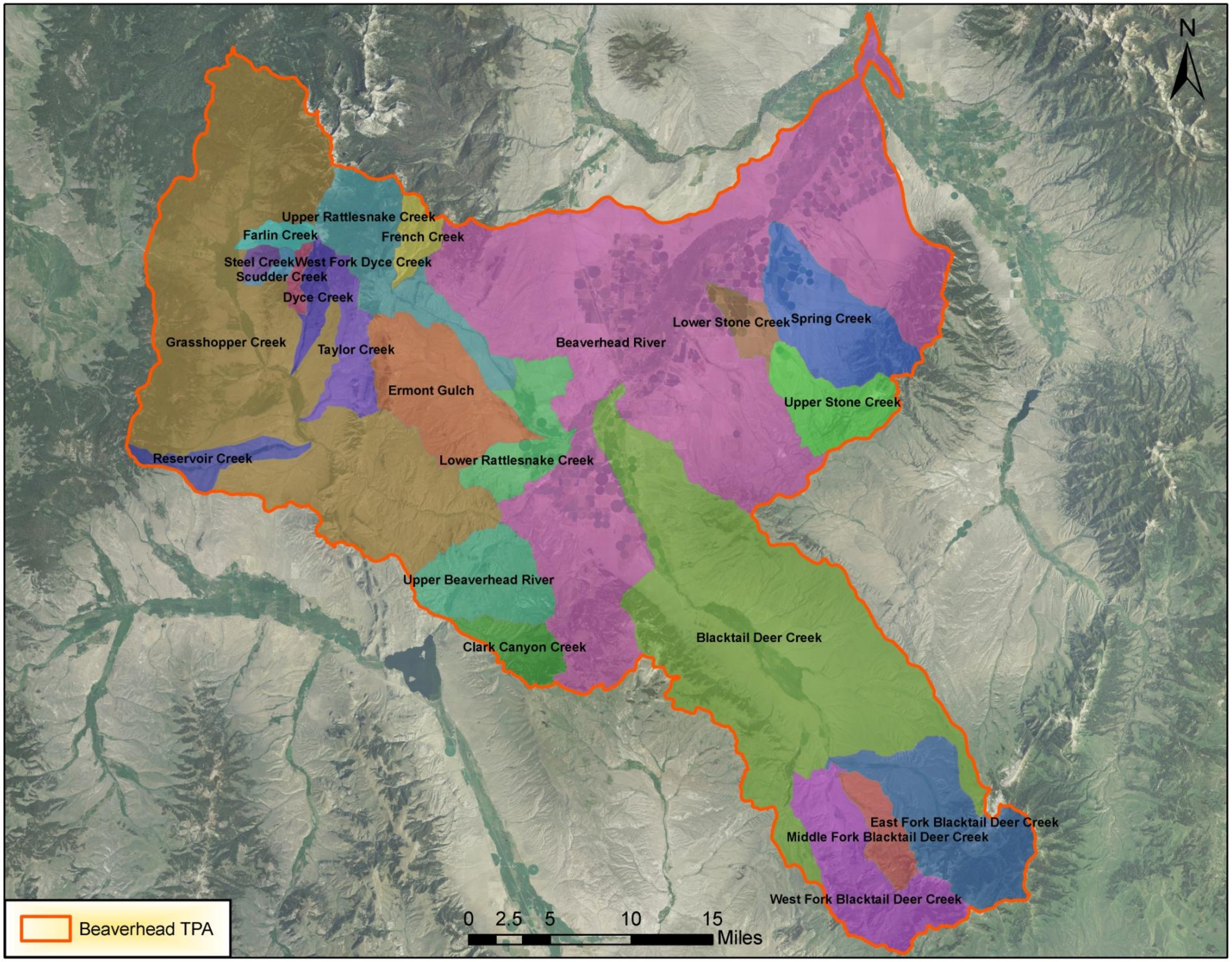

Figure G3-4. 6th Code Subwatersheds in the Beaverhead TPA.

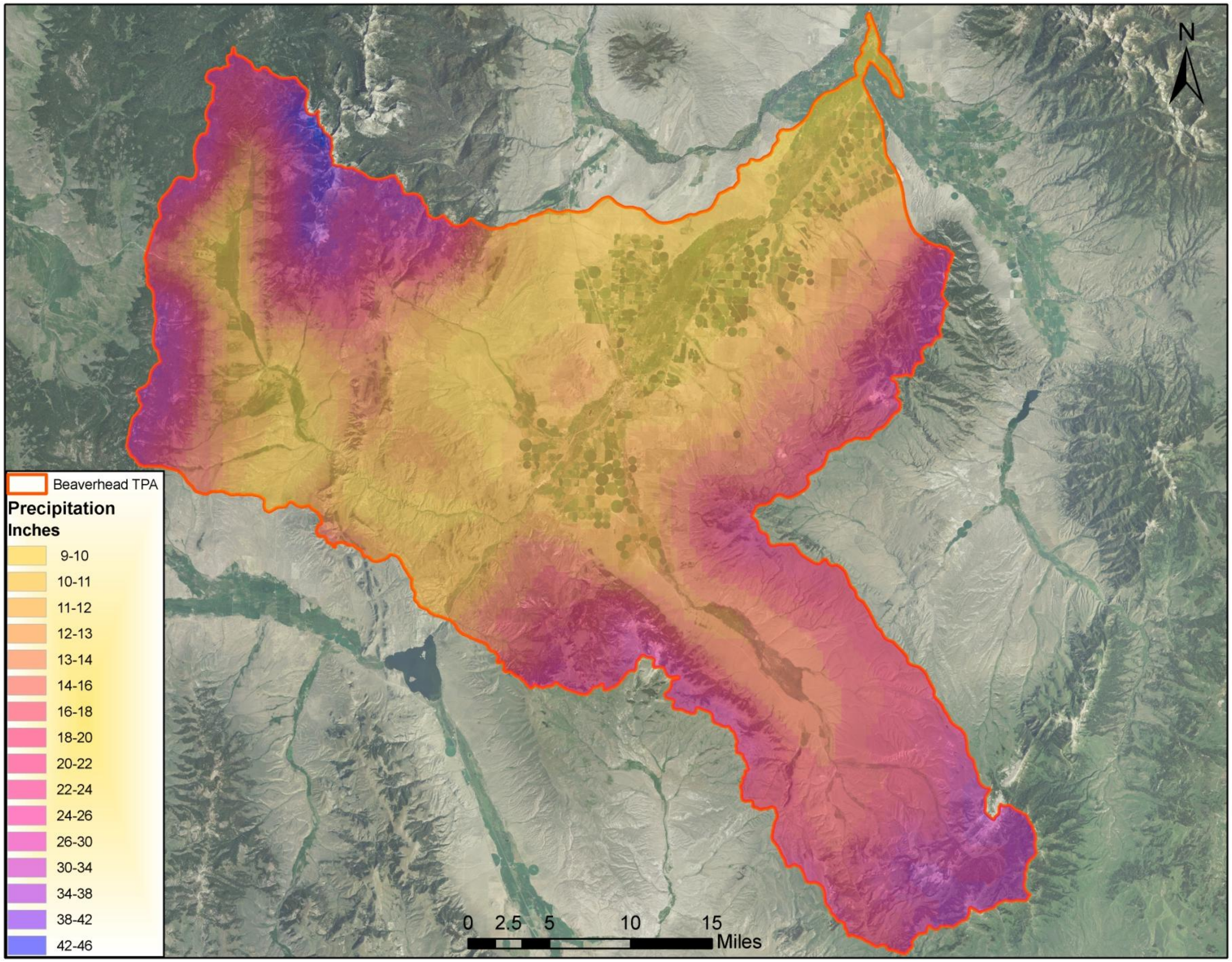

Figure G3-5. Precipitation Patterns in the Beaverhead TPA.

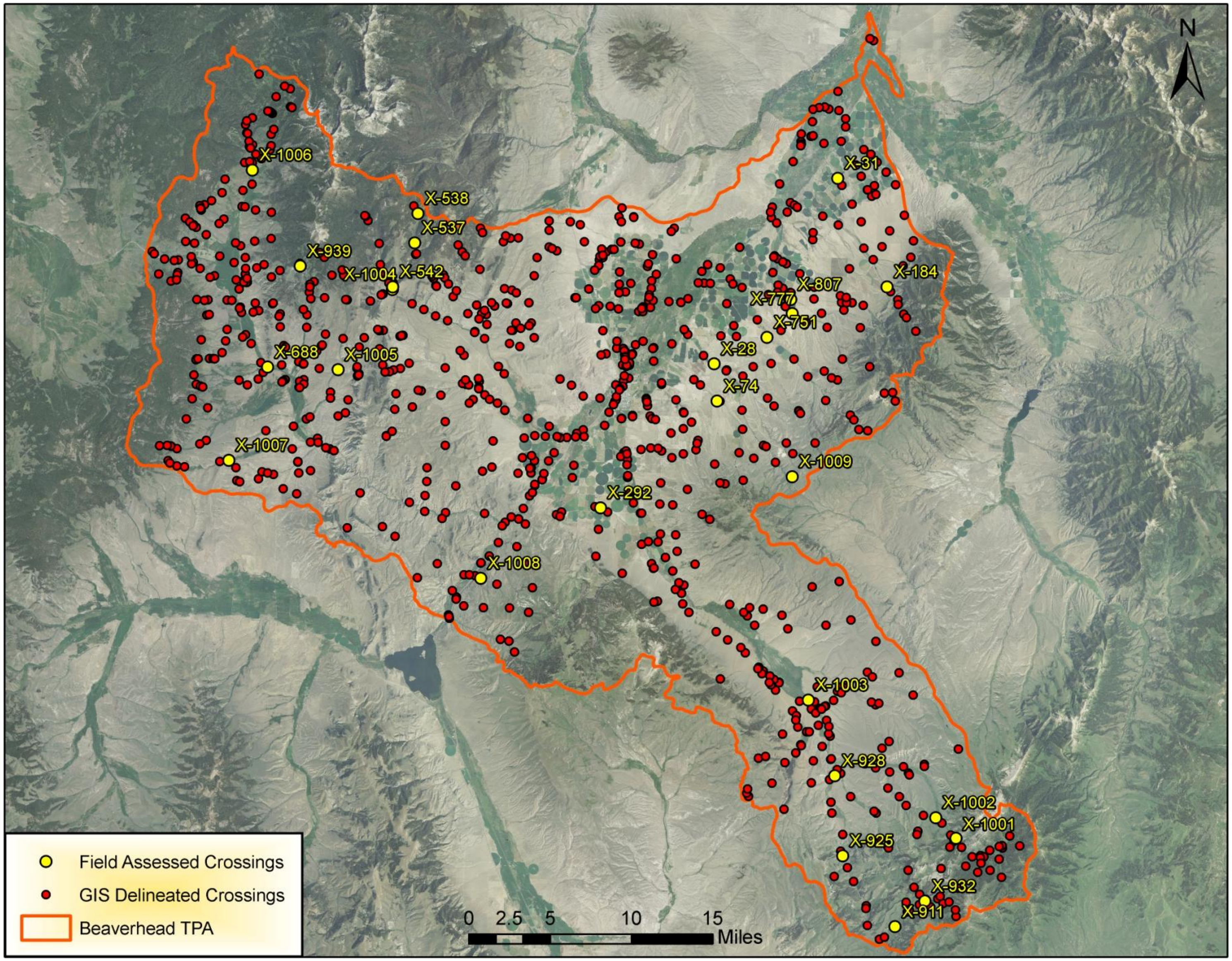

Figure G3-6. Unpaved Road Crossings in the Beaverhead TPA.

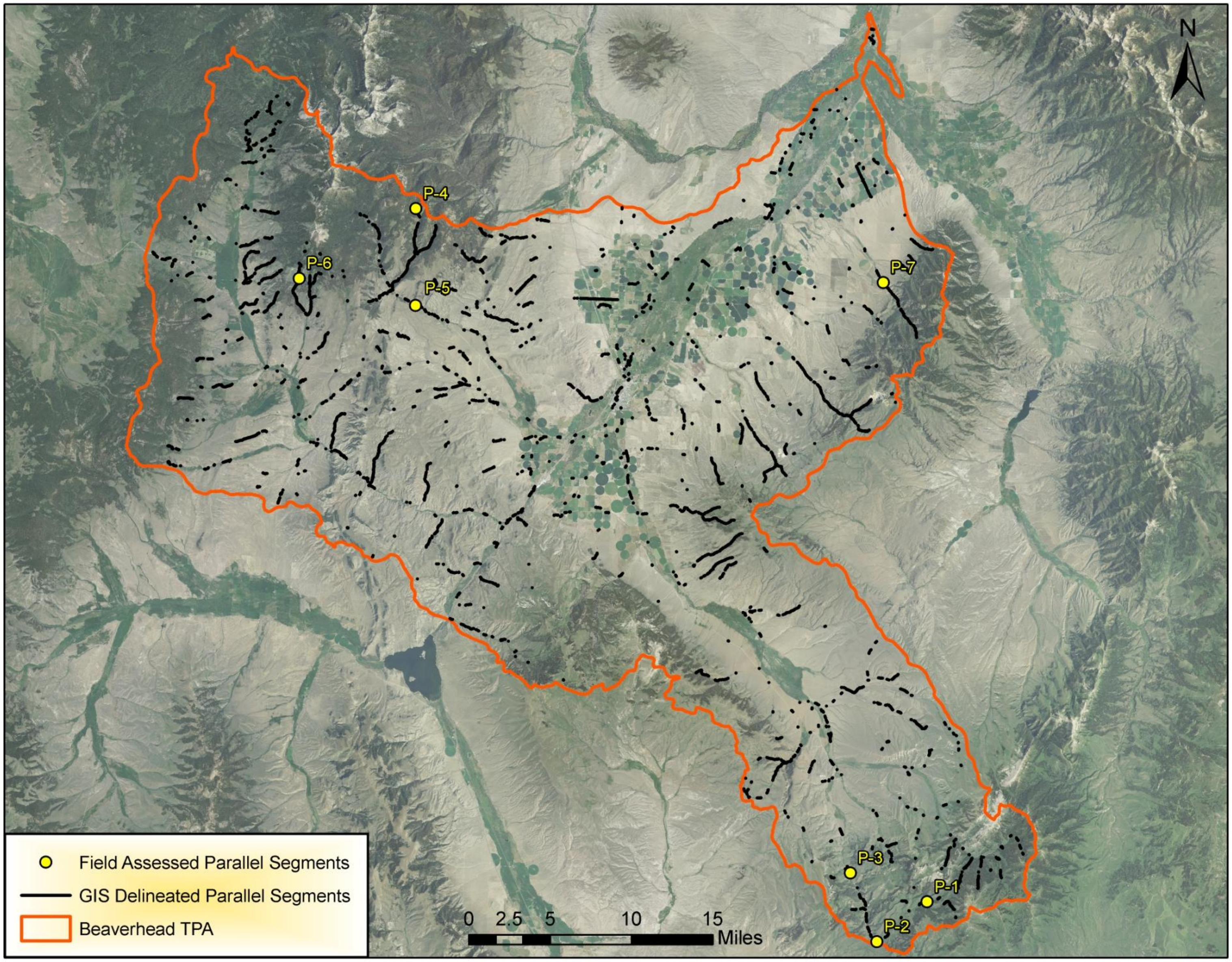

Figure G3-7. Unpaved Parallel Road Segments in the Beaverhead TPA.

G3.1.4 Potential Culvert Failures

Within the Beaverhead TPA, all 19 culverts assessed in the field are capable of passing the two-year flood event, while only two of these culverts (11%) pass a 100-year flood event (**Tables G3-7** and **G3-8**, **Attachment G-6**). Once a culvert's carrying capacity is exceeded, the potential for culvert failure increases, though the point at which a given culvert will fail remains uncertain. Hydraulic analysis of a culvert is extremely complex and potential sediment loads from the eroding fill as presented in **Table G3-7** are estimates assuming the entire height and length of road fill are eroded to a width equal to the bankfull width of the stream.

Table G3-7. Culvert Failure and Potential Sediment Load Evaluation.

Location ID	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Culvert Capacity (cfs)	Potential Sediment Load if Culvert Fails (Tons)
X-932	7	21	35	62	88	123	102	117
X-911	2	7	13	25	38	55	22	15
X-925	57	120	175	264	341	435	68	92
X-928	139	255	348	490	608	746	401	362
X-1001	27	63	97	154	207	273	314	154
X-1002	1	3	6	13	20	31	13	4
X-292	14	36	58	96	134	181	47	37
X-538	10	28	46	79	111	152	94	37
X-542	14	36	58	96	134	181	108	46
X-1005	38	84	126	196	259	336	54	96
X-1006	38	84	126	196	259	336	243	181
X-1007	14	36	58	96	134	181	104	65
X-1008	22	53	83	134	182	242	208	137
X-31	5	15	25	46	67	95	47	184
X-777	10	28	46	79	111	152	64	58
X-751	38	84	126	196	259	336	180	903
X-28	7	21	35	62	88	123	96	35
X-74	3	9	17	32	47	68	106	235
X-1009	3	9	17	32	47	68	9	10

Grey cells indicate culvert fails to pass a given discharge

Table G3-8. Culvert Failure Summary.

Flood Frequency	Number of Culverts Passing	Number of Culverts Failing	Percent Passing	Percent Failing
Q2	19	0	100%	0%
Q5	16	3	84%	16%
Q10	15	4	79%	21%
Q25	11	8	58%	42%
Q50	5	14	26%	74%
Q100	2	17	11%	89%

If a culvert fails for a given event, the replacement culvert should address several issues. First, culverts typically cause changes in the upstream elevation and the new culvert should mitigate these effects to ensure that culvert placement does not negatively affect the surrounding habitat. Next, environmental considerations such as fish passage need to be accurately predicted. New three-sided culverts, where the bottom of the culvert is typically the natural channel bottom, allow better holding habitat and maintain a continuous stream channel bottom. The hydrology of the area should also be determined and directly related to the culvert design size for the given watershed. Following these principals will improve the stream system, increase fish habitat, and reduce potential sediment loads from failed culverts.

G3.2 Traction Sand Application

Montana Department of Transportation traction sand application rates based on the three year average (2009-2011) along State Highway 278, State Highway 41, State Highway 91, and Interstate 15 indicate State Highway 278 has the highest rate of application per plowed mile, while Interstate 15 has the lowest rate of application per plowed mile (**Table G3-9**, **Attachment G-7**). An average of 3,447 tons of traction sand are applied to these four travel routes annually, with application rates per plowed mile ranging from 0.11 tons along Interstate 15 to 0.20 tons along State Highway 278. Average annual traction sand application rates range from 149 tons along State Highway 91 to 1,703 tons along Interstate 15. No data was available from the Beaverhead Roads Department for traction sand application rates along the Pioneer Mountains Scenic Byway or Blacktail Road.

Table G3-9. Traction Sand Application Rates.

Travel Route	Management Responsibility	Length (miles)	Average Annual Traction Sand Application Rate (Tons)		Affected Stream Segments
			Travel Route	Per Plowed Mile	
State Highway 278	Montana Department of Transportation	13.9	998	0.20	Rattlesnake Creek from headwaters to mouth (Beaverhead R) Grasshopper Creek from headwaters to mouth (Beaverhead R)
State Highway 41	Montana Department of Transportation	27.6	598	0.17	Beaverhead River from Grasshopper Creek to mouth (Jefferson R) Stone Creek below confluence with unnamed creek in NE, S34, T6S, R7W
State Highway 91	Montana Department of Transportation	14.5	149	0.16	Beaverhead River from Grasshopper Creek to mouth (Jefferson R) Blacktail Deer Creek from headwaters to mouth (Beaverhead R)
Interstate 15	Montana Department of Transportation	30.3	1,703	0.11	Beaverhead River from Clark Canyon Res to Grasshopper Cr Beaverhead River from Grasshopper Creek to mouth (Jefferson R)
Pioneer Mountains National Scenic Byway	Beaverhead County Roads Department	16.5	Not available	Not available	Grasshopper Creek from headwaters to mouth (Beaverhead R)
Blacktail Road	Beaverhead County Roads Department	27.4*	Not available	Not available	Blacktail Deer Creek from headwaters to mouth (Beaverhead R)

* portion of Blacktail Road is gravel

G3.3 Fish Passage Analysis

Out of 26 road crossings assessed in the field, 19 had culverts, each of which was assessed as a potential fish passage barrier based on the United States Forest Service Region 10 Fish Passage Evaluation Criteria. This analysis utilizes site-specific information to evaluate fish passage at culverts, which are classified as “green”, “red”, or “grey” (**Table G3-10**). Culvert slope, the culvert span-to-bedwidth ratio, and the outlet perch are evaluated as potential limiting factors affecting fish passage. In the Beaverhead TPA, five of the culverts (26%) allowed fish passage, while 14 culverts (74%) were classified as fish passage barriers (**Attachment G-8**).

Table G3-10. Fish Passage Evaluation.

Fish Passage Evaluation Categories	Fish Passage Evaluation Criteria	Number of Culverts	Percentage of Total Culverts Assessed
Green[1]	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	5	26%
Grey[2]	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	0	0%
Red[3]	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	14	74%

G4.0 DISCUSSION

In the Beaverhead TPA, sediment contributions from unpaved roads average 66.35 tons per year (**Table G4-1**). Through the application of BMPs, it is estimated that this sediment load can be reduced to 19.60 tons per year, which is a 70% reduction in sediment loads. This reduction is achieved by reducing contributing road lengths at unpaved road crossing to 100 feet from either side of the crossing and by reducing contributing road lengths along unpaved parallel road segments to 100 feet.

Table G4-1. Potential Reduction in Sediment Loads from Unpaved Roads through the Application of BMPs.

Subwatershed	Total Mean Annual Sediment Load from Unpaved Roads (Tons)	Total Mean Annual Sediment Load from Unpaved Road with BMPs (Tons)	Total Percent Reduction in Sediment Contributions from Unpaved Roads
Beaverhead River	19.11	6.09	68%
Blacktail Deer Creek	9.49	3.07	68%
Clark Canyon Creek	0.33	0.11	67%
Dyce Creek	1.22	0.29	77%
East Fork Blacktail Deer Creek	4.28	0.90	79%
Ermont Gulch	2.71	0.90	67%
Farlin Creek	0.40	0.10	75%
French Creek	1.69	0.46	73%
Grasshopper Creek	11.54	3.21	72%
Lower Rattlesnake Creek	0.89	0.28	68%
Lower Stone Creek	0.28	0.09	68%
Middle Fork Blacktail Deer Creek	0.64	0.19	71%
Reservoir Creek	0.51	0.17	67%
Scudder Creek	0.40	0.10	74%
Spring Creek	2.50	0.74	70%
Steel Creek	0.71	0.23	67%
Taylor Creek	1.05	0.28	73%
Upper Beaverhead River	1.21	0.37	70%
Upper Rattlesnake Creek	2.02	0.55	73%
Upper Stone Creek	1.69	0.58	66%
West Fork Blacktail Deer Creek	3.06	0.70	77%
West Fork Dyce Creek	0.63	0.19	70%
BEAVERHEAD TPA	**66.35**	**19.60**	**70%**

G5.0 REFERENCES

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ATTACHMENT G-1. UNPAVED ROAD CROSSING FIELD DATA AND WEPP MODELED SEDIMENT LOADS BEAVERHEAD TMDL PLANNING AREA

Waterbody	Location ID	Date	Latitude	Longitude	Level 4 Ecoregion	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
													L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R		
Bonita Fork	X-932	08/24/10	44.78053	-112.22952	DGSVH	24.52	Sand L	10	Insloped Veg/rock ditch	Native	Low	30	3.0	401	11	70	10	3	36	65.21	6.0	148	11	70	15	3	5	59.73	124.94	42.49
tributary to West Fork Blacktail Deer Creek	X-911	08/24/10	44.75685	-112.26570	DGSVH	24.52	Sand L	5	Outsloped Unrutted	Native	Low	30	0.5	5	12	36	5	36	5	0.70	8.0	239	12	36	5	36	5	60.69	61.39	26.09
West Fork Blacktail Deer Creek	X-925	08/24/10	44.81826	-112.33421	DGSVH	17.41	Sand L	10	Outsloped Unrutted	Native	Low	50	0.5	77	20	84	3	0.3	1	21.26	0.5	10	20	84	3	0.3	1	2.76	24.02	24.02
West Fork Blacktail Deer Creek	X-928	08/24/10	44.88919	-112.34758	DISV	17.41	Sand L	30	Outsloped Unrutted	Native	Low	50	0.5	5	20	58	10	0.3	1	1.99	0.5	5	20	58	10	0.3	1	1.99	3.98	3.98
Indian Creek	X-1001	08/24/10	44.83737	-112.19342	BM	24.52	Silt L	5	Outsloped Unrutted	Native	Low	30	0.5	36	9	84	10	84	5	2.64	4.0	99	9	84	15	0.3	1	10.07	12.71	12.71
tributary to East Fork Blacktail Deer Creek	X-1002	08/24/10	44.85511	-112.21970	DGSVH	24.52	Sand L	10	Outsloped Unrutted	Native	Low	30	1.0	40	15	58	3	1	1	6.52	5.0	125	15	58	3	1	1	27.97	34.49	28.89
Blacktail Deer Creek	X-1003	08/24/10	44.95570	-112.38423	DISV	17.41	Silt L	10	Insloped Veg/rock ditch	Native	Low	50	1.0	25	12	0.3	1	0.3	1	1.45	2.0	26	12	0.3	1	0.3	1	1.73	3.18	3.18
Sheep Creek	X-292	08/24/10	45.11956	-112.65396	DISV	11.21	Sand L	20	Outsloped Unrutted	Gravel	Low	50	0.5	21	23	150	2	0.3	1	2.24	0.5	19	23	150	2	0.3	1	2.03	4.27	4.27
French Creek	X-538	08/25/10	45.37448	-112.89925	EPSM	24.52	Sand L	10	Insloped Veg/rock ditch	Native	Low	30	9.0	162	10	100	7	0.3	1	74.75	3.0	5	10	84	7	0.3	1	0.48	75.23	41.67
French Creek	X-537	08/25/10	45.34817	-112.90182	EPSM	24.52	Loam	5	Outsloped Rutted	Native	Low	30	4.0	12	7	0.3	1	0.3	1	0.23	5.0	51	7	0.3	1	0.3	1	4.67	4.90	4.90
French Creek	X-542	08/25/10	45.30819	-112.92726	DISV	17.41	Sand L	5	Outsloped Unrutted	Native	Low	50	0.5	5	13	119	9	0.3	1	1.21	6.0	281	13	100	9	0.3	1	100.24	101.45	36.88
Rattlesnake Creek	X-1004	08/25/10	45.30591	-112.92741	DISV	17.41	Sand L	5	Outsloped Unrutted	Native	Low	50	7.0	123	20	70	10	18	12	50.15	0.5	39	17	58	4	27	3	9.62	59.77	50.39
Taylor Creek	X-1005	08/25/10	45.23233	-112.99125	DISV	11.21	Sand L	5	Outsloped Unrutted	Native	Low	50	3.0	140	14	100	8	0.3	1	7.90	0.5	5	14	100	8	0.3	1	0.23	8.13	5.87
West Fork Dyce Creek	X-939	08/25/10	45.32299	-113.04462	PAR	24.52	Sand L	20	Outsloped Rutted	Native	Low	30	15.0	616	8	0.3	1	0.3	1	749.34	2.0	51	8	0.3	1	0.3	1	3.98	753.32	41.70
Grasshopper Creek	X-688	08/25/10	45.23190	-113.08007	BH	11.21	Sand L	20	Outsloped Unrutted	Gravel	Low	50	-	-	-	-	-	-	-	0.00	4.0	156	19	0.3	1	0.3	1	12.30	12.30	7.89
Grasshopper Creek	X-1006	08/25/10	45.40641	-113.11069	BH	11.21	Sand L	10	Outsloped Unrutted	Gravel	Low	50	0.5	12	25	84	10	0.3	1	1.84	0.5	14	25	84	10	0.3	1	2.15	3.99	3.99
Reservoir Creek	X-1007	08/25/10	45.14744	-113.12333	DISV	11.21	Sand L	5	Outsloped Unrutted	Native	Low	50	4.0	208	11	47	14	0.3	1	8.70	-	-	-	-	-	-	-	0.00	8.70	4.18
tributary to Ashbaugh Creek	X-1008	08/26/10	45.05252	-112.80085	DGSVH	11.21	Silt L	20	Outsloped Rutted	Native	Low	50	9.0	783	11	0.3	1	18	73	315.70	-	-	-	-	-	-	-	0.00	315.70	1.29
Big Dry Gulch	X-31	08/26/10	45.42075	-112.37136	DISV	11.21	Sand L	20	Outsloped Unrutted	Gravel	High	50	6.0	273	36	70	17	0.3	1	279.12	0.5	5	36	70	17	0.3	1	2.68	281.80	104.92
tributary to McHennesy Creek	X-184	08/26/10	45.32575	-112.30422	DISV	17.41	Sand L	20	Outsloped Rutted	Native	Low	50	6.0	47	9	0.3	1	0.3	1	7.00	7.0	18	9	0.3	1	0.3	1	1.60	8.60	8.60
un-named	X-807	08/26/10	45.31134	-112.42515	DISV	11.21	Sand L	10	Outsloped Unrutted	Gravel	Low	50	1.0	187	14	0.3	1	0.3	1	5.61	4.0	106	14	0.3	1	0.3	1	4.89	10.50	7.61
Spring Creek	X-777	08/26/10	45.29870	-112.42234	DISV	11.21	Sand L	5	Outsloped Unrutted	Native	Low	50	2.0	60	12	47	9	0.3	1	1.95	6.5	5	12	47	9	0.3	1	0.29	2.24	2.24
Stone Creek	X-751	08/26/10	45.27695	-112.45329	DISV	11.21	Sand L	10	Outsloped Unrutted	Gravel	High	50	3.0	249	40	47	20	0.3	1	185.27	0.5	10	40	47	20	0.3	1	5.64	190.91	80.04
Carter Creek	X-28	08/26/10	45.25144	-112.51839	DISV	11.21	Sand L	10	Outsloped Unrutted	Native	Low	50	6.0	482	15	36	10	0.3	1	35.75	6.0	250	15	36	10	0.3	1	18.54	54.29	14.84
un-named	X-74	08/26/10	45.21842	-112.51294	DISV	11.21	Sand L	30	Outsloped Unrutted	Gravel	High	50	6.0	769	25	150	25	0.3	1	584.73	0.5	5	25	27	29	0.3	1	1.38	586.11	77.42
un-named	X-1009	08/26/10	45.15380	-112.41488	DGSVH	17.41	Silt L	5	Outsloped Unrutted	Native	Low	50	5.0	224	21	47	7	47	1	134.09	2.0	30	21	47	7	47	1	12.20	146.29	72.06

Waterbody	Location ID	Date	Segment 1 Installed BMPs		Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
			L	R	L	R	
Bonita Fork	X-932	08/24/10	none	slash filter	waterbars	sediment pond	-
tributary to West Fork Blacktail Deer Creek	X-911	08/24/10	water bar above contributing segment	-	-	-	Brook trout in pool below culvert, puddling from RR
West Fork Blacktail Deer Creek	X-925	08/24/10	-	-	re-vegetation	re-vegetation	Berm located along upstream end
West Fork Blacktail Deer Creek	X-928	08/24/10	none	none	re-vegetation	re-vegetation	relatively flat crossing
Indian Creek	X-1001	08/24/10	none	none	N/A	waterbar	small puddles at crossing
tributary to East Fork Blacktail Deer Creek	X-1002	08/24/10	none	none	waterbar	waterbar	grassy/willow veg existing buffer
Blacktail Deer Creek	X-1003	08/24/10	none	none	bridge replacement	bridge replacement	wooden bridge allows sediment into stream, tracked auto bridge
Sheep Creek	X-292	08/24/10	none	none	re-vegetation	re-vegetation	perhaps replace with longer culvert
French Creek	X-538	08/25/10	rolling dip	-	slash filter, improve dip u/s	-	rolling dip at upstream end is headcutting and should be improved. Effectively capture flow
French Creek	X-537	08/25/10	none	none	add culvert	add culvert	add bottomless arch culvert
French Creek	X-542	08/25/10	none	none	-	waterbars	small gullies observed in both "tracks"
Rattlesnake Creek	X-1004	08/25/10	none	none	manage cutslope, sediment pond	re-vegetation, slash filter	cutslope/hillslope load could be captured w/ditch and pond
Taylor Creek	X-1005	08/25/10	none	none	waterbars	none	road wash directly on top of culvert, add slash filter
West Fork Dyce Creek	X-939	08/25/10	rolling dip	none	improve rolling dips	waterbar	rolling dips are not effective
Grasshopper Creek	X-688	08/25/10	-	none	-	barriers along bridge	erosion down road with direct inputs from bridge deck
Grasshopper Creek	X-1006	08/25/10	none	none	re-vegetation	re-vegetation	short contributing distances directly on top of culvert
Reservoir Creek	X-1007	08/25/10	-	-	waterbars	-	drains from River L past culvert and into stream
tributary to Ashbaugh Creek	X-1008	08/26/10	none	-	waterbars, rolling dips	-	majority of contribution from left rut, right flows past crossing.
Big Dry Gulch	X-31	08/26/10	none	none	sediment basin	-	430 ft from the top of the hill to ditch along west side of road from River Left, assessed from ditch to diversion, ditch is sediment buffer
tributary to McHennesy Creek	X-184	08/26/10	none	none	bridge/culvert	bridge/culvert	stream ford
un-named	X-807	08/26/10	none	none	waterbars	waterbars	stream ford w/obvious fine sediment accumulation
Spring Creek	X-777	08/26/10	none	none	waterbars	none	
Stone Creek	X-751	08/26/10	BMP-sediment basin at top	none	additional sediment basin	re-vegetation	small stream along N (d/s) side of road, flows in ditch mostly
Carter Creek	X-28	08/26/10	none	none	waterbars/sediment ponds	waterbars/sediment ponds	
un-named	X-74	08/26/10	-	-	sediment traps, re-veg	sediment traps, re-veg	road surface "very hard", clear sides of erosion in roadside ditches
un-named	X-1009	08/26/10	none	none	waterbars	none	obvious flow observed

ATTACHMENT G-2. UNPAVED ROAD CROSSING ECOREGION ANALYSIS BEAVERHEAD TMDL PLANNING AREA

Location ID	Level IV Ecoregion	Level IV Ecoregion	Number of Sites Assessed	MEAN ANNUAL LOAD (tons)	MEAN ANNUAL LOAD with BMPs (tons)	Percent Reduction
X-688	BH	Big Hole		0.006	0.004	36%
X-1006	BH	Big Hole		0.002	0.002	0%
		Big Hole	2	0.004	0.003	27%
X-928	DISV	Dry Intermontane Sagebrush Valleys		0.002	0.002	0%
X-1003	DISV	Dry Intermontane Sagebrush Valleys		0.002	0.002	0%
X-292	DISV	Dry Intermontane Sagebrush Valleys		0.002	0.002	0%
X-542	DISV	Dry Intermontane Sagebrush Valleys		0.051	0.018	64%
X-1004	DISV	Dry Intermontane Sagebrush Valleys		0.030	0.025	16%
X-1005	DISV	Dry Intermontane Sagebrush Valleys		0.004	0.003	28%
X-1007	DISV	Dry Intermontane Sagebrush Valleys		0.004	0.002	52%
X-31	DISV	Dry Intermontane Sagebrush Valleys		0.141	0.052	63%
X-184	DISV	Dry Intermontane Sagebrush Valleys		0.004	0.004	0%
X-807	DISV	Dry Intermontane Sagebrush Valleys		0.005	0.004	28%
X-777	DISV	Dry Intermontane Sagebrush Valleys		0.001	0.001	0%
X-751	DISV	Dry Intermontane Sagebrush Valleys		0.095	0.040	58%
X-28	DISV	Dry Intermontane Sagebrush Valleys		0.027	0.007	73%
X-74	DISV	Dry Intermontane Sagebrush Valleys		0.293	0.039	87%
		Dry Intermontane Sagebrush Valleys	14	0.047	0.014	69%
X-932	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.062	0.021	66%
X-911	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.031	0.013	58%
X-925	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.012	0.012	0%
X-1002	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.017	0.014	16%
X-1008	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.158	0.001	100%
X-1009	DGSVH	Dry Gneissic-Schistose-Volcanic Hills		0.073	0.036	51%
		Dry Gneissic-Schistose-Volcanic Hills	6	0.059	0.016	72%
X-1001	BM	Barren Mountains		0.006	0.006	0%
X-538	EPSM	Eastern Pioneer Sedimentary Mountains		0.038	0.021	45%
X-537	EPSM	Eastern Pioneer Sedimentary Mountains		0.002	0.002	0%
X-939	PAR	Pioneer-Anaconda Ranges		0.377	0.021	94%
		Barren Mountains, Eastern Pioneer Sedimentary Mountains, Pioneer-Anaconda Ranges, Forested Beaverhead Mountains	4	0.106	0.013	88%

ATTACHMENT G-3. UNPAVED ROAD CROSSING SUBWATERSHED SEDIMENT LOADS BEAVERHEAD TMDL PLANNING AREA

Subwatershed	Owner Name	Level IV Ecoregion	MEAN ANNUAL LOAD per CROSSING (tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (tons)	# of Crossings	MEAN ANNUAL LOAD (tons)	MEAN ANNUAL LOAD with BMPs (tons)	Percent Reduction
Beaverhead River	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	31	1.466	0.448	69%
					31	1.466	0.448	69%
Beaverhead River	Private Land	Barren Mountains	0.106	0.013	7	0.740	0.088	88%
Beaverhead River	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	14	0.825	0.227	72%
Beaverhead River	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	176	8.322	2.542	69%
Beaverhead River	Private Land	Eastern Pioneer Sedimentary Mountains	0.106	0.013	1	0.106	0.013	88%
					198	9.993	2.870	71%
Beaverhead River	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	18	0.851	0.260	69%
					18	0.851	0.260	69%
Beaverhead River	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
Beaverhead River	US Forest Service	Eastern Pioneer Sedimentary Mountains	0.106	0.013	6	0.635	0.076	88%
					8	0.729	0.105	86%
Beaverhead River					**255**	**13.039**	**3.683**	**72%**
Blacktail Deer Creek	Montana State Trust Lands	Barren Mountains	0.106	0.013	1	0.106	0.013	88%
Blacktail Deer Creek	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
Blacktail Deer Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	33	1.560	0.477	69%
					37	1.843	0.538	71%
Blacktail Deer Creek	Private Land	Barren Mountains	0.106	0.013	5	0.529	0.063	88%
Blacktail Deer Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	6	0.353	0.097	72%
Blacktail Deer Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	63	2.979	0.910	69%
					74	3.861	1.070	72%
Blacktail Deer Creek	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
Blacktail Deer Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
					6	0.319	0.092	71%
Blacktail Deer Creek					**117**	**6.022**	**1.700**	**72%**
Clark Canyon Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	2	0.118	0.032	72%
					2	0.118	0.032	72%
Clark Canyon Creek	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	1	0.059	0.016	72%
					1	0.059	0.016	72%
Clark Canyon Creek					**3**	**0.177**	**0.049**	**72%**
Dyce Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
Dyce Creek	Private Land	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					5	0.353	0.069	81%
Dyce Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
Dyce Creek	US Bureau of Land Management	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					4	0.306	0.054	82%
Dyce Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					2	0.212	0.025	88%
Dyce Creek					**11**	**0.871**	**0.148**	**83%**
East Fork Blacktail Deer Creek	Montana Fish, Wildlife, and Parks	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	6	0.353	0.097	72%
East Fork Blacktail Deer Creek	Montana Fish, Wildlife, and Parks	Dry Intermontane Sagebrush Valleys	0.047	0.014	11	0.520	0.159	69%
					17	0.874	0.256	71%
East Fork Blacktail Deer Creek	Montana State Trust Lands	Barren Mountains	0.106	0.013	1	0.106	0.013	88%
East Fork Blacktail Deer Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					2	0.153	0.027	82%
East Fork Blacktail Deer Creek	US Bureau of Land Management	Barren Mountains	0.106	0.013	5	0.529	0.063	88%
					5	0.529	0.063	88%
East Fork Blacktail Deer Creek	US Forest Service	Barren Mountains	0.106	0.013	18	1.904	0.227	88%
					18	1.904	0.227	88%
East Fork Blacktail Deer Creek					**42**	**3.459**	**0.574**	**83%**
Ermont Gulch	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
					3	0.142	0.043	69%
Ermont Gulch	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	19	0.898	0.274	69%
					19	0.898	0.274	69%
Ermont Gulch	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
Ermont Gulch	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	11	0.520	0.159	69%
					14	0.697	0.208	70%
Ermont Gulch	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
					2	0.095	0.029	69%
Ermont Gulch					**38**	**1.832**	**0.554**	**70%**
Farlin Creek	Private Land	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Farlin Creek	US Bureau of Land Management	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Farlin Creek					**2**	**0.212**	**0.025**	**88%**
French Creek	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
French Creek	US Forest Service	Eastern Pioneer Sedimentary Mountains	0.106	0.013	7	0.740	0.088	88%
					7	0.740	0.088	88%
French Creek					**8**	**0.788**	**0.103**	**87%**
Grasshopper Creek	Montana Fish, Wildlife, and Parks	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
					3	0.142	0.043	69%
Grasshopper Creek	Montana State Trust Lands	Barren Mountains	0.106	0.013	1	0.106	0.013	88%
Grasshopper Creek	Montana State Trust Lands	Big Hole	0.004	0.003	10	0.041	0.030	27%
Grasshopper Creek	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	1	0.059	0.016	72%
Grasshopper Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	7	0.331	0.101	69%
Grasshopper Creek	Montana State Trust Lands	Forested Beaverhead Mountains	0.106	0.013	2	0.212	0.025	88%
Grasshopper Creek	Montana State Trust Lands	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					22	0.854	0.198	77%
Grasshopper Creek	Private Land	Big Hole	0.004	0.003	35	0.143	0.104	27%
Grasshopper Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	6	0.353	0.097	72%
Grasshopper Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	21	0.993	0.303	69%
Grasshopper Creek	Private Land	Pioneer-Anaconda Ranges	0.106	0.013	6	0.635	0.076	88%
					68	2.124	0.580	73%
Grasshopper Creek	US Bureau of Land Management	Big Hole	0.004	0.003	3	0.012	0.009	27%
Grasshopper Creek	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	8	0.471	0.130	72%
Grasshopper Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	21	0.993	0.303	69%
Grasshopper Creek	US Bureau of Land Management	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					34	1.688	0.467	72%
Grasshopper Creek	US Forest Service	Big Hole	0.004	0.003	1	0.004	0.003	27%
Grasshopper Creek	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
Grasshopper Creek	US Forest Service	Forested Beaverhead Mountains	0.106	0.013	16	1.692	0.202	88%
Grasshopper Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	9	0.952	0.114	88%
					29	2.790	0.362	87%
Grasshopper Creek					**156**	**7.597**	**1.651**	**78%**

Subwatershed	Owner Name	Level IV Ecoregion	MEAN ANNUAL LOAD per CROSSING (tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (tons)	# of Crossings	MEAN ANNUAL LOAD (tons)	MEAN ANNUAL LOAD with BMPs (tons)	Percent Reduction
Lower Rattlesnake Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	16	0.757	0.231	69%
					16	0.757	0.231	69%
Lower Rattlesnake Creek					**16**	**0.757**	**0.231**	**69%**
Lower Stone Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	5	0.236	0.072	69%
					5	0.236	0.072	69%
Lower Stone Creek					**5**	**0.236**	**0.072**	**69%**
Middle Fork Blacktail Deer Creek	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	2	0.118	0.032	72%
Middle Fork Blacktail Deer Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					3	0.165	0.047	72%
Middle Fork Blacktail Deer Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	4	0.189	0.058	69%
					4	0.189	0.058	69%
Middle Fork Blacktail Deer Creek	US Forest Service	Barren Mountains	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Middle Fork Blacktail Deer Creek					**8**	**0.460**	**0.117**	**74%**
Reservoir Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
Reservoir Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	4	0.189	0.058	69%
					4	0.189	0.058	69%
Reservoir Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
Reservoir Creek	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
					2	0.095	0.029	69%
Reservoir Creek					**8**	**0.378**	**0.116**	**69%**
Scudder Creek	Montana State Trust Lands	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Scudder Creek	Private Land	Big Hole	0.004	0.003	2	0.008	0.006	27%
					2	0.008	0.006	27%
Scudder Creek	US Bureau of Land Management	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Scudder Creek					**4**	**0.220**	**0.031**	**86%**
Spring Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
					3	0.142	0.043	69%
Spring Creek	Private Land	Barren Mountains	0.106	0.013	2	0.212	0.025	88%
Spring Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	1	0.059	0.016	72%
Spring Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	33	1.560	0.477	69%
					36	1.831	0.518	72%
Spring Creek	US Bureau of Land Management	Barren Mountains	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Spring Creek					**40**	**2.078**	**0.574**	**72%**
Steel Creek	Private Land	Big Hole	0.004	0.003	8	0.033	0.024	27%
Steel Creek	Private Land	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					9	0.138	0.036	74%
Steel Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					1	0.106	0.013	88%
Steel Creek					**10**	**0.244**	**0.049**	**80%**
Taylor Creek	Montana State Trust Lands	Big Hole	0.004	0.003	2	0.008	0.006	27%
Taylor Creek	Montana State Trust Lands	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
					4	0.103	0.035	66%
Taylor Creek	Private Land	Big Hole	0.004	0.003	1	0.004	0.003	27%
Taylor Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	3	0.142	0.043	69%
					4	0.146	0.046	68%
Taylor Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	2	0.095	0.029	69%
Taylor Creek	US Bureau of Land Management	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					4	0.306	0.054	82%
Taylor Creek	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	5	0.236	0.072	69%
Taylor Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	1	0.106	0.013	88%
					6	0.342	0.085	75%
Taylor Creek					**18**	**0.897**	**0.220**	**75%**
Upper Beaverhead River	Montana Fish, Wildlife, and Parks	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
					3	0.177	0.049	72%
Upper Beaverhead River	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	1	0.059	0.016	72%
					1	0.059	0.016	72%
Upper Beaverhead River	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	5	0.295	0.081	72%
					5	0.295	0.081	72%
Upper Beaverhead River	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	7	0.412	0.114	72%
					7	0.412	0.114	72%
Upper Beaverhead River					**16**	**0.942**	**0.260**	**72%**
Upper Rattlesnake Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	10	0.473	0.144	69%
					10	0.473	0.144	69%
Upper Rattlesnake Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
Upper Rattlesnake Creek	US Forest Service	Dry Intermontane Sagebrush Valleys	0.047	0.014	6	0.284	0.087	69%
Upper Rattlesnake Creek	US Forest Service	Eastern Pioneer Sedimentary Mountains	0.106	0.013	2	0.212	0.025	88%
Upper Rattlesnake Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	4	0.423	0.050	88%
					12	0.918	0.162	82%
Upper Rattlesnake Creek					**23**	**1.438**	**0.321**	**78%**
Upper Stone Creek	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
					3	0.177	0.049	72%
Upper Stone Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	5	0.295	0.081	72%
Upper Stone Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	4	0.189	0.058	69%
					9	0.484	0.139	71%
Upper Stone Creek	US Bureau of Land Management	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	3	0.177	0.049	72%
					3	0.177	0.049	72%
Upper Stone Creek					**15**	**0.837**	**0.236**	**72%**
West Fork Blacktail Deer Creek	Montana State Trust Lands	Barren Mountains	0.106	0.013	4	0.423	0.050	88%
West Fork Blacktail Deer Creek	Montana State Trust Lands	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	2	0.118	0.032	72%
					6	0.541	0.083	85%
West Fork Blacktail Deer Creek	Private Land	Barren Mountains	0.106	0.013	2	0.212	0.025	88%
West Fork Blacktail Deer Creek	Private Land	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	2	0.118	0.032	72%
West Fork Blacktail Deer Creek	Private Land	Dry Intermontane Sagebrush Valleys	0.047	0.014	6	0.284	0.087	69%
					10	0.613	0.144	76%
West Fork Blacktail Deer Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
West Fork Blacktail Deer Creek	US Forest Service	Barren Mountains	0.106	0.013	8	0.846	0.101	88%
West Fork Blacktail Deer Creek	US Forest Service	Dry Gneissic-Schistose-Volcanic Hills	0.059	0.016	6	0.353	0.097	72%
					14	1.200	0.198	83%
West Fork Blacktail Deer Creek					**31**	**2.401**	**0.440**	**82%**
West Fork Dyce Creek	US Bureau of Land Management	Dry Intermontane Sagebrush Valleys	0.047	0.014	1	0.047	0.014	69%
					1	0.047	0.014	69%
West Fork Dyce Creek	US Forest Service	Pioneer-Anaconda Ranges	0.106	0.013	2	0.212	0.025	88%
					2	0.212	0.025	88%
West Fork Dyce Creek					**3**	**0.259**	**0.040**	**85%**
BEAVERHEAD TPA					**829**	**45.144**	**11.194**	**75%**

ATTACHMENT G-4. UNPAVED PARALLEL ROAD SEGMENT FIELD DATA AND WEPP MODELED SEDIMENT LOADS BEAVERHEAD TMDL PLANNING AREA

Waterbody	Location ID	Date	Upstream		Downstream		Level IV Ecoregion	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient (%)	Length (Feet)	Length with BMPs (Feet)	Width (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD (lbs) with BMPs
			Latitude	Longitude	Latitude	Longitude																		
Bonita Fork	P-1	08/24/10	44.78064	-112.22701	44.78070	-112.22796	BM	24.52	Sand L	10	Insloped Veg/rock ditch	Native	Low	30	7.0	261	100	12	70	10	2	30	63.09	10.63
West Fork Blacktail Deer Creek	P-2	08/24/10	44.74370	-112.28789	44.74378	-112.28883	DGSVH	24.52	Sand L	30	Outsloped Unrutted	Native	Low	30	6.0	264	100	21	47	8	0.3	1	115.33	43.68
West Fork Blacktail Deer Creek	P-3	08/24/10	44.80396	-112.32388	44.80372	-112.32373	BM	17.41	Sand L	30	Outsloped Unrutted	Native	Low	50	1.0	98	98	19	70	15	0.3	1	53.02	53.02
French Creek	P-4	08/25/10	45.37941	-112.90262	45.37899	-112.90211	EPSM	24.52	Sand L	10	Outsloped Unrutted	Native	Low	30	9.0	196	100	9	100	20	9	5	51.56	26.31
Rattlesnake Creek	P-5	08/25/10					DISV	11.21	Sand L	10	Outsloped Unrutted	Native	Low	50	3.0	116	100	17	36	5	0.3	1	6.8	5.86
West Fork Dyce Creek	P-6	08/25/10	45.31491	-113.04537	45.31232	-113.04511	PAR	24.52	Sand L	20	Outsloped Rutted	Native	Low	30	10.0	991	100	12	84	5	9	20	1075.21	30.82
McHennesy Creek	P-7	08/26/10	45.32963	-112.30913	45.33008	-112.30961	DISV	17.41	Sand L	20	Outsloped Unrutted	Native	Low	50	4.0	200	100	8	84	3	0.3	1	19.86	9.93

Waterbody	Location ID	Date	Installed BMPs	Potential BMPs	Parallel Segement Notes/Comments
Bonita Fork	P-1	08/24/10	vegetated ditch	waterbars	culvert discharge at toe of slope, flows through wetland vegetation
West Fork Blacktail Deer Creek	P-2	08/24/10	trench along inside of road	slash filters	meandering channel at road bend with distinct input point
West Fork Blacktail Deer Creek	P-3	08/24/10	berm of graded gravel	revegetation along river right bank	channel abuts road occasionally, portion flows into culvert, portion directly into channel
French Creek	P-4	08/25/10	waterbars, rolling dips, vegetated buffer	waterbars	steep slope, gullies on road observed
Rattlesnake Creek	P-5	08/25/10	slash filters, blade berms	additional slash filters	slash filters in several places
West Fork Dyce Creek	P-6	08/25/10	none	rolling dips, waterbars	parallel to small stream, steep road, rutted with rocks
McHennesy Creek	P-7	08/26/10	none	waterbars	grassed median

ATTACHMENT G-5. UNPAVED PARALLEL ROAD SEGMENT SUBWATERSHED SEDIMENT LOADS BEAVERHEAD TMDL PLANNING AREA

Subwatershed	Owner Name	Parallel Segment Length (Miles)	Parallel Segment Length (Feet)	MEAN ANNUAL LOAD per 100 Feet for 7.2% (tons)	MEAN ANNUAL LOAD per 100 Feet for 7.2% with BMPs (tons)	MEAN ANNUAL LOAD (tons)	MEAN ANNUAL LOAD with BMPs (tons)	Percent Reduction
Beaverhead River	US Bureau of Land Management	4.25	22445	0.0023	0.0009	0.526	0.209	60%
Beaverhead River	US Forest Service	3.00	15842	0.0023	0.0009	0.372	0.147	60%
Beaverhead River	Montana State Trust Lands	2.72	14354	0.0023	0.0009	0.337	0.133	60%
Beaverhead River	Montana Fish, Wildlife, and Parks	0.37	1941	0.0023	0.0009	0.046	0.018	60%
Beaverhead River	Montana Department of Transportation	0.02	106	0.0023	0.0009	0.002	0.001	60%
Beaverhead River	Private Land	38.66	204121	0.0023	0.0009	4.787	1.898	60%
Beaverhead River		49.02	258808			6.069	2.406	60%
Blacktail Deer Creek	US Bureau of Land Management	8.46	44675	0.0023	0.0009	1.048	0.415	60%
Blacktail Deer Creek	Montana State Trust Lands	4.03	21304	0.0023	0.0009	0.500	0.198	60%
Blacktail Deer Creek	Montana Fish, Wildlife, and Parks	0.18	936	0.0023	0.0009	0.022	0.009	60%
Blacktail Deer Creek	Private Land	15.30	80809	0.0023	0.0009	1.895	0.751	60%
Blacktail Deer Creek		27.98	147723			3.464	1.373	60%
Clark Canyon Creek	US Bureau of Land Management	0.21	1111	0.0023	0.0009	0.026	0.010	60%
Clark Canyon Creek	Montana State Trust Lands	0.03	161	0.0023	0.0009	0.004	0.001	60%
Clark Canyon Creek	Private Land	1.01	5311	0.0023	0.0009	0.125	0.049	60%
Clark Canyon Creek		1.25	6584			0.154	0.061	60%
Dyce Creek	US Bureau of Land Management	1.98	10439	0.0023	0.0009	0.245	0.097	60%
Dyce Creek	US Forest Service	0.09	492	0.0023	0.0009	0.012	0.005	60%
Dyce Creek	Private Land	0.72	3811	0.0023	0.0009	0.089	0.035	60%
Dyce Creek		2.79	14742			0.346	0.137	60%
East Fork Blacktail Deer Creek	US Bureau of Land Management	0.44	2314	0.0023	0.0009	0.054	0.022	60%
East Fork Blacktail Deer Creek	US Forest Service	5.09	26871	0.0023	0.0009	0.630	0.250	60%
East Fork Blacktail Deer Creek	Montana State Trust Lands	0.42	2196	0.0023	0.0009	0.051	0.020	60%
East Fork Blacktail Deer Creek	Montana Fish, Wildlife, and Parks	0.72	3819	0.0023	0.0009	0.090	0.035	60%
East Fork Blacktail Deer Creek		6.67	35199			0.825	0.327	60%
Ermont Gulch	US Bureau of Land Management	2.15	11366	0.0023	0.0009	0.267	0.106	60%
Ermont Gulch	US Forest Service	0.49	2564	0.0023	0.0009	0.060	0.024	60%
Ermont Gulch	Montana State Trust Lands	0.83	4405	0.0023	0.0009	0.103	0.041	60%
Ermont Gulch	Private Land	3.62	19117	0.0023	0.0009	0.448	0.178	60%
Ermont Gulch		7.09	37451			0.878	0.348	60%
Farlin Creek	US Bureau of Land Management	0.40	2097	0.0023	0.0009	0.049	0.019	60%
Farlin Creek	US Forest Service	0.03	133	0.0023	0.0009	0.003	0.001	60%
Farlin Creek	Private Land	1.08	5705	0.0023	0.0009	0.134	0.053	60%
Farlin Creek		1.50	7936			0.186	0.074	60%
French Creek	US Forest Service	7.26	38356	0.0023	0.0009	0.899	0.357	60%
French Creek		7.26	38356			0.899	0.357	60%
Grasshopper Creek	US Bureau of Land Management	12.55	66276	0.0023	0.0009	1.554	0.616	60%
Grasshopper Creek	US Forest Service	4.09	21605	0.0023	0.0009	0.507	0.201	60%
Grasshopper Creek	Montana State Trust Lands	1.15	6074	0.0023	0.0009	0.142	0.056	60%
Grasshopper Creek	Montana Fish, Wildlife, and Parks	1.66	8773	0.0023	0.0009	0.206	0.082	60%
Grasshopper Creek	Private Land	12.40	65466	0.0023	0.0009	1.535	0.609	60%
Grasshopper Creek		31.86	168195			3.944	1.564	60%
Lower Rattlesnake Creek	Private Land	1.07	5658	0.0023	0.0009	0.133	0.053	60%
Lower Rattlesnake Creek		1.07	5658			0.133	0.053	60%
Lower Stone Creek	Private Land	0.34	1810	0.0023	0.0009	0.042	0.017	60%
Lower Stone Creek		0.34	1810			0.042	0.017	60%
Middle Fork Blacktail Deer Creek	US Forest Service	0.01	66	0.0023	0.0009	0.002	0.001	60%
Middle Fork Blacktail Deer Creek	Montana State Trust Lands	1.13	5942	0.0023	0.0009	0.139	0.055	60%
Middle Fork Blacktail Deer Creek	Private Land	0.30	1593	0.0023	0.0009	0.037	0.015	60%
Middle Fork Blacktail Deer Creek		1.44	7601			0.178	0.071	60%
Reservoir Creek	US Bureau of Land Management	0.13	707	0.0023	0.0009	0.017	0.007	60%
Reservoir Creek	US Forest Service	0.20	1074	0.0023	0.0009	0.025	0.010	60%
Reservoir Creek	Montana State Trust Lands	0.40	2110	0.0023	0.0009	0.049	0.020	60%
Reservoir Creek	Private Land	0.33	1721	0.0023	0.0009	0.040	0.016	60%
Reservoir Creek		1.06	5613			0.132	0.052	60%
Scudder Creek	US Bureau of Land Management	0.22	1140	0.0023	0.0009	0.027	0.011	60%
Scudder Creek	Montana State Trust Lands	0.58	3070	0.0023	0.0009	0.072	0.029	60%
Scudder Creek	Private Land	0.67	3560	0.0023	0.0009	0.083	0.033	60%
Scudder Creek		1.47	7770			0.182	0.072	60%
Spring Creek	US Bureau of Land Management	0.18	955	0.0023	0.0009	0.022	0.009	60%
Spring Creek	Montana State Trust Lands	0.03	158	0.0023	0.0009	0.004	0.001	60%
Spring Creek	Private Land	3.19	16824	0.0023	0.0009	0.395	0.156	60%
Spring Creek		3.40	17937			0.421	0.167	60%
Steel Creek	US Bureau of Land Management	0.31	1658	0.0023	0.0009	0.039	0.015	60%
Steel Creek	US Forest Service	0.65	3431	0.0023	0.0009	0.080	0.032	60%
Steel Creek	Private Land	2.82	14870	0.0023	0.0009	0.349	0.138	60%
Steel Creek		3.78	19959			0.468	0.186	60%
Taylor Creek	US Bureau of Land Management	0.88	4620	0.0023	0.0009	0.108	0.043	60%
Taylor Creek	US Forest Service	0.14	747	0.0023	0.0009	0.018	0.007	60%
Taylor Creek	Montana State Trust Lands	0.05	256	0.0023	0.0009	0.006	0.002	60%
Taylor Creek	Private Land	0.19	1011	0.0023	0.0009	0.024	0.009	60%
Taylor Creek		1.26	6635			0.156	0.062	60%
Upper Beaverhead River	US Bureau of Land Management	0.55	2913	0.0023	0.0009	0.068	0.027	60%
Upper Beaverhead River	Montana State Trust Lands	0.82	4331	0.0023	0.0009	0.102	0.040	60%
Upper Beaverhead River	Montana Fish, Wildlife, and Parks	0.06	308	0.0023	0.0009	0.007	0.003	60%
Upper Beaverhead River	Private Land	0.75	3984	0.0023	0.0009	0.093	0.037	60%
Upper Beaverhead River		2.18	11536			0.271	0.107	60%
Upper Rattlesnake Creek	US Bureau of Land Management	0.04	234	0.0023	0.0009	0.005	0.002	60%
Upper Rattlesnake Creek	US Forest Service	2.83	14924	0.0023	0.0009	0.350	0.139	60%
Upper Rattlesnake Creek	Private Land	1.80	9511	0.0023	0.0009	0.223	0.088	60%
Upper Rattlesnake Creek		4.67	24669			0.578	0.229	60%
Upper Stone Creek	US Bureau of Land Management	2.15	11329	0.0023	0.0009	0.266	0.105	60%
Upper Stone Creek	Montana State Trust Lands	0.13	689	0.0023	0.0009	0.016	0.006	60%
Upper Stone Creek	Private Land	4.64	24497	0.0023	0.0009	0.574	0.228	60%
Upper Stone Creek		6.92	36515			0.856	0.339	60%
West Fork Blacktail Deer Creek	US Bureau of Land Management	0.44	2299	0.0023	0.0009	0.054	0.021	60%
West Fork Blacktail Deer Creek	US Forest Service	2.02	10661	0.0023	0.0009	0.250	0.099	60%
West Fork Blacktail Deer Creek	Montana State Trust Lands	1.96	10343	0.0023	0.0009	0.243	0.096	60%
West Fork Blacktail Deer Creek	Montana Fish, Wildlife, and Parks	0.10	532	0.0023	0.0009	0.012	0.005	60%
West Fork Blacktail Deer Creek	Private Land	0.77	4077	0.0023	0.0009	0.096	0.038	60%
West Fork Blacktail Deer Creek		5.29	27912			0.655	0.259	60%
West Fork Dyce Creek	US Bureau of Land Management	2.75	14539	0.0023	0.0009	0.341	0.135	60%
West Fork Dyce Creek	US Forest Service	0.22	1138	0.0023	0.0009	0.027	0.011	60%
West Fork Dyce Creek		2.97	15677			0.368	0.146	60%
BEAVERHEAD TPA		**171.27**	**904287**			**21.206**	**8.407**	**60%**

Attachment G-6. Culvert Failure Analysis Beaverhead TMDL Planning Area

Location ID	Structure Type	Culvert Dimensions	Culvert Slope	Bankfull Width	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Capacity at Cross Section	Headwater Hieght (Fill Hieght)	Field Measured Fill Width	Modeled Fill Width*	Fill Length	Fill Volume*	Fill Volume*	Potential Sediment Load if Culvert Fails*
		(ft)	(%)	(ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft³)	(CY)	(tons)
X-932	Round CMP	3	4	5	7	21	35	62	88	123	102	10	66	5	38	1900	70	117
X-911	Round CMP	2	1	2.5	2	7	13	25	38	55	22	4	22	2.5	24	240	9	15
X-925	Round CMP	5	0.5	15	57	120	175	264	341	435	68	4	29	15	25	1500	56	92
X-928	Squash CMP	9 span 6 rise	1	24	139	255	348	490	608	746	401	7	25	24	35	5880	218	362
X-1001	Squash CMP	6 span 4 rise	3	10	27	63	97	154	207	273	314	10	51	10	25	2500	93	154
X-1002	Round CMP	2	2	1.5	1	3	6	13	20	31	13	2	11	1.5	24	72	3	4
X-292	Round CMP	4	1	7	14	36	58	96	134	181	47	3	21	7	29	609	23	37
X-538	Round CMP	4	3	6	10	28	46	79	111	152	94	5	18	6	20	600	22	37
X-542	Round CMP	4	2	7	14	36	58	96	134	181	108	6	41	7	18	756	28	46
X-1005	Round CMP	3	1	12	38	84	126	196	259	336	54	5	20	12	26	1560	58	96
X-1006	Round CMP	10	1	12	38	84	126	196	259	336	243	7	42	12	35	2940	109	181
X-1007	Round CMP	4	1	7	14	36	58	96	134	181	104	6	31	7	25	1050	39	65
X-1008	Round CMP	5	3	9	22	53	83	134	182	242	208	8	22	9	31	2232	83	137
X-31	Round CMP	2	3	4	5	15	25	46	67	95	47	15	427	4	50	3000	111	184
X-777	Round CMP	3	1	6	10	28	46	79	111	152	64	6	30	6	26	936	35	58
X-751	Round CMP	4	4	12	38	84	126	196	259	336	180	12	289	12	102	14688	544	903
X-28	Round CMP	4	2	5	7	21	35	62	88	123	96	5	76	5	23	575	21	35
X-74	Round CMP	3	3	3	3	9	17	32	47	68	106	15	270	3	85	3825	142	235
X-1009	Round CMP	1.5	4	3	3	9	17	32	47	68	9	2	25	3	28	168	6	10

*Assuming a fill width equal to the bankfull width

culvert fails to pass discharge

ATTACHMENT G-7. MONTANA DEPARTMENT OF TRANSPORTATION TRACTION SAND APPLICATION RATES 2009-2011 BEAVERHEAD TMDL PLANNING AREA

TRAVEL ROUTE	TRAVEL ROUTE DESCRIPTION	TRAVEL ROUTE LENGTH (MILES)	YEAR	YARDS OF SAND	MILES PLOWED	RATE = LBS PER PLOWED MILE	TONS PER PLOWED MILE	TONS OF SAND
State Highway 278	**Mile Marker 0 - 13.9**	**13.9**	2009	745	5,492	407	0.20	1,118
			2010	472	3,341	424	0.21	708
			2011	778	6,500	359	0.18	1,167
			3 YEAR AVERAGE	**665.0**	**5,111**	**390**	**0.20**	**998**
State Highway 41	**Mile Marker 0 -27.6**	**27.6**	2009	400	3,672	327	0.16	600
			2010	348	3,029	345	0.17	522
			2011	448	3,999	336	0.17	672
			3 YEAR AVERAGE	**398.7**	**3,567**	**335**	**0.17**	**598**
State Highway 91	**This is two MDT routes:**	**14.5**	2009	59	724	244	0.12	89
	Mile Marker 0 - 3.5 (S-222)		2010	85	656	389	0.19	128
	Mile Marker 0 -11 (X-81001)		2011	153	1,438	319	0.16	230
			3 YEAR AVERAGE	**99.0**	**939**	**316**	**0.16**	**149**
Interstate 15	**Mile Marker 44.7 - 75**	**30.3**	2009	1140	17,123	200	0.10	1,710
			2010	955	11,825	242	0.12	1,433
			2011	1311	17,898	220	0.11	1,967
			3 YEAR AVERAGE	**1135.3**	**15,615**	**218**	**0.11**	**1,703**
							TOTAL	**3,447**
RATE OF SAND PER PLOWED MILE IS BASED ON AN AVERAGE WEIGHT OF 3000 LBS. PER YARD								
All of the years are MDT fiscal years (July 1st - June 30th)								

Attachment G-8. Fish Passage Assessment Beaverhead TMDL Planning Area

Location ID	Structure Type	Evaluation Method	Culvert Dimensions (ft)	Width (ft)	Culvert Slope (%)	Bankfull Width (ft)	Culvert/ Bankfull Ratio	Outlet Perch (inches)	Final Classification (# of failures)
X-932	Round CMP	3	3	3	4[3]	**5**	0.60[2]	9.6[3]	2[3]
X-911	Round CMP	3	2	2	1[2]	**2.5**	0.80[1]	0[1]	0[1]
X-925	Round CMP	4	5	5	0.5[2]	**15**	0.33[3]	0[1]	1[3]
X-928	Squash CMP	4	9 span 6 rise	9	1[2]	**24**	0.38[3]	0[1]	1[3]
X-1001	Squash CMP	4	6 span 4 rise	6	3[3]	**10**	0.60[2]	27.6[3]	2[3]
X-1002	Round CMP	3	2	2	2[3]	**1.5**	1.33[1]	3.6[2]	1[3]
X-292	Round CMP	3	4	4	1[2]	**7**	0.57[2]	0[1]	0[1]
X-538	Round CMP	3	4	4	3[3]	**6**	0.67[2]	6[3]	2[3]
X-542	Round CMP	3	4	4	2[3]	**7**	0.57[2]	0[1]	1[3]
X-1005	Round CMP	3	3	3	1[2]	**12**	0.25[3]	0[1]	1[3]
X-1006	Round CMP	4	10	10	1[2]	**12**	0.83[1]	0[1]	0[1]
X-1007	Round CMP	3	4	4	1[2]	**7**	0.57[2]	0[1]	0[1]
X-1008	Round CMP	4	5	5	3[3]	**9**	0.56[2]	0[1]	1[3]
X-31	Round CMP	3	2	2	3[3]	**4**	0.50[2]	0[1]	1[3]
X-777	Round CMP	3	3	3	1[2]	**6**	0.50[2]	0[1]	0[1]
X-751	Round CMP	3	4	4	4[3]	**12**	0.33[3]	26.4[3]	3[3]
X-28	Round CMP	3	4	4	2[3]	**5**	0.80[1]	0[1]	1[3]
X-74	Round CMP	3	3	3	3[3]	**3**	1.00[1]	36[3]	2[3]
X-1009	Round CMP	3	1.5	1.5	4[3]	**3**	0.50[2]	0[1]	1[3]

Note: Evaluation Method based on Table:1 Fish Passage Evaluation Criteria located in *A Summary of Techincal Considerations to Minimize the Blockage of Fish at Culverts on the National Forests of Alaska*

1 conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows

2 conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability

3 conditions that have a high certainty of <u>not</u> providing juvenile fish passage at all desired stream flows

APPENDIX H - TOTAL MAXIMUM DAILY LOADS

H1.0 SEDIMENT

H1.1 OVERVIEW

A percent reduction based on average yearly loading was used as the primary approach for expressing the sediment TMDLs within this document because there is uncertainty associated with the loads derived from the source assessment, and using the estimated sediment loads alone creates a rigid perception that the loads are absolutely conclusive. However, in this appendix the TMDL is expressed using daily loads to satisfy an additional EPA required TMDL element. Daily loads should not be considered absolutely conclusive and may be refined in the future as part of the adaptive management process. The TMDLs may not be feasible at all locations within the watershed but if the allocations are followed, sediment loads are expected to be reduced to a degree that the sediment targets are met and beneficial uses are no longer impaired. It is not expected that daily loads will drive implementation activities.

H1.2 APPROACH

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. Within the entire Beaverhead watershed, there are several USGS gage stations with extensive discharge datasets; however there is only one gauging station with daily suspended sediment measurements and the data was collected over a 13 year period. Mean daily suspended sediment data collected from 1961 to 1974 at the USGS station on the Beaverhead River near Twin Bridges, MT (06018500) was used to calculate daily sediment loads on the Beaverhead River.

Although the annual suspended sediment for this time period is less than the total load from the source assessment, it provides an approximation of the relationship between sediment and flow in the Beaverhead River. Based on the sum of the calculated daily sediment loads, a daily percentage relative to the annual suspended sediment load was calculated for each day. The daily percentages were then applied to the total average annual loads associated with the TMDL percent reductions from **Section 5.0** to determine the average daily load.

To conserve resources, this appendix contains daily loads for the Beaverhead River as an example. As discussed in **Section 5.7.3.1**, the TMDL for the Beaverhead River is a 69% reduction in the total average annual sediment load and the TMDL is roughly 26,836 tons/year. The daily percentages discussed above were then multiplied by the annual load of 26,836 tons to get a daily expression of the Beaverhead River TMDL (**Table H-1**). For all other **waterbodies**, daily TMDLs may be derived by using the daily percentages in **Table H-1** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.7** and presented in **Table H-2**. The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.7** to the daily load.

Table H-1. Daily Sediment TMDL for the Beaverhead River based on suspended sediment discharge from USGS 06018500 (Beaverhead River near Twin Bridges)

Month	Day	Mean Tons/Day	Daily Percent of Annual Load	Month	Day	Mean Tons/Day	Daily Percent of Annual Load
January	1	76.74	0.29%	February	1	95.27	0.35%
January	2	67.92	0.25%	February	2	89.97	0.34%
January	3	68.80	0.26%	February	3	89.97	0.34%
January	4	62.63	0.23%	February	4	113.79	0.42%
January	5	57.34	0.21%	February	5	147.31	0.55%
January	6	60.86	0.23%	February	6	134.08	0.50%
January	7	67.92	0.25%	February	7	129.67	0.48%
January	8	66.16	0.25%	February	8	139.37	0.52%
January	9	89.09	0.33%	February	9	110.26	0.41%
January	10	82.03	0.31%	February	10	94.38	0.35%
January	11	67.92	0.25%	February	11	97.91	0.36%
January	12	50.28	0.19%	February	12	94.38	0.35%
January	13	57.34	0.21%	February	13	97.03	0.36%
January	14	69.69	0.26%	February	14	96.15	0.36%
January	15	76.74	0.29%	February	15	91.74	0.34%
January	16	82.03	0.31%	February	16	89.97	0.34%
January	17	97.91	0.36%	February	17	92.62	0.35%
January	18	89.97	0.34%	February	18	97.91	0.36%
January	19	89.97	0.34%	February	19	94.38	0.35%
January	20	84.68	0.32%	February	20	91.74	0.34%
January	21	83.80	0.31%	February	21	90.86	0.34%
January	22	82.03	0.31%	February	22	90.86	0.34%
January	23	84.68	0.32%	February	23	90.86	0.34%
January	24	77.62	0.29%	February	24	91.74	0.34%
January	25	74.98	0.28%	February	25	90.86	0.34%
January	26	74.98	0.28%	February	26	89.97	0.34%
January	27	72.33	0.27%	February	27	95.27	0.35%
January	28	74.10	0.28%	February	28	96.15	0.36%
January	29	68.80	0.26%	February	29	125.26	0.47%
January	30	70.57	0.26%				
January	31	82.03	0.31%				
March	1	92.62	0.35%	April	1	197.59	0.74%
March	2	97.91	0.36%	April	2	159.66	0.59%
March	3	99.68	0.37%	April	3	137.61	0.51%
March	4	94.38	0.35%	April	4	125.26	0.47%
March	5	99.68	0.37%	April	5	119.97	0.45%
March	6	99.68	0.37%	April	6	119.97	0.45%
March	7	93.50	0.35%	April	7	116.44	0.43%
March	8	90.86	0.34%	April	8	113.79	0.42%

Table H-1. Daily Sediment TMDL for the Beaverhead River based on suspended sediment discharge from USGS 06018500 (Beaverhead River near Twin Bridges)

Month	Day	Mean Tons/Day	Daily Percent of Annual Load	Month	Day	Mean Tons/Day	Daily Percent of Annual Load
March	9	89.09	0.33%	April	9	120.85	0.45%
March	10	94.38	0.35%	April	10	112.91	0.42%
March	11	98.79	0.37%	April	11	118.20	0.44%
March	12	103.21	0.38%	April	12	104.97	0.39%
March	13	119.97	0.45%	April	13	109.38	0.41%
March	14	122.61	0.46%	April	14	107.62	0.40%
March	15	111.14	0.41%	April	15	85.56	0.32%
March	16	127.02	0.47%	April	16	79.39	0.30%
March	17	150.84	0.56%	April	17	82.03	0.31%
March	18	156.13	0.58%	April	18	84.68	0.32%
March	19	123.49	0.46%	April	19	77.62	0.29%
March	20	116.44	0.43%	April	20	75.86	0.28%
March	21	112.03	0.42%	April	21	79.39	0.30%
March	22	106.73	0.40%	April	22	72.33	0.27%
March	23	115.55	0.43%	April	23	74.10	0.28%
March	24	119.97	0.45%	April	24	84.68	0.32%
March	25	112.91	0.42%	April	25	80.27	0.30%
March	26	109.38	0.41%	April	26	80.27	0.30%
March	27	140.25	0.52%	April	27	100.56	0.37%
March	28	189.65	0.71%	April	28	104.09	0.39%
March	29	177.30	0.66%	April	29	82.92	0.31%
March	30	157.90	0.59%	April	30	79.39	0.30%
March	31	174.65	0.65%				
May	1	82.92	0.31%	June	1	53.81	0.20%
May	2	87.33	0.33%	June	2	54.69	0.20%
May	3	67.92	0.25%	June	3	56.45	0.21%
May	4	65.28	0.24%	June	4	62.63	0.23%
May	5	58.22	0.22%	June	5	74.10	0.28%
May	6	54.69	0.20%	June	6	79.39	0.30%
May	7	51.16	0.19%	June	7	95.27	0.35%
May	8	56.45	0.21%	June	8	160.54	0.60%
May	9	52.04	0.19%	June	9	137.61	0.51%
May	10	42.34	0.16%	June	10	164.07	0.61%
May	11	40.58	0.15%	June	11	161.42	0.60%
May	12	42.34	0.16%	June	12	133.20	0.50%
May	13	37.93	0.14%	June	13	142.90	0.53%
May	14	32.64	0.12%	June	14	145.55	0.54%
May	15	31.76	0.12%	June	15	130.55	0.49%
May	16	26.46	0.10%	June	16	125.26	0.47%

Table H-1. Daily Sediment TMDL for the Beaverhead River based on suspended sediment discharge from USGS 06018500 (Beaverhead River near Twin Bridges)

Month	Day	Mean Tons/Day	Daily Percent of Annual Load	Month	Day	Mean Tons/Day	Daily Percent of Annual Load
May	17	23.82	0.09%	June	17	132.31	0.49%
May	18	22.93	0.09%	June	18	121.73	0.45%
May	19	24.70	0.09%	June	19	103.21	0.38%
May	20	42.34	0.16%	June	20	104.09	0.39%
May	21	42.34	0.16%	June	21	112.03	0.42%
May	22	41.46	0.15%	June	22	119.08	0.44%
May	23	42.34	0.16%	June	23	98.79	0.37%
May	24	70.57	0.26%	June	24	107.62	0.40%
May	25	56.45	0.21%	June	25	98.79	0.37%
May	26	61.75	0.23%	June	26	91.74	0.34%
May	27	47.63	0.18%	June	27	97.03	0.36%
May	28	44.10	0.16%	June	28	119.97	0.45%
May	29	43.22	0.16%	June	29	108.50	0.40%
May	30	40.58	0.15%	June	30	92.62	0.30%
May	31	45.87	0.17%				
July	1	98.79	0.32%	August	1	25.58	0.08%
July	2	116.44	0.38%	August	2	21.17	0.07%
July	3	88.21	0.29%	August	3	21.17	0.07%
July	4	74.10	0.24%	August	4	25.58	0.08%
July	5	69.69	0.23%	August	5	26.46	0.09%
July	6	57.34	0.19%	August	6	29.11	0.10%
July	7	56.45	0.19%	August	7	26.46	0.09%
July	8	47.63	0.16%	August	8	26.46	0.09%
July	9	44.99	0.15%	August	9	28.23	0.09%
July	10	46.75	0.15%	August	10	26.46	0.09%
July	11	43.22	0.14%	August	11	24.70	0.08%
July	12	39.69	0.13%	August	12	26.46	0.09%
July	13	34.40	0.11%	August	13	32.64	0.11%
July	14	35.28	0.12%	August	14	30.87	0.10%
July	15	43.22	0.14%	August	15	27.34	0.09%
July	16	44.99	0.15%	August	16	24.70	0.08%
July	17	40.58	0.13%	August	17	26.46	0.09%
July	18	36.17	0.12%	August	18	29.11	0.10%
July	19	37.93	0.12%	August	19	29.11	0.10%
July	20	33.52	0.11%	August	20	26.46	0.09%
July	21	40.58	0.13%	August	21	29.99	0.10%
July	22	37.93	0.12%	August	22	35.28	0.12%
July	23	37.05	0.12%	August	23	37.05	0.12%
July	24	28.23	0.09%	August	24	35.28	0.12%

Table H-1. Daily Sediment TMDL for the Beaverhead River based on suspended sediment discharge from USGS 06018500 (Beaverhead River near Twin Bridges)

Month	Day	Mean Tons/Day	Daily Percent of Annual Load	Month	Day	Mean Tons/Day	Daily Percent of Annual Load
July	25	24.70	0.08%	August	25	32.64	0.11%
July	26	23.82	0.08%	August	26	33.52	0.11%
July	27	23.82	0.08%	August	27	32.64	0.11%
July	28	24.70	0.08%	August	28	32.64	0.11%
July	29	26.46	0.09%	August	29	34.40	0.11%
July	30	25.58	0.08%	August	30	42.34	0.14%
July	31	26.46	0.09%	August	31	46.75	0.15%
September	1	59.10	0.19%	October	1	39.69	0.13%
September	2	63.51	0.21%	October	2	34.40	0.11%
September	3	59.10	0.19%	October	3	35.28	0.12%
September	4	59.98	0.20%	October	4	41.46	0.14%
September	5	63.51	0.21%	October	5	37.05	0.12%
September	6	58.22	0.19%	October	6	35.28	0.12%
September	7	58.22	0.19%	October	7	35.28	0.12%
September	8	63.51	0.21%	October	8	37.05	0.12%
September	9	61.75	0.20%	October	9	40.58	0.13%
September	10	54.69	0.18%	October	10	46.75	0.15%
September	11	53.81	0.18%	October	11	44.99	0.15%
September	12	54.69	0.18%	October	12	46.75	0.15%
September	13	52.93	0.17%	October	13	46.75	0.15%
September	14	52.04	0.17%	October	14	49.40	0.16%
September	15	52.04	0.17%	October	15	52.93	0.17%
September	16	49.40	0.16%	October	16	56.45	0.19%
September	17	52.04	0.17%	October	17	58.22	0.19%
September	18	55.57	0.18%	October	18	53.81	0.18%
September	19	53.81	0.18%	October	19	49.40	0.16%
September	20	55.57	0.18%	October	20	52.93	0.17%
September	21	54.69	0.18%	October	21	56.45	0.19%
September	22	55.57	0.18%	October	22	51.16	0.17%
September	23	53.81	0.18%	October	23	56.45	0.19%
September	24	52.04	0.17%	October	24	57.34	0.19%
September	25	52.04	0.17%	October	25	57.34	0.19%
September	26	54.69	0.18%	October	26	52.93	0.17%
September	27	46.75	0.15%	October	27	52.04	0.17%
September	28	40.58	0.13%	October	28	50.28	0.17%
September	29	37.05	0.12%	October	29	50.28	0.17%
September	30	37.05	0.12%	October	30	56.45	0.19%
				October	31	54.69	0.18%
November	1	62.63	0.21%	December	1	70.57	0.23%

Table H-1. Daily Sediment TMDL for the Beaverhead River based on suspended sediment discharge from USGS 06018500 (Beaverhead River near Twin Bridges)

Month	Day	Mean Tons/Day	Daily Percent of Annual Load	Month	Day	Mean Tons/Day	Daily Percent of Annual Load
November	2	61.75	0.20%	December	2	74.10	0.24%
November	3	54.69	0.18%	December	3	78.51	0.26%
November	4	54.69	0.18%	December	4	82.03	0.27%
November	5	68.80	0.23%	December	5	74.98	0.25%
November	6	76.74	0.25%	December	6	72.33	0.24%
November	7	74.98	0.25%	December	7	80.27	0.26%
November	8	73.21	0.24%	December	8	81.15	0.27%
November	9	74.10	0.24%	December	9	89.09	0.29%
November	10	75.86	0.25%	December	10	89.09	0.29%
November	11	78.51	0.26%	December	11	82.92	0.27%
November	12	82.03	0.27%	December	12	83.80	0.28%
November	13	83.80	0.28%	December	13	79.39	0.26%
November	14	80.27	0.26%	December	14	82.92	0.27%
November	15	82.92	0.27%	December	15	84.68	0.28%
November	16	78.51	0.26%	December	16	82.92	0.27%
November	17	74.10	0.24%	December	17	76.74	0.25%
November	18	75.86	0.25%	December	18	79.39	0.26%
November	19	74.10	0.24%	December	19	87.33	0.29%
November	20	74.98	0.25%	December	20	83.80	0.28%
November	21	74.10	0.24%	December	21	77.62	0.26%
November	22	70.57	0.23%	December	22	79.39	0.26%
November	23	63.51	0.21%	December	23	99.68	0.33%
November	24	64.39	0.21%	December	24	84.68	0.28%
November	25	67.04	0.22%	December	25	75.86	0.25%
November	26	63.51	0.21%	December	26	72.33	0.24%
November	27	65.28	0.21%	December	27	69.69	0.23%
November	28	59.98	0.20%	December	28	74.10	0.24%
November	29	56.45	0.19%	December	29	78.51	0.26%
November	30	60.86	0.20%	December	30	70.57	0.23%
				December	31	74.10	0.24%

Table H-2. TMDLs expressed as an average annual load and can be used in conjunction with the values in Table H-1 to compute daily loads.

Stream Segment	Waterbody ID	TMDL Expressed as Average Annual Load (tons/year)
Beaverhead River, lower segment	MT41B001_020	26,836
Blacktail Deer Creek	MT41B002_030	5,394
Clark Canyon Creek	MT41B002_110	500
Dyce Creek	MT41B002_140	660
Farlin Creek	MT41B002_020	355
French Creek	MT41B002_100	376
Grasshopper Creek	MT41B002_010	6,376
Rattlesnake Creek, upper segment	MT41B002_091	1,954
Rattlesnake Creek, lower segment	MT41B002_090	2,452
Reservoir Creek	MT41B002_120	987
Scudder Creek	MT41B002_180	536
Spring Creek	MT41B002_080	1,387
Steel Creek	MT41B002_160	184
Stone Creek, upper segment	MT41B002_132	942
Stone Creek, lower segment	MT41B002_131	1,346
Taylor Creek	MT41B002_170	1,061
West Fork Blacktail Deer Creek	MT41B002_060	1,089
West Fork Dyce Creek	MT41B002_070	173

ATTACHMENT A – BEAVERHEAD RIVER FLUSHING FLOW STUDY

RECLAMATION
Managing Water in the West

Beaverhead River Flushing Flow Study

Clark Canyon Dam, Montana
Montana Area Office
Billings, Montana

U.S. Department of the Interior
Bureau of Reclamation

September 2010

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Group, D86-68240

Beaverhead River Flushing Flow Study

Clark Canyon Dam
Montana Area Office
Billings, Montana

Prepared: Cassie C. Klumpp
Sedimentation and River Hydraulics Group, 86-68240

Peer Review: David Varyu,P.E
Sedimentation and River Hydraulics Group, 86-68240

Date

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Introduction

The Montana Area Office has requested that the Technical Service Center (TSC) perform a qualitative study to estimate the discharge necessary to remove fine sediment below Clark Canyon Reservoir on the Beaverhead River (Figure 1). Clark Canyon Creek flows into the Beaverhead River below Clark Canyon Reservoir approximately 1.5 miles below the dam. The creek delivers a great deal of fine sediment to the river. The Montana Area Office provided bed material size data for Clark Canyon Creek and the Beaverhead River. This report summarizes the results of the flushing flow analysis.

Clark Canyon Creek delivers a large load of fine sediment into the Beaverhead River each spring (Figures 2 through 5). This large sediment load has affected fisheries during years when storage and releases from Clark Canyon Dam are limited. Limited releases in the spring have resulted in deposition of fine sediment, which has affected the trout fishery just downstream of the dam. The purpose of this study was to investigate flow releases from Clark Canyon Dam that would help mobilize and move fine sediment downstream. The Beaverhead River is listed as "impaired" for TMDL for heavy metals. The lower sections of the Beaverhead River below Grasshopper Creek are impaired for sedimentation and temperature (http://montanatmdlflathead.pbworks.com/Beaverhead-TMDL-Planning-Area). Regular high flow releases could result in improvement and maintenance of the channel and could be effective in moving fine sediments downstream from Clark Canyon Creek.

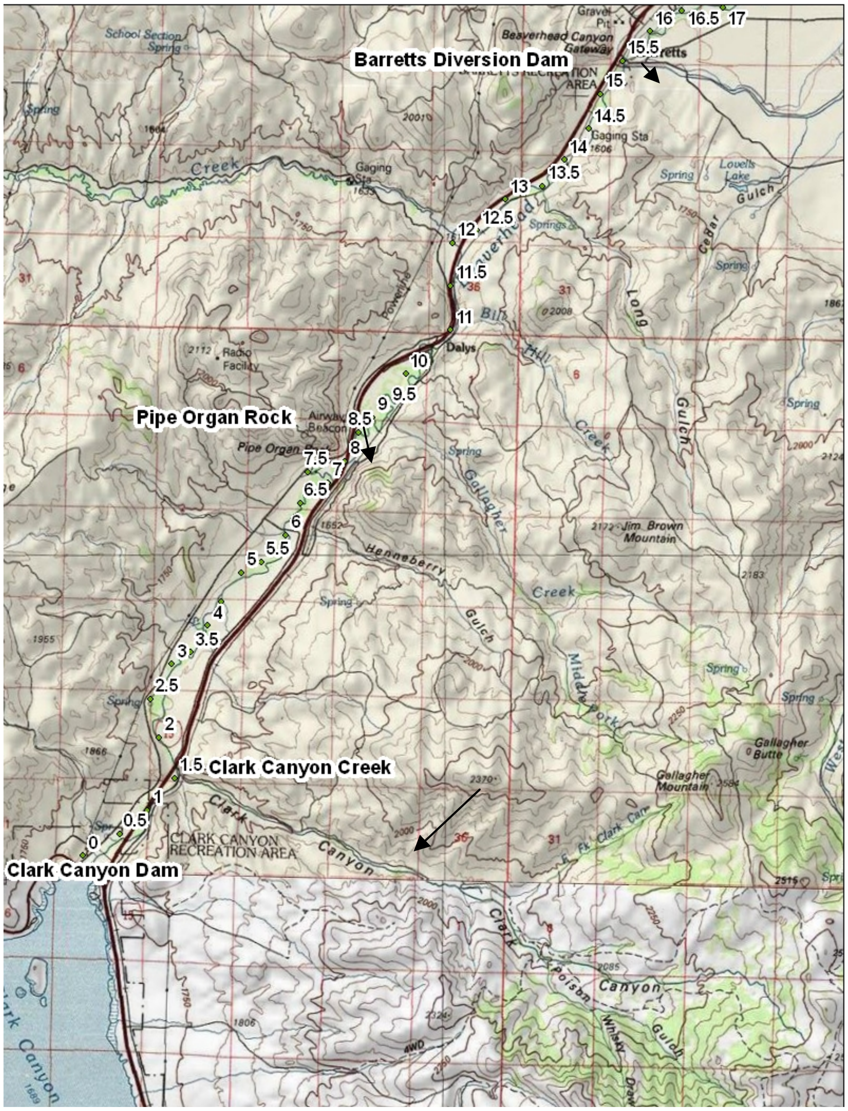

Figure 1-Location Map with River Miles as distance downstream of dam.

Figure 2-Fine sediment entering the Beaverhead River at Clark Canyon Creek

Figure 3-Different view of fine sediment entering the Beaverhead River at Clark Canyon Creek.

Figure 4-Clark Canyon Creek looking upstream about one quarter mile above the mouth.

Figure 5-Typical sediment sizes on the Beaverhead River just below Clark Canyon Creek.

Literature Review

Flushing flows are defined as releases of water from water control structures that produce high flows that remove or flush deposited sediment from flow-regulated streams (Reiser et al. 1989). In streams inhabited by salmonids, flushing flows can remove fine sediments from gravels and can be used for spawning, survival and recruitment.

Simkins and Wesch studied flushing flows on the Big Horn River, downstream from Boysen Dam in west-central Wyoming. The release from Boysen Dam provides a coldwater fishery that extends approximately 90 km downstream. Simkins and Wesch evaluated the movement of juvenile rainbow trout in a portion of the reach downstream of Boysen Dam. The river slope was 0.5 percent in this reach. Radio transmitters were used to capture and tag juvenile fish.. Flushing flows were approximately three times the mean annual flow. The dam released 300 cfs for a 24 hour period in March 1988. The results of the study indicated that flushing flows can enhance spawning without causing extensive downstream movements or habitat displacement of juvenile rainbow trout.

The State of Oregon (Robson, 2007) completed an information document on elevated flows. Elevated flows can have many objectives. Specific channel maintenance objectives include;

1. Move existing streambeds and gravels allowing for cleaning of gravels that have been intruded with fines, which includes spawning habitat and food sources in the medium and long term.
2. Scour and fill against encroaching riparian vegetation, which allows a stream to maintain its bedform.
3. Assist in retention of bed configuration including the formation of riffles, pools and other channel unit habitats.
4. Create conditions for replenishment of streamside vegetation such as cottonwoods.

To determine trigger levels or flows that will activate the gravel, gravel bed versus stream characteristics are analyzed for each stream. This could vary from 80 percent of the bankfull discharge to a streamflow that only occurs once every two years or more.

Model Development

The HEC-RAS program was used to create a model of the Clark Canyon Dam to Barretts Diversion Dam (U.S. Corps of Engineers, 2010). HEC-RAS is a one-dimensional computer program that models the hydraulics of water flow. HEC-GeoRAS is a set of procedures, tools and utilities used for processing geospatial data in ArcGIS 9.3 (ESRI, 2009). The geometry for this study utilized a USGS 10-meter digital elevation model (DEM). The data is available on the USGS website.

The DEM data was used as a topographic representation in ArcGIS. Inherent errors were apparent in the DEM because of the large grid cell size of 10 meters (approximately 30 feet). HEC-RAS model data was developed using HEC-GeoRAS. Pre-processing GIS data consists of creating line themes that represent the center of the channel, river banks, overbank flow paths and cross-sections. HEC-GeoRAS was utilized to digitize 52 cross sections with an approximate spacing of 1500 feet (Figures 6 and 7). The 16 mile reach from Clark Canyon Dam to Barrett's Diversion Dam included additional cross-sections interpolated in HEC-RAS. The total cross-sections equaled 354. Additional cross-sections were interpolated in the hydraulic model to improve accuracy of hydraulic calculations.

The DEM data were limited because of the large grid cell size and because bathymetric data are usually not captured in a DEM. To improve model geometry, the three measured cross-sections provided by the state were entered manually into each of the 52 digitized cross sections in HEC-RAS, prior to developing interpolated cross sections. The measured cross-sections provided by the state and locations where they were used are shown in Figures 8-10 (Montana Department of Environmental Quality, Watershed Management Section, 2010). The area office and the TSC agreed on this approach. A model Manning's n roughness of 0.04 was selected for the main channel and a roughness of 0.06 for the overbanks. A series of flows were modeled based on historical releases from Clark Canyon Dam.

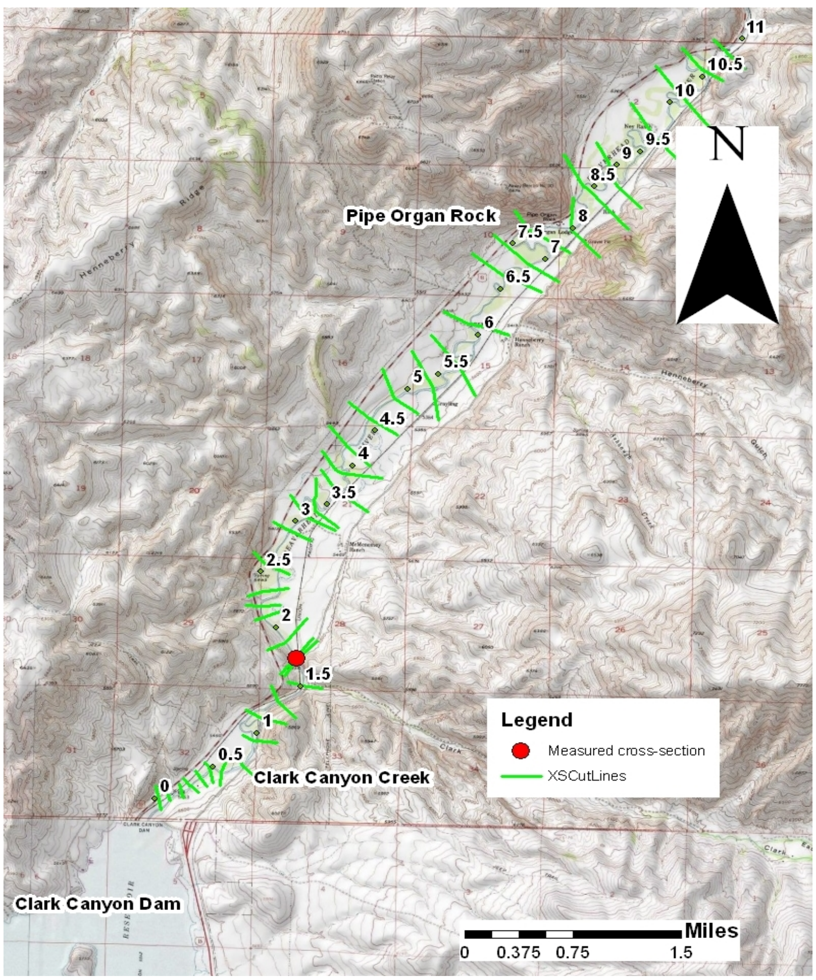

Figure 6-Cross-section layout for the upstream portion of the reach

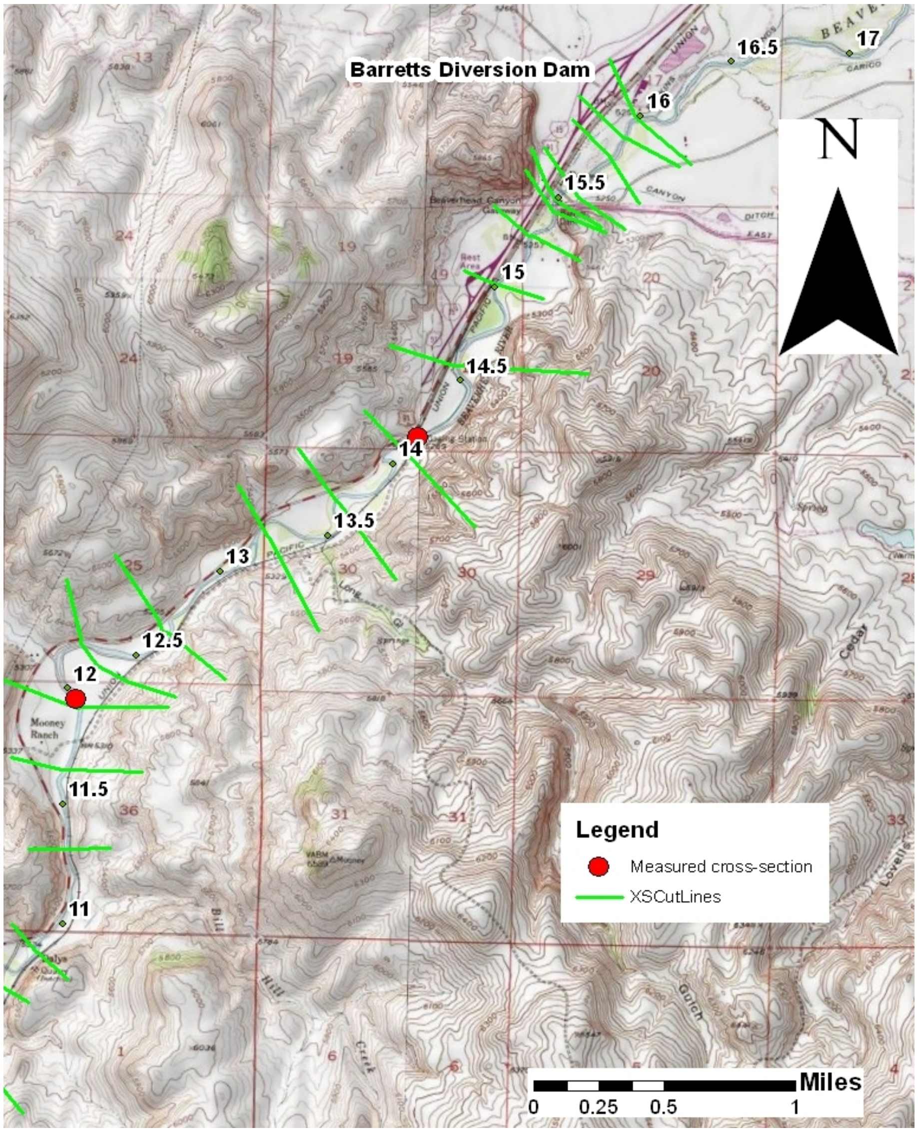

Figure 7- Cross-section layout for the downstream portion of the reach

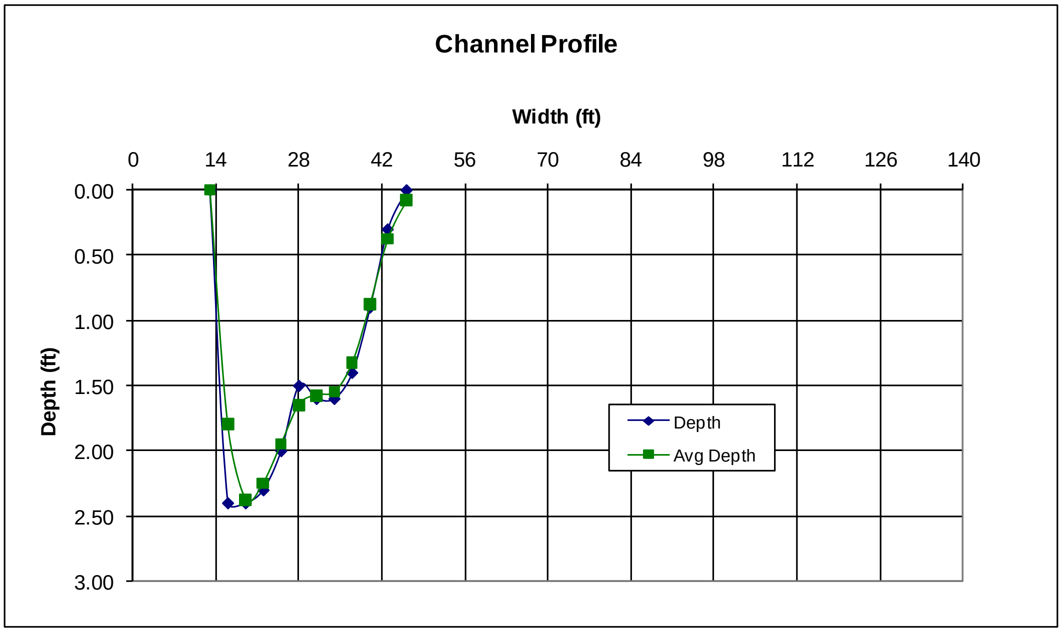

Figure 8-BVHR 2 used in the HEC-RAS model from river miles 0 to 2

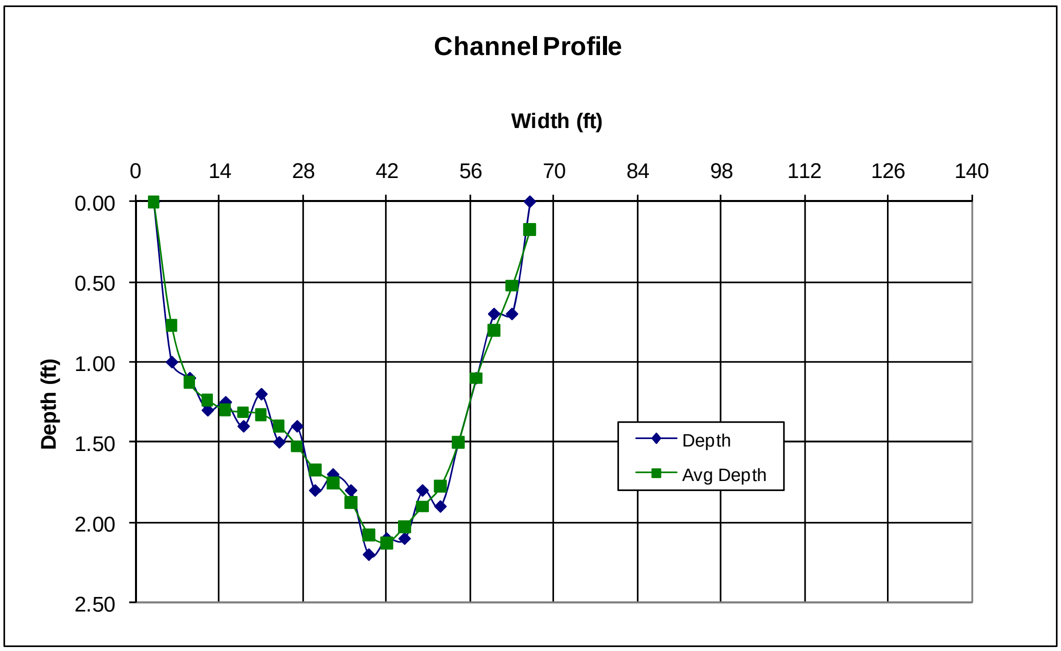

Figure 9-BVHR 3 used in the model from river miles 2 to 13

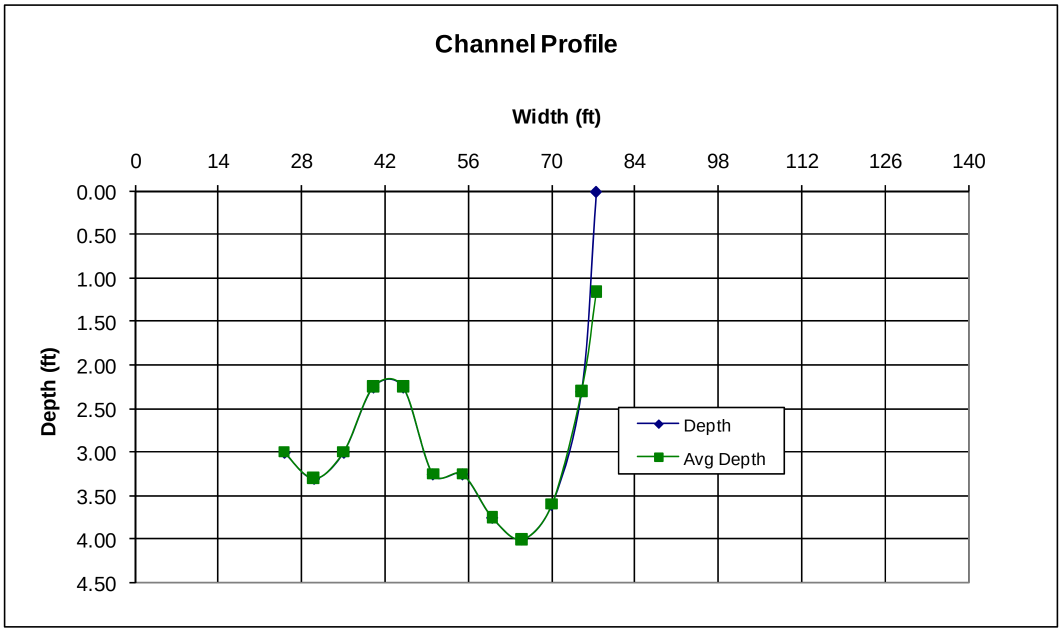

Figure 10-BVHR 3A used in the model from river mile 14 to river mile 16.

Historical Releases from Clark Canyon Dam

Clark Canyon Creek historically discharges large amounts of sediment into the Beaverhead River during spring runoff (typically April and early May). This has included very large volumes of sediment that have created sediment plugs, especially during rain on snow events. The reservoir releases from Clark Canyon Dam have not been timed with sediment discharges into the Beaverhead River from Clark Canyon Creek. Reservoir releases have remained small even with large sediment deposition causing little mobilization of the sediment.

Chuck Heinje of the area office provided historical releases from Clark Canyon dam. These data were sorted and graphed to look at the historical range of flows, especially during April and early May. The data were also plotted seasonally because the potential time period for release is after the start of irrigation season (April 1st). Seasonal historic release data for 2005-2009 are shown in Figure 1111. A review of the data show flow minimums of less than 100 cfs up to a maximum release of nearly 900 cfs in 2007.

A reasonable range of flows for the low flows would be peak discharges from 200 cfs to 800 cfs. These discharges were utilized based on discussions with Reclamation staff in the reservoir operations group in Montana. The flow hydrographs that were used in the model were based on the 2010 Clark Canyon dam flow release data for April and early May provided by the area office. The portion of the hydrograph used in the model was from around May 1st to May 21st. A comparison of the April 2010 monthly to the other years is shown in Figure 12. Two of the hydrographs used in the HEC-RAS model are shown in

Figure 13; 275 cfs peak flow and 800 cfs peak flow. The peak of the April 2010 release was 277 cfs, which was rounded to 275 cfs.

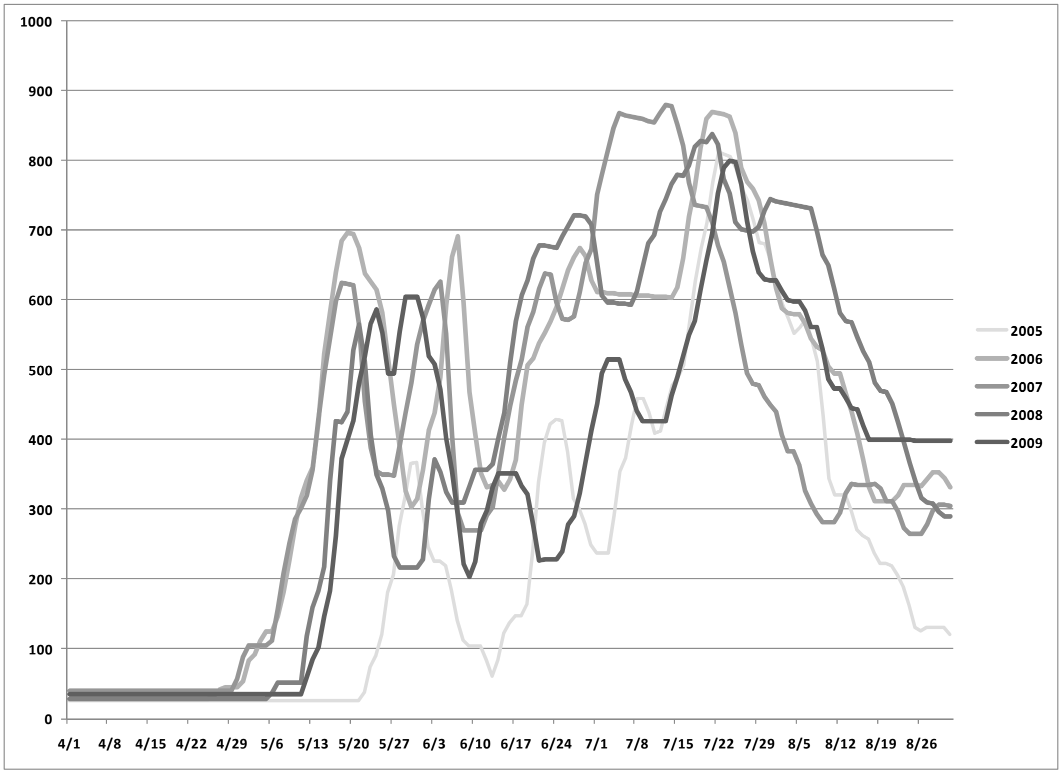

Figure 11-Historical releases from Clark Canyon Dam from 2005 to 2009.

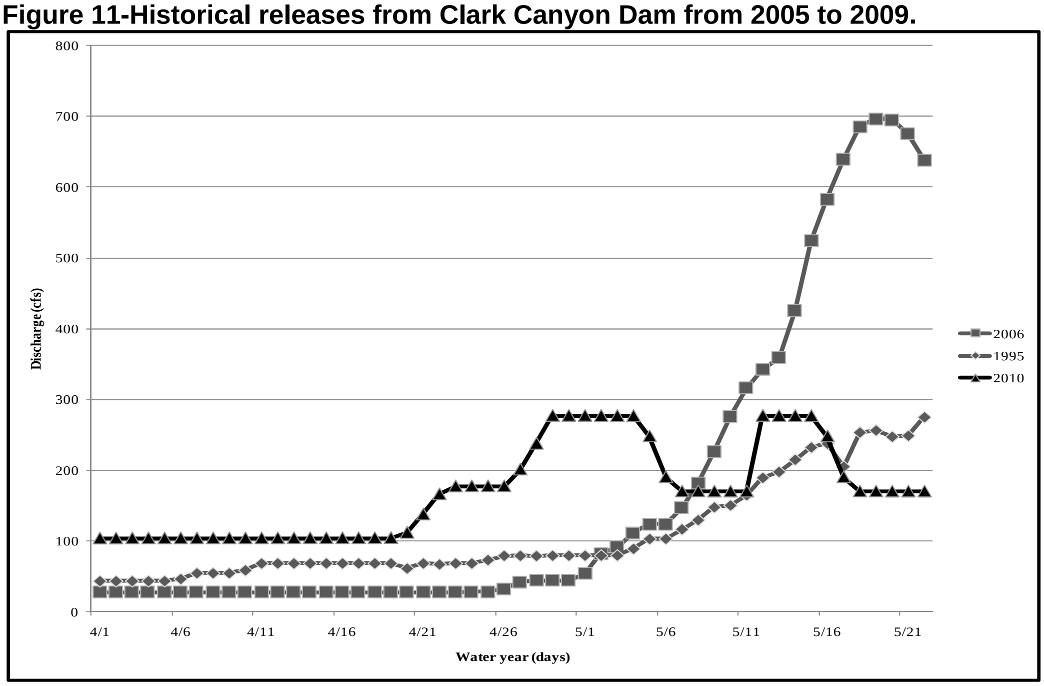

Figure 12-Example historic releases for April and May only (darkened line represents 2010).

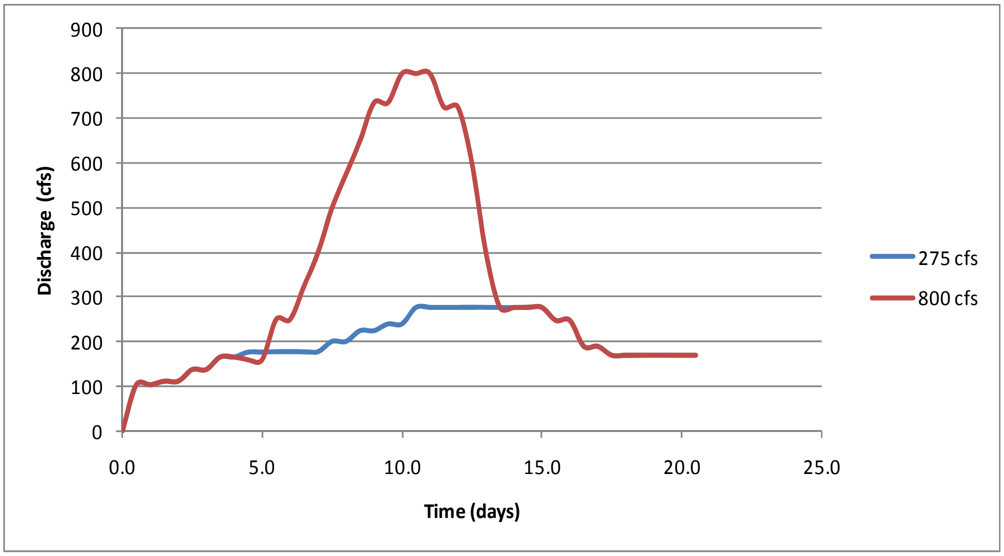

Figure 13-Typical hydrographs used in model

Hydraulic Model Results

The HEC-RAS model was used to determine the hydraulics of the reach at specific cross-sections. The hydraulic model results utilized in the flushing flow analysis included slope, velocity, and hydraulic radius. The model was run as an unsteady flow model for a range of hydrographs, with the maximum peak discharge for all hydrographs being 800 cfs.

The model runs utilized the unsteady flow module. This module requires input of an upstream and downstream boundary condition. Boundary conditions for the unsteady flow model included the assumption of an inflow hydrograph for the upstream boundary and normal depth for the downstream boundary assuming a friction slope of 0.0008 ft/ft. Inflow hydrographs were based on the 2010 release from April 1st to May 22nd and a range of flows from 200 to 800 cfs (Figure 13).

This study was focused on the smaller discharges to determine what minimum flow could flush the fine sediments downstream. Hydraulic results were coupled with sediment calculations to determine the possibility of particle mobilization or possible sediment movement downstream. Typical HEC-RAS results for select cross sections are shown in Tables 1 and 2. Channel velocities range between 1 and 4 ft/s for a discharge of 275 cfs. Channel velocities range from 2 to 5 ft/s for a discharge of 800 cfs. Additional hydraulic data is shown in Appendix A for four of the discharges (200, 400. 600 and 800 cfs).

Table 1-HEC-RAS results at select cross sections for an approximate discharge of 275 cfs

River	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl
		(cfs)	(ft)	(ft)	(ft/s)
Beaverhead	25550.6	277	5460.6	5463.81	2.22
Beaverhead	23172.0	277	5436.5	5439.31	3.5
Beaverhead	19788.5	277	5399.77	5402.88	2.03
Beaverhead	18719.1	277	5393.77	5397.24	2.96
Beaverhead	16527.4	277	5378.06	5380.73	3.4
Beaverhead	15075.9	277	5363.69	5367.14	2.79
Beaverhead	12853.3	277	5354.31	5357.1	3.29
Beaverhead	11341.2	277	5340.7	5342.92	3.07
Beaverhead	9492.8	277	5327.89	5330.3	2.64
Beaverhead	7021.2	277	5304.92	5307.46	2.13
Beaverhead	3097.1	277	5260.86	5264.4	1.76
Beaverhead	2321.8	277	5259.31	5261.89	2.86
Beaverhead	1173.3	277	5245.91	5250.76	1.12
Beaverhead	831.7	277	5245	5249.73	2.28

Table 2-HEC-RAS results at select cross sections for a discharge of 800 cfs

River	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl
		(cfs)	(ft)	(ft)	(ft/s)
Beaverhead	25550.6	800	5460.6	5465.27	3.74
Beaverhead	23172.0	800	5436.5	5440.95	5.13
Beaverhead	19788.5	800	5399.77	5403.66	3.27
Beaverhead	18719.1	799	5393.77	5399.26	4.42
Beaverhead	16527.4	800	5378.06	5381.78	5.59
Beaverhead	15075.9	800	5363.69	5368.86	4.36
Beaverhead	12853.3	800	5354.31	5358.24	4.39
Beaverhead	11341.2	800	5340.7	5343.91	4.83
Beaverhead	9492.8	800	5327.89	5331.39	3.63
Beaverhead	7021.2	800	5304.92	5308.7	3.15
Beaverhead	3097.1	800	5260.86	5266.32	2.71
Beaverhead	2321.8	800	5259.31	5263.26	4.22
Beaverhead	1173.3	801	5245.91	5254.89	1.41
Beaverhead	831.7	800	5245	5254.1	2.55

Bed Material Data

The Reclamation Montana Area Office collected bed material samples along the Beaverhead River in January 2010. The samples were taken at 4 locations near the edge of the river. Because of the time of year and water temperature, shovel samples were taken rather than pebble counts. Dowl HKM Engineering (Material Laboratory for Dowl HKM Engineering, 2010) analyzed the samples. Dowl HKM also provided a particle size distribution report on the samples. Figure 14 shows bed material sampling locations. The river locations near Clark Canyon Dam and Pipe Organ contain the coarsest material (Figure 1515 through Figure 1818, Table 3). The finest material is coming out of Clark Canyon Creek. The average bed material size decreases in the downstream direction except where Clark Canyon Creek enters the river.

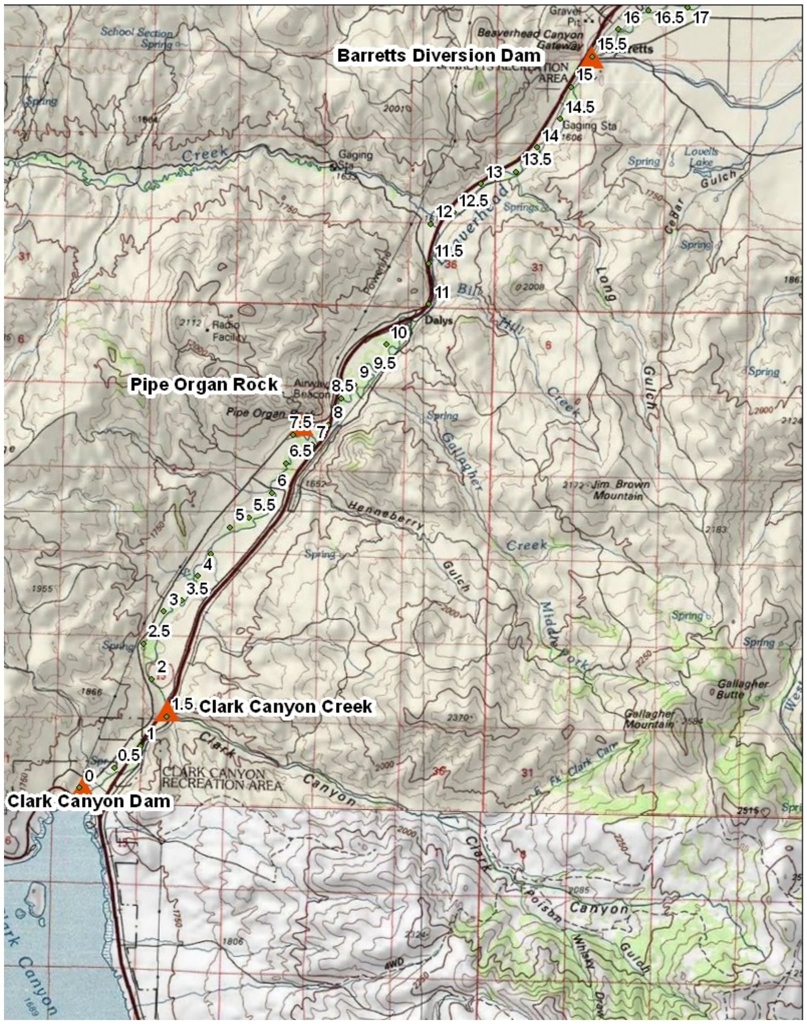

Figure 14-Bed material sampling locations

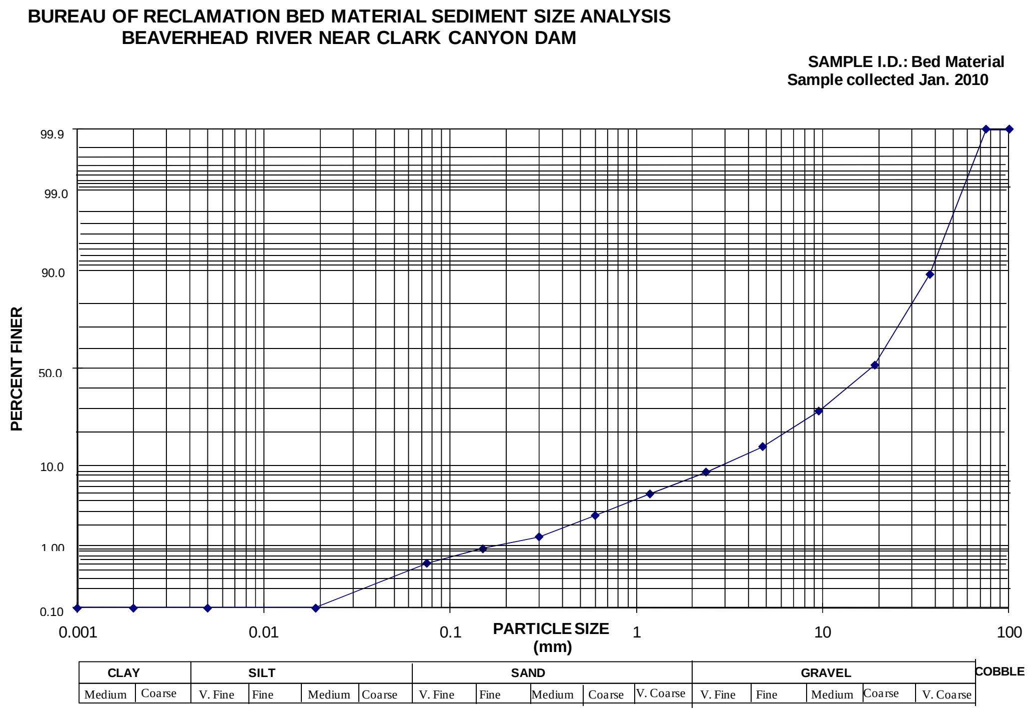

Figure 15-Bed Material Sediment Size Analysis near Clark Canyon Dam.

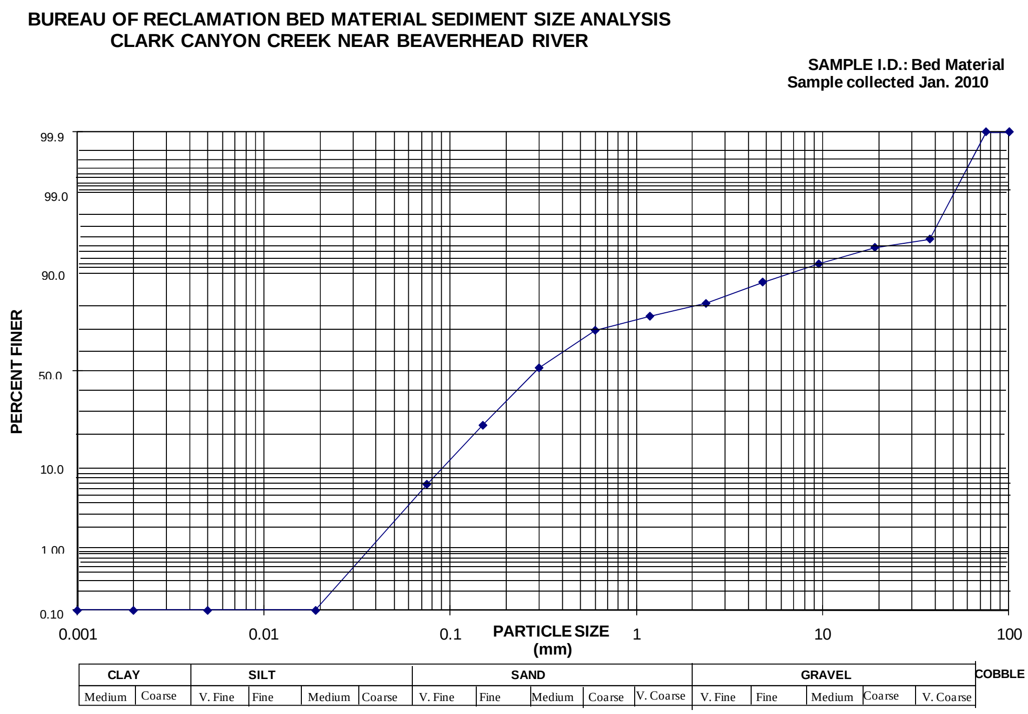

Figure 16- Bed Material Sediment Size Analysis near the mouth of Clark Canyon Creek .

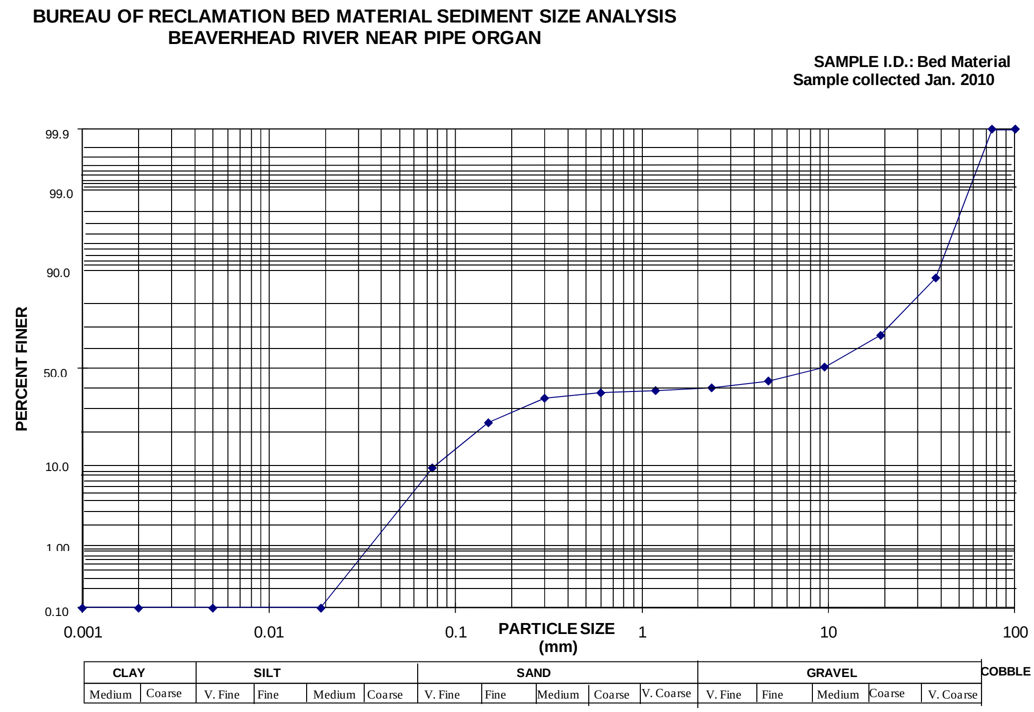

Figure 17- Bed Material Sediment Size Analysis near Pipe Organ

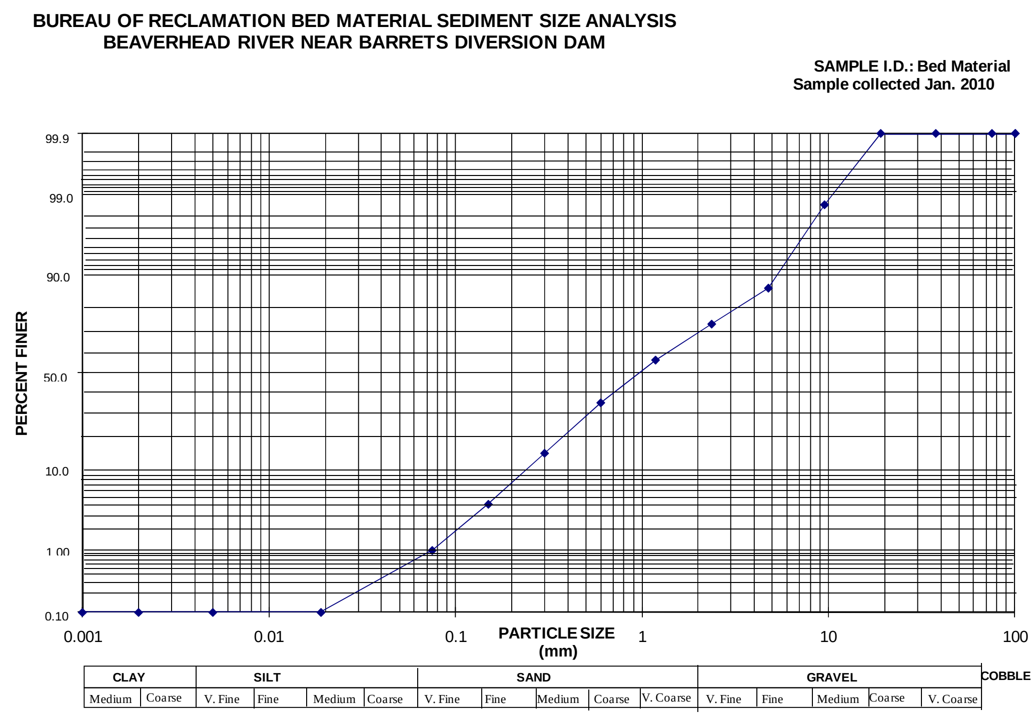

Figure 18- Bed Material Sediment Size Analysis near Barretts Diversion Dam.

Table 3-Bed Material Size Analysis

Location	D_{50}	D_{90}
Clark Canyon Dam	18.3	39.3
Clark Canyon Creek	0.3	6.7
Pipe Organ	9	41.4
Barrets	1	5.7

Initial Motion or Incipient Motion of Bed Material and Flushing Flow

Incipient motion or initial motion can be described as the point when a sediment particle will begin to move. The determination of incipient or beginning motion was utilized to determine the potential for different bed material sizes to move. The concept of beginning motion is difficult to quantify, but is dependent on a particle's location with respect to other different sized particles as well as bed forms. Clark Canyon Creek enters the Beaverhead River about 1.5 miles downstream from the dam. All of the particles from the creek are deposited in the upper layer of the sediment. The assumption is that if the underlying bed material will mobilize then it will also carry the smaller size particles downstream allowing flushing of the sediment.

The methodology used in this section is the determination of the particle size that would form an armor layer (Strand and Pemberton, 1982). The method includes the computation of a particle size for which any greater size particle would not move. After computing the particle size, the particle diameter was compared to the median size or 90^{th} percentile size of the bed material data at each of the four locations in Table 3. If the measured bed material size data were smaller than the computed armoring size, then the particle would be able to move downstream. Several different methods were computed to determine initiation of movement including Shields Diagram, Meyer-Peter and Muller Bedload Transport Equation, Competent Velocity, and Yang's critical velocity criteria (Yang, 1996).

The methods utilize the hydraulic data from the HEC-RAS model (velocity, slope, hydraulic radius). The analysis utilized two reaches: Clark Canyon Dam to Pipe Organ (river miles 0 to 8) and Pipe Organ to Barrets Diversion Dam (8 to 16). The results were averaged on the reaches identified to equalize the results. The assumption seemed reasonable because of the coarseness of the geometry data.

The Shields Method utilizes the d_{50} particle size for the analysis. Meyer-Peter and Müller bed load equation is based on the d_{90} particle size. Competent Velocity and Yang's critical velocity criteria are based on hydraulics alone and do not use bed material information to solve for the critical sediment size.

The Shields method for bed material great than 1 mm and shear velocity Reynold's numbers greater that 500 is equal to:

$$D_c = \frac{\tau_c}{.06(\gamma_s - \gamma_w)}$$

Where τ_c = critical shear stress = $\gamma_w RS$ (lb/ft^2)
γ_s = unit weight of the particle (165 lb/ft^3)
γ_w= unit weight of water (62.4 lb/ ft^3)
R = hydraulic radius (ft)
D_c = critical particle diameter (ft)
S = slope (ft/ft)

Calculations were made to determine the critical diameter using the Shields parameter to determine whether particles of various size in the Beaverhead River would move at various cross sections during a flow event to potentially flush sediment downstream.

From Meyer-Peter and Müller (1948 and Yang, 1996) bed load equation, the sediment size at incipient motion can be determined as:

$$D = \frac{SR}{K_1\left(\frac{n}{D_{90}^{\frac{1}{6}}}\right)^{1.5}}$$

Where D= sediment size at beginning of motion (meters)
S= channel slope
R= hydraulic radius (meters)
K_1= .058
n= Manning's roughness coefficient (0.04)
d_{90} = bed material size (mm)where 90% of the particles are finer

Competent velocity (Yang, 1996) was calculated based on the equation:

$$D_c = 1.88V^2$$

Where V=mean channel velocity (unit) and
D_c = (mm) critical diameter at beginning of motion.

Finally, Yang's critical velocity (Yang, 1996) criteria are based on the following equation:

$$D_c = .00659V^2$$

Where V=mean channel velocity (ft/s), and
D_c= critical diameter (mm) at beginning of motion.

Variables from the HEC-RAS runs were utilized along with D_{50} and D_{90} bed material results to determine the beginning of motion based on the four equations. The hydraulic and sediment parameters were used for each cross-section to calculate the critical particle diameter. The data were then averaged to determine critical particle diameters for two reaches: Clark Canyon Dam to Pipe Organ and Pipe Organ to Barretts Diversion Dam for three of the methods (Shield's Parameter, Competent Velocity and Yang). Table 4 summarizes the results.

For Meyer-Peter and Müller, the calculations were more site specific based on the D90 particle diameter. Four reaches were utilized. The first reach was from the dam to river mile 1.4 (Clark Canyon Dam). The second site was right at the confluence of Clark Canyon Creek and the mainstem (river mile 1.5). The third reach was river mile 5 to 12 (Pipe Organ) and the fourth reach was river miles 12 to 16 (Barrets) (Table 5).

The Shields Method is valid for the data based on the bed material sizes. The competent velocity and Yang's method are valid for particle sizes greater than 1 mm. With this assumption, the critical sediment size for the upper reach at a discharge of 350 cfs is 20.4 mm based on the Shields Method. This is greater than the size of the d_{50} sediment that was collected near Clark Canyon Dam (18.3 mm) indicating that the sediment could be mobilized for this discharge or any greater discharge. For the reach from Pipe Organ to Barretts Dam, the results indicate that the sediment could be mobilized for a smaller discharge (200 cfs and an estimated diameter 14.1 mm). When this diameter is compared to the d_{50} particle size collected at Pipe Organ (9 mm), then the material could mobilize. Because of the sedimentation issues at Clark Canyon Creek, the more conservative estimate of minimum needed release from Clark Canyon Dam is based on the results at Clark Canyon Cree. (river mile 1.5).

The results for the Meyer-Peter and Müller are similar, except sediment mobilization indicates a smaller discharge may mobilize the sediment at Clark Canyon Dam (particle diameter 16.5-17 mm, Table 5). This is compared to the d_{90} bed material size with a size of 39 mm. Calculations for Meyer-Peter and Müller are based on the D_{90} particle size. This would indicate that a flow of 200 cfs could mobilize particles in both reaches. Both sets of results are valid for the Clark Canyon Dam data and the Pipe Organ data. The data from Clark Canyon Creek and the diversion dam are outside the applicable range for Meyer-Peter and Müller.

Table 4-Summary Result for Initiation of Sediment Movement for both Reaches

Location	Discharge (cfs)	Shield's Method (Diameter mm)	Competent Bottom Velocity (Diameter mm)	Yang's Incipient Motion (Diameter mm)
Upper Reach	200	14.2	18.1	19.2
Lower Reach	200	13.1	10.6	11.3
Upper Reach	225	15.0	19.2	20.5
Lower Reach	225	13.3	14.2	15.2
Upper Reach	275	16.0	21.8	23.3
Lower Reach	275	15.3	15.7	16.8
Upper Reach	300	17.3	23.0	24.5
Lower Reach	300	15.6	13.4	14.3
Upper Reach	350	19.7	27.5	29.3
Lower Reach	350	15.9	14.1	15.1
Upper Reach	400	20.2	27.9	29.8
Lower Reach	400	18.2	24.9	26.6
Upper Reach	600	26.7	38.2	40.7
Lower Reach	600	26.4	27.0	28.8
Upper Reach	800	26.7	41.6	44.4
Lower Reach	800	26.4	29.9	32.0

Table 5-Summary Results for Initiation of Sediment Movement at four sites.

Meyer-Peter, Müller (Diameter, mm)								
Discharge (cfs)	200	225	275	300	350	400	600	800
Clark Canyon Dam	16.5	17.1	17.6	17.7	17.2	20.5	21.6	22.4
Creek	10.4	14.6	10.4	12.2	17.2	17.0	17.4	18.0
Pipe Organ	9.7	9.9	10.0	11.3	12.1	12.9	14.5	15.7
Barrets	6.7	6.9	6.7	7.2	7.2	7.8	8.9	9.9

Summary and Conclusions

Clark Canyon Creek delivers a large load of fine sediment into the Beaverhead River each spring. This large sediment load has affected fisheries during years when storage and releases from Clark Canyon Dam are limited. Limited releases in the spring have resulted in deposition of fine sediment, which has affected the trout fishery just downstream of the dam. Katie Tackett from the Beaverhead Watershed Group has observed sediment deposition from the creek when the timing between dam release and the creek flow are not coordinated. It is difficult to predict when the creek will flow from snowmelt runoff. The purpose of this study was to investigate flow releases from Clark Canyon Dam that would help mobilize and move fine sediment downstream.

Hydraulic variables were determined with a HEC-RAS model for a range of discharges between 200 and 800 cfs. Model results were utilized with sediment mobilization equations to determine what flow could mobilize sediment downstream. The results of the analysis indicate that a flow of 350 cfs may mobilize the sediment in the upper reach near the dam based on the Shields Method. Alternatively, Meyer-Peter and Müller results show that the sediment may mobilize for a discharge of 200 cfs. The conservative assumption is that the larger discharge would be an estimate of the flow necessary to mobilize the sediment. Results of the study are limited because of the resolution of the DEM and the subsequent geometric data, which is based on only three measured cross-sections within the 16 mile reach. Measured cross-sections every 2000 feet through the reach would improve model results. Additional collection of bed material data at key locations annually would help determine sediment deposition and mobilization.

A one dimensional sediment transport model would provide more detailed, quantitative results of sediment mobilization along the Beaverhead River. The model can be run as either a steady state discharge model with flows ranging from 200-800 cfs or could be based on typical hydrographs like the 2010 release flows. Utilizing bed material data, Clark Canyon Dam releases, and sediment inflow from Clark Canyon Creek, the sediment model could provides a more concise answer of the type of flows necessary to mobilize and flush the sediment downstream. The one dimensional transport model could also provides answers on the spatial distribution and movement of sediment downstream.

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Appendix A

Table 6-Hydraulic data for 200 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
25550.59	200.00	5460.60	5463.47		5463.53	0.00	1.84	108.98	112.46	0.21	0.12	2.25	0.00084	0.120	0.003	0.373
25434.88	200.04	5460.08	5463.01		5463.10	0.00	2.47	96.64	269.36	0.33	0.23	1.66	0.00201	0.230	0.003	0.275
25281.99	200.06	5459.11	5462.19		5462.25	0.00	2.08	114.91	202.69	0.27	0.16	1.83	0.00153	0.160	0.003	0.304
25159.76	200.01	5458.60	5461.17		5461.37	0.01	3.55	58.21	91.75	0.50	0.50	1.50	0.00518	0.500	0.003	0.249
25003.31	199.99	5456.10	5458.67		5458.86	0.01	3.50	58.44	95.85	0.52	0.50	1.37	0.00534	0.500	0.003	0.227
24849.91	200.03	5453.66	5456.31		5456.47	0.01	3.23	67.43	78.71	0.50	0.43	1.29	0.00539	0.430	0.003	0.214
24691.63	200.03	5451.46	5454.69		5454.75	0.00	2.11	136.29	416.43	0.24	0.15	2.21	0.00108	0.150	0.003	0.367
24436.65	200.05	5450.83	5453.25		5453.44	0.01	3.54	57.21	625.26	0.54	0.52	1.33	0.00383	0.520	0.003	0.221
24098.59	199.53	5447.09	5452.22		5452.22	0.00	0.32	1217.76	579.68	0.03	0.00	3.76	0.00001	0.000	0.003	0.624
23809.35	200.07	5446.60	5450.45	5450.13	5451.11	0.02	6.53	30.65	21.97	0.97	1.79	1.25	0.00505	1.790	0.003	0.207
23515.53	200.01	5441.66	5444.20		5444.42	0.01	3.73	53.87	35.32	0.51	0.54	1.61	0.00491	0.540	0.003	0.267
23171.99	200.02	5436.50	5439.00		5439.15	0.00	3.03	66.08	44.28	0.43	0.36	1.52	0.00392	0.360	0.003	0.252
22861.21	199.96	5432.21	5436.30		5436.36	0.00	1.99	114.60	195.55	0.20	0.13	2.90	0.00146	0.130	0.003	0.481
22823.47	199.88	5433.26	5435.89		5436.04	0.00	3.12	64.07	53.84	0.47	0.40	1.33	0.00443	0.400	0.003	0.221
22593.14	199.79	5430.33	5434.27		5434.31	0.00	1.50	133.44	244.86	0.16	0.07	2.75	0.00035	0.070	0.003	0.456
22204.23	201.02	5430.48	5433.04		5433.25	0.00	3.73	58.31	601.86	0.49	0.52	1.74	0.00416	0.520	0.003	0.289
22058.46	200.97	5428.43	5431.01		5431.20	0.01	3.51	58.23	728.28	0.55	0.52	1.23	0.00647	0.520	0.003	0.204
21869.39	203.39	5424.78	5427.36		5427.57	0.01	3.63	57.54	694.59	0.50	0.51	1.59	0.00528	0.510	0.003	0.264
21471.82	207.03	5418.97	5421.65		5421.81	0.00	3.29	69.88	905.67	0.46	0.42	1.53	0.00440	0.420	0.003	0.254
20909.86	204.84	5411.91	5414.40		5414.60	0.01	3.62	56.63	131.03	0.62	0.58	1.05	0.00889	0.580	0.003	0.174

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
20649.23	202.31	5407.10	5409.78		5409.94	0.00	3.26	65.34	67.85	0.47	0.42	1.46	0.00482	0.420	0.003	0.242
20295.12	201.85	5402.90	5406.01		5406.11	0.00	2.52	88.16	771.27	0.34	0.24	1.69	0.00227	0.240	0.003	0.280
19788.48	201.88	5399.77	5402.67		5402.70	0.00	1.85	180.24	881.59	0.25	0.13	1.69	0.00147	0.130	0.003	0.280
19395.33	201.70	5398.54	5401.34		5401.41	0.00	2.27	156.49	574.95	0.34	0.21	1.39	0.00244	0.210	0.003	0.231
18719.05	201.62	5393.77	5396.82		5396.93	0.00	2.64	76.32	62.81	0.34	0.26	1.79	0.00231	0.260	0.003	0.297
18222.59	201.85	5390.24	5392.83		5393.03	0.00	3.58	57.01	722.97	0.49	0.49	1.63	0.00499	0.490	0.003	0.270
17823.87	201.78	5384.78	5387.75		5387.86	0.00	2.75	92.14	107.86	0.35	0.28	1.87	0.00233	0.280	0.003	0.310
17238.95	201.81	5381.27	5384.36		5384.43	0.00	2.12	109.03	264.69	0.27	0.17	1.82	0.00149	0.170	0.003	0.302
16527.38	201.74	5378.06	5380.51		5380.62	0.00	2.93	83.31	292.25	0.44	0.35	1.35	0.00332	0.350	0.003	0.224
15829.81	201.70	5371.54	5374.32		5374.45	0.00	2.87	72.50	123.93	0.42	0.33	1.42	0.00369	0.330	0.003	0.236
15075.90	201.73	5363.69	5366.76		5366.85	0.00	2.45	84.59	192.31	0.31	0.22	1.92	0.00180	0.220	0.003	0.319
14657.52	201.70	5361.45	5364.49		5364.55	0.00	2.07	110.72	145.04	0.27	0.16	1.73	0.00158	0.160	0.003	0.287
13349.66	201.41	5354.96	5358.12		5358.13	0.00	0.91	269.30	597.47	0.11	0.03	1.97	0.00027	0.030	0.003	0.327
12853.27	201.75	5354.31	5356.83		5356.97	0.00	3.12	82.59	282.50	0.44	0.38	1.54	0.00381	0.380	0.003	0.255
12202.33	201.72	5347.61	5349.74		5349.82	0.00	2.33	94.74	110.55	0.35	0.22	1.35	0.00260	0.220	0.003	0.224
11341.18	201.61	5340.70	5342.69		5342.80	0.00	2.65	76.53	62.89	0.42	0.30	1.23	0.00235	0.300	0.003	0.204
10205.43	201.63	5335.01	5336.93		5337.04	0.00	2.64	79.10	697.50	0.43	0.30	1.16	0.00347	0.300	0.003	0.192
9492.80	201.72	5327.89	5329.95		5330.05	0.00	2.51	80.28	62.02	0.39	0.26	1.29	0.00323	0.260	0.003	0.214
8715.94	201.67	5321.34	5323.35		5323.45	0.00	2.60	77.45	62.66	0.41	0.29	1.23	0.00382	0.290	0.003	0.204
8284.83	201.65	5316.37	5319.22		5319.25	0.00	1.56	129.46	217.49	0.19	0.09	2.05	0.00070	0.090	0.003	0.340
7539.84	201.72	5315.05	5315.67	5316.45	5325.33	2.05	24.94	8.09	25.08	7.74	41.10	0.32	1.35484	41.100	0.003	0.053
7021.16	201.70	5304.92	5307.12		5307.18	0.00	2.01	117.04	104.30	0.30	0.16	1.41	0.00201	0.160	0.003	0.234
6597.77	201.66	5302.25	5304.13		5304.26	0.00	2.93	73.82	74.70	0.47	0.36	1.22	0.00474	0.360	0.003	0.202

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
6003.30	201.70	5294.93	5297.24		5297.30	0.00	2.07	108.66	127.53	0.30	0.17	1.52	0.00185	0.170	0.003	0.252
5397.06	201.76	5291.59	5293.55		5293.62	0.00	2.29	106.88	104.24	0.36	0.22	1.22	0.00288	0.220	0.003	0.202
4455.76	201.73	5284.05	5286.02		5286.18	0.01	3.28	63.61	70.06	0.57	0.49	1.00	0.00779	0.490	0.003	0.166
3688.93	201.77	5270.25	5272.33		5272.47	0.01	3.02	66.92	60.73	0.51	0.40	1.09	0.00543	0.400	0.003	0.181
3097.11	201.68	5260.86	5263.97		5264.00	0.00	1.55	131.35	63.49	0.19	0.08	2.09	0.00066	0.080	0.003	0.347
2321.82	201.76	5259.31	5261.58		5261.68	0.00	2.60	78.89	64.90	0.40	0.28	1.29	0.00341	0.280	0.003	0.214
1608.91	201.61	5252.24	5254.36		5254.46	0.00	2.66	82.26	81.10	0.44	0.31	1.12	0.00471	0.310	0.003	0.186
1173.31	202.00	5245.91	5250.05		5250.07	0.00	1.02	199.02	515.18	0.10	0.03	2.91	0.00043	0.030	0.003	0.483
915.60	201.84	5245.02	5249.02		5249.08	0.00	1.92	104.86	26.64	0.17	0.11	3.10	0.00062	0.110	0.003	0.514
831.68	201.71	5245.00	5248.84	5246.27	5248.90	0.00	2.05	98.29	26.14	0.19	0.13	2.99		0.130	0.003	0.496

Table 7-Hydraulic data for 400 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
25550.59	400.00	5460.60	5464.25		5464.36	0.0013	2.68	154.01	182.39	0.27	0.23	2.80	0.0011	0.23	0.0027	0.46
25434.88	400.14	5460.08	5463.74		5463.87	0.0022	3.09	165.54	283.13	0.35	0.32	2.38	0.0017	0.32	0.0027	0.39
25281.99	400.00	5459.11	5462.96		5463.06	0.0015	2.72	187.11	299.33	0.29	0.24	2.58	0.0017	0.24	0.0027	0.43
25159.76	400.15	5458.60	5461.90		5462.15	0.0046	4.25	119.79	247.66	0.50	0.63	2.20	0.0049	0.63	0.0027	0.36
25003.31	400.02	5456.10	5459.25		5459.58	0.0067	4.73	93.87	134.79	0.59	0.81	1.94	0.0056	0.81	0.0027	0.32
24849.91	400.08	5453.66	5456.92		5457.13	0.0054	3.87	122.52	202.00	0.52	0.57	1.70	0.0050	0.57	0.0027	0.28
24691.63	399.80	5451.46	5455.50		5455.57	0.0011	2.57	247.88	568.13	0.26	0.21	2.99	0.0010	0.21	0.0027	0.50
24436.65	401.16	5450.83	5453.89		5454.21	0.0064	4.65	95.63	644.97	0.58	0.78	1.95	0.0009	0.78	0.0027	0.32
24098.59	393.79	5447.09	5453.27		5453.27	0.0000	0.39	1833.56	600.07	0.03	0.00	4.75	0.0000	0.00	0.0027	0.79
23809.35	546.48	5446.60	5451.26	5451.90	5453.05	0.0427	10.73	50.91	27.71	1.40	4.41	1.66	0.0043	4.41	0.0027	0.28
23515.53	541.90	5441.66	5445.34		5445.83	0.0070	5.70	99.65	76.62	0.62	1.08	2.50	0.0054	1.08	0.0027	0.41
23171.99	541.06	5436.50	5440.24		5440.54	0.0038	4.47	127.85	57.44	0.47	0.64	2.74	0.0039	0.64	0.0027	0.45
22861.21	530.37	5432.21	5437.50		5437.65	0.0013	3.38	197.43	218.66	0.29	0.32	4.04	0.0022	0.32	0.0027	0.67
22823.47	528.74	5433.26	5437.01		5437.32	0.0045	4.50	120.07	169.49	0.50	0.68	2.42	0.0040	0.68	0.0027	0.40
22593.14	481.37	5430.33	5435.42		5435.52	0.0008	2.55	188.49	249.09	0.23	0.19	3.89	0.0006	0.19	0.0027	0.65
22204.23	446.92	5430.48	5433.92		5434.21	0.0045	4.72	125.19	610.98	0.51	0.73	2.59	0.0045	0.73	0.0027	0.43
22058.46	420.04	5428.43	5431.63		5431.94	0.0068	4.61	109.31	776.27	0.59	0.78	1.83	0.0067	0.78	0.0027	0.30
21869.39	415.43	5424.78	5428.13		5428.41	0.0047	4.46	120.65	868.88	0.51	0.68	2.34	0.0047	0.68	0.0027	0.39
21471.82	412.10	5418.97	5422.29		5422.51	0.0043	4.06	145.08	1076.91	0.48	0.58	2.16	0.0042	0.58	0.0027	0.36
20909.86	410.49	5411.91	5414.97		5415.30	0.0081	4.62	98.51	196.49	0.63	0.82	1.62	0.0065	0.82	0.0027	0.27
20649.23	407.16	5407.10	5410.38		5410.59	0.0045	4.03	148.60	184.15	0.49	0.58	2.04	0.0045	0.58	0.0027	0.34
20295.12	405.00	5402.90	5406.61		5406.76	0.0027	3.37	180.80	1039.61	0.39	0.39	2.28	0.0026	0.39	0.0027	0.38

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
19788.48	402.74	5399.77	5403.09		5403.15	0.0016	2.44	269.63	976.37	0.29	0.21	2.11	0.0015	0.21	0.0027	0.35
19395.33	402.33	5398.54	5401.99		5402.02	0.0008	1.73	468.82	667.34	0.21	0.11	2.03	0.0012	0.11	0.0027	0.34
18719.05	401.06	5393.77	5397.81		5397.99	0.0022	3.40	120.27	518.96	0.36	0.37	2.73	0.0022	0.37	0.0027	0.45
18222.59	400.80	5390.24	5393.62		5393.95	0.0050	4.70	91.73	1044.49	0.53	0.75	2.39	0.0049	0.75	0.0027	0.40
17823.87	400.87	5384.78	5388.49		5388.61	0.0021	3.18	183.03	129.84	0.35	0.34	2.52	0.0021	0.34	0.0027	0.42
17238.95	400.64	5381.27	5385.10		5385.21	0.0017	2.81	166.11	274.78	0.31	0.26	2.54	0.0015	0.26	0.0027	0.42
16527.38	400.79	5378.06	5381.02		5381.23	0.0053	4.09	121.57	495.69	0.52	0.62	1.85	0.0037	0.62	0.0027	0.31
15829.81	400.61	5371.54	5375.08		5375.27	0.0032	3.54	130.09	414.05	0.42	0.44	2.17	0.0032	0.44	0.0027	0.36
15075.90	400.67	5363.69	5367.67		5367.83	0.0019	3.24	133.71	204.45	0.34	0.34	2.81	0.0019	0.34	0.0027	0.47
14657.52	400.55	5361.45	5365.30		5365.40	0.0014	2.61	205.13	225.04	0.29	0.23	2.53	0.0015	0.23	0.0027	0.42
13349.66	400.68	5354.96	5358.96		5358.98	0.0003	1.34	370.30	797.67	0.14	0.06	2.79	0.0004	0.06	0.0027	0.46
12853.27	400.67	5354.31	5357.43		5357.59	0.0035	3.63	159.59	306.67	0.44	0.46	2.14	0.0034	0.46	0.0027	0.36
12202.33	400.26	5347.61	5350.18		5350.33	0.0035	3.20	153.85	261.47	0.42	0.38	1.77	0.0036	0.38	0.0027	0.29
11341.18	400.56	5340.70	5343.22		5343.42	0.0046	3.65	115.35	97.92	0.49	0.50	1.74	0.0024	0.50	0.0027	0.29
10205.43	400.58	5335.01	5337.36		5337.58	0.0058	3.82	109.78	892.03	0.54	0.57	1.57	0.0038	0.57	0.0027	0.26
9492.80	400.53	5327.89	5330.59		5330.73	0.0029	3.05	159.95	143.70	0.39	0.34	1.89	0.0029	0.34	0.0027	0.31
8715.94	400.67	5321.34	5323.88		5324.05	0.0040	3.41	141.27	151.37	0.45	0.44	1.75	0.0040	0.44	0.0027	0.29
8284.83	400.62	5316.37	5320.23		5320.30	0.0007	2.07	193.66	231.28	0.21	0.13	3.07	0.0007	0.13	0.0027	0.51
7539.84	400.53	5313.44	5316.20	5316.66	5317.65	0.0892	9.66	41.46	50.14	1.87	4.52	0.81	0.0720	4.52	0.0027	0.13
7021.16	400.52	5304.92	5307.80		5307.88	0.0017	2.48	198.22	133.76	0.30	0.22	2.09	0.0018	0.22	0.0027	0.35
6597.77	400.51	5302.25	5304.79		5304.98	0.0040	3.56	130.22	95.16	0.46	0.47	1.85	0.0041	0.47	0.0027	0.31
6003.30	400.48	5294.93	5297.94		5298.03	0.0016	2.49	199.68	130.93	0.29	0.21	2.20	0.0017	0.21	0.0027	0.36
5397.06	400.50	5291.59	5294.24		5294.33	0.0024	2.67	183.87	115.64	0.35	0.27	1.80	0.0024	0.27	0.0027	0.30

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
4455.76	400.48	5284.05	5286.67		5286.88	0.0057	3.81	113.42	146.58	0.53	0.56	1.60	0.0057	0.56	0.0027	0.27
3688.93	400.60	5270.25	5272.96		5273.18	0.0052	3.77	106.20	62.64	0.51	0.54	1.67	0.0052	0.54	0.0027	0.28
3097.11	400.48	5260.86	5264.99		5265.05	0.0007	2.06	199.27	92.74	0.21	0.13	3.03	0.0007	0.13	0.0027	0.50
2321.82	400.47	5259.31	5262.26		5262.43	0.0033	3.32	126.02	72.98	0.42	0.40	1.92	0.0033	0.40	0.0027	0.32
1608.91	400.54	5252.24	5254.97		5255.13	0.0039	3.28	135.05	88.64	0.44	0.41	1.67	0.0042	0.41	0.0027	0.28
1173.31	400.50	5245.91	5252.41		5252.42	0.0001	1.09	368.10	532.34	0.09	0.03	4.60	0.0002	0.03	0.0027	0.76
915.60	400.84	5245.02	5251.82		5251.90	0.0005	2.22	180.19	27.23	0.15	0.13	4.56	0.0005	0.13	0.0027	0.76
831.68	400.44	5245.00	5251.67	5247.01	5251.75	0.0007	2.22	180.35	41.94	0.19	0.15	3.35		0.15	0.0027	0.56

Table 8-Hydraulic data for 600 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_0(lb/ft$^{2)}$
25550.59	600	5460.6	5464.81		5464.97	0.0016	3.31	206.38	255.47	0.31	0.33	3.32	0.0012	0.33	0.0027	0.55
25434.88	599.84	5460.08	5464.29		5464.45	0.0022	3.56	221.75	307.94	0.36	0.4	2.91	0.0016	0.4	0.0027	0.48
25281.99	600.03	5459.11	5463.54		5463.66	0.0016	3.16	248.24	361.52	0.31	0.31	3.15	0.0018	0.31	0.0027	0.52
25159.76	600.15	5458.6	5462.43		5462.71	0.0043	4.72	167.28	280.32	0.5	0.72	2.72	0.0045	0.72	0.0027	0.45
25003.31	600.04	5456.1	5459.66		5460.13	0.0075	5.67	120.51	323.45	0.64	1.09	2.34	0.0058	1.09	0.0027	0.39
24849.91	600.02	5453.66	5457.33		5457.6	0.0055	4.5	163.16	210.72	0.54	0.71	2.09	0.0044	0.71	0.0027	0.35
24691.63	600.1	5451.46	5456.17		5456.25	0.0010	2.76	372.77	758.9	0.25	0.22	3.64	0.0009	0.22	0.0027	0.60
24436.65	600.15	5450.83	5454.06		5454.65	0.0106	6.3	107.39	645.89	0.75	1.4	2.12	0.0017	1.4	0.0027	0.35
24098.59	600.15	5447.09	5453.17		5453.17	0.0000	0.39	1775.93	598.2	0.03	0	4.66	0.0000	0	0.0027	0.77
23809.35	600.15	5446.6	5451.41	5451.9	5454.11	0.0604	13.2	55.13	28.59	1.67	6.55	1.74	0.0046	6.55	0.0027	0.29
23515.53	600.15	5441.66	5445.72		5446.35	0.0076	6.5	115.97	79.24	0.66	1.35	2.86	0.0056	1.35	0.0027	0.47
23171.99	600.15	5436.5	5440.69		5441.06	0.0038	4.94	154.87	62.36	0.49	0.75	3.19	0.0039	0.75	0.0027	0.53
22861.21	600.15	5432.21	5437.87		5438.06	0.0015	3.79	224.2	222.72	0.31	0.4	4.39	0.0024	0.4	0.0027	0.73
22823.47	600.15	5433.26	5437.34		5437.71	0.0046	4.92	137.88	171.28	0.52	0.78	2.75	0.0038	0.78	0.0027	0.46
22593.14	600.15	5430.33	5435.88		5436.01	0.0008	2.85	210.76	343.16	0.24	0.22	4.35	0.0006	0.22	0.0027	0.72
22204.23	600.04	5430.48	5434.28		5434.63	0.0047	5.24	153.93	611.77	0.53	0.87	2.94	0.0046	0.87	0.0027	0.49
22058.46	600.22	5428.43	5432.05		5432.38	0.0060	4.92	157.33	785.14	0.57	0.84	2.25	0.0060	0.84	0.0027	0.37
21869.39	600.12	5424.78	5428.54		5428.88	0.0049	5.08	159.06	879.97	0.53	0.84	2.74	0.0049	0.84	0.0027	0.45
21471.82	600.39	5418.97	5422.72		5422.94	0.0038	4.28	213.28	1079.68	0.46	0.6	2.58	0.0038	0.6	0.0027	0.43
20909.86	599.88	5411.91	5415.34		5415.72	0.0078	5.17	141.52	214.14	0.64	0.96	1.97	0.0067	0.96	0.0027	0.33
20649.23	599.92	5407.1	5410.71		5410.95	0.0046	4.48	211.58	195.49	0.51	0.68	2.37	0.0047	0.68	0.0027	0.39
20295.12	600.16	5402.9	5407.01		5407.16	0.0025	3.59	312.5	1180.36	0.38	0.42	2.67	0.0026	0.42	0.0027	0.44

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
19788.48	600.17	5399.77	5403.41		5403.49	0.0018	2.87	336.5	1049.76	0.32	0.28	2.42	0.0014	0.28	0.0027	0.40
19395.33	600.49	5398.54	5402.46		5402.48	0.0006	1.61	714.69	682.58	0.18	0.09	2.49	0.0007	0.09	0.0027	0.41
18719.05	596.45	5393.77	5398.58		5398.82	0.0021	3.94	156.36	620.77	0.37	0.46	3.48	0.0022	0.46	0.0027	0.58
18222.59	604.62	5390.24	5394.21		5394.67	0.0053	5.57	118.76	1247.44	0.56	0.98	2.97	0.0051	0.98	0.0027	0.49
17823.87	607.75	5384.78	5389.03		5389.17	0.0021	3.54	251.92	572.41	0.35	0.39	3.05	0.0020	0.39	0.0027	0.51
17238.95	600.09	5381.27	5385.64		5385.8	0.0019	3.38	207.62	282.4	0.34	0.36	3.07	0.0015	0.36	0.0027	0.51
16527.38	599.93	5378.06	5381.47		5381.76	0.0056	4.82	157.49	793.06	0.55	0.8	2.29	0.0035	0.8	0.0027	0.38
15829.81	600.08	5371.54	5375.59		5375.83	0.0033	4.11	180.16	439.24	0.44	0.55	2.67	0.0033	0.55	0.0027	0.44
15075.9	600.07	5363.69	5368.34		5368.55	0.0020	3.83	175.38	265.65	0.36	0.44	3.46	0.0020	0.44	0.0027	0.57
14657.52	600.18	5361.45	5365.92		5366.01	0.0012	2.79	304.37	326.31	0.28	0.24	3.13	0.0014	0.24	0.0027	0.52
13349.66	599.72	5354.96	5359.58		5359.61	0.0004	1.67	446.3	959.59	0.16	0.08	3.4	0.0004	0.08	0.0027	0.56
12853.27	599.9	5354.31	5357.87		5358.05	0.0033	4.03	217.21	319.31	0.44	0.54	2.58	0.0034	0.54	0.0027	0.43
12202.33	599.97	5347.61	5350.52		5350.71	0.0038	3.78	200.89	588.46	0.46	0.5	2.1	0.0035	0.5	0.0027	0.35
11341.18	599.94	5340.7	5343.59		5343.88	0.0051	4.36	159.65	138.36	0.53	0.67	2.11	0.0025	0.67	0.0027	0.35
10205.43	599.9	5335.01	5337.66		5337.99	0.0071	4.75	139.12	1063.38	0.61	0.83	1.87	0.0039	0.83	0.0027	0.31
9492.8	599.8	5327.89	5331.02		5331.2	0.0030	3.57	243.11	290.19	0.41	0.44	2.32	0.0030	0.44	0.0027	0.38
8715.939	599.69	5321.34	5324.32		5324.5	0.0035	3.71	208.37	154.32	0.44	0.48	2.19	0.0035	0.48	0.0027	0.36
8284.83	599.97	5316.37	5321.04		5321.13	0.0007	2.46	244.2	234.99	0.22	0.17	3.87	0.0007	0.17	0.0027	0.64
7539.836	599.84	5313.44	5317.01	5317.01	5317.75	0.0215	6.91	86.82	59.57	1.01	1.92	1.43	0.0163	1.92	0.0027	0.24
7021.157	599.99	5304.92	5308.36		5308.46	0.0015	2.76	279.79	158.04	0.3	0.25	2.65	0.0016	0.25	0.0027	0.44
6597.772	600.04	5302.25	5305.16		5305.44	0.0049	4.4	172.56	146.58	0.52	0.67	2.2	0.0049	0.67	0.0027	0.36
6003.298	599.93	5294.93	5298.52		5298.62	0.0014	2.75	276.42	135.91	0.29	0.24	2.77	0.0015	0.24	0.0027	0.46
5397.061	599.92	5291.59	5294.71		5294.83	0.0024	3.05	239.09	118.29	0.36	0.32	2.19	0.0024	0.32	0.0027	0.36

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
4455.757	599.78	5284.05	5287.07		5287.37	0.0059	4.48	148.82	165.01	0.56	0.73	1.96	0.0059	0.73	0.0027	0.33
3688.934	599.88	5270.25	5273.48		5273.77	0.0050	4.32	138.86	64.18	0.52	0.66	2.12	0.0050	0.66	0.0027	0.35
3097.111	599.72	5260.86	5265.73		5265.81	0.0007	2.43	275.66	113.64	0.22	0.17	3.76	0.0008	0.17	0.0027	0.62
2321.815	599.85	5259.31	5262.83		5263.04	0.0032	3.77	169.41	79.7	0.42	0.48	2.43	0.0032	0.48	0.0027	0.40
1608.905	599.92	5252.24	5255.45		5255.65	0.0037	3.74	177.84	90.02	0.45	0.49	2.12	0.0035	0.49	0.0027	0.35
1173.305	600.13	5245.91	5253.85		5253.87	0.0001	1.25	492.99	537.77	0.09	0.04	6.01	0.0002	0.04	0.0027	1.00
915.5991	599.88	5245.02	5253.28		5253.39	0.0006	2.73	220.12	27.54	0.17	0.19	5.19	0.0006	0.19	0.0027	0.86
831.679	599.74	5245	5253.15	5247.54	5253.23	0.0007	2.33	257.74	58.47	0.2	0.16	3.51		0.16	0.0027	0.58

Table 9-Hydraulic data for 800 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
25550.59	800	5460.6	5465.27		5465.47	0.00175	3.74	267.95	289.82	0.33	3.75	0.0012	0.41	0.0027	0.62
25434.88	800.04	5460.08	5464.76		5464.95	0.00227	3.98	302.85	362.51	0.38	3.37	0.0014	0.48	0.0027	0.56
25281.99	800.27	5459.11	5464.02		5464.17	0.00161	3.51	301.22	369.11	0.32	3.62	0.0019	0.36	0.0027	0.60
25159.76	800	5458.6	5462.87		5463.19	0.00414	5.13	207.55	322.45	0.5	3.15	0.0042	0.81	0.0027	0.52
25003.31	800.06	5456.1	5459.98		5460.59	0.00846	6.54	140.95	355.75	0.7	2.65	0.0063	1.4	0.0027	0.44
24849.91	799.84	5453.66	5457.66		5458.04	0.00613	5.25	201.5	257.8	0.59	2.42	0.0045	0.93	0.0027	0.40
24691.63	800.04	5451.46	5456.73		5456.8	0.00086	2.82	482.95	763.45	0.24	4.17	0.0008	0.22	0.0027	0.69
24436.65	800.07	5450.83	5454.39		5455.11	0.01112	7.1	130.14	647.63	0.79	2.44	0.0017	1.69	0.0027	0.40
24098.59	800.07	5447.09	5453.29		5453.3	0.00002	0.46	1850.86	600.63	0.04	4.77	0.0000	0.01	0.0027	0.79
23809.35	799.83	5446.6	5451.45	5451.9	5454.58	0.06865	14.19	56.35	28.84	1.79	1.76	0.0033	7.55	0.0027	0.29
23515.53	800.2	5441.66	5445.91		5446.62	0.00770	6.84	124.53	80.59	0.67	3.04	0.0056	1.46	0.0027	0.50
23171.99	800.07	5436.5	5440.95		5441.34	0.00366	5.13	171.6	65.22	0.48	3.45	0.0038	0.79	0.0027	0.57
22861.21	800.15	5432.21	5438.31		5438.53	0.00153	4.14	260.34	241.76	0.32	4.81	0.0023	0.46	0.0027	0.80
22823.47	800.07	5433.26	5437.8		5438.2	0.00401	5.11	163.05	175.22	0.5	3.2	0.0035	0.8	0.0027	0.53
22593.14	799.74	5430.33	5436.45		5436.62	0.00098	3.36	237.99	382.25	0.27	4.91	0.0007	0.3	0.0027	0.81
22204.23	800.02	5430.48	5434.71		5435.12	0.00479	5.76	188.31	612.71	0.54	3.35	0.0049	1	0.0027	0.56
22058.46	799.93	5428.43	5432.4		5432.77	0.00583	5.35	196.94	785.99	0.58	2.59	0.0062	0.94	0.0027	0.43
21869.39	800.38	5424.78	5428.97		5429.34	0.00473	5.49	199.67	891.52	0.54	3.15	0.0046	0.93	0.0027	0.52
21471.82	800.37	5418.97	5423.02		5423.27	0.00394	4.71	261.09	1080.07	0.48	2.87	0.0039	0.71	0.0027	0.48
20909.86	800.13	5411.91	5415.63		5416.08	0.00798	5.72	177.06	234.93	0.66	2.26	0.0063	1.13	0.0027	0.37
20649.23	799.93	5407.1	5410.87		5411.2	0.00600	5.34	244.25	209.91	0.58	2.53	0.0053	0.95	0.0027	0.42
20295.12	799.96	5402.9	5407.25		5407.41	0.00267	3.91	449.25	1393	0.4	2.91	0.0027	0.48	0.0027	0.48
19788.48	799.84	5399.77	5403.66		5403.76	0.00211	3.27	388.72	1052.02	0.35	2.66	0.0013	0.35	0.0027	0.44

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
19395.33	800.62	5398.54	5402.84		5402.86	0.00046	1.61	916.28	758.53	0.17	2.86	0.0006	0.08	0.0027	0.47
18719.05	793.98	5393.77	5399.26		5399.55	0.00212	4.39	188.29	733.3	0.37	4.12	0.0022	0.54	0.0027	0.68
18222.59	804.28	5390.24	5394.68		5395.26	0.00563	6.33	140.49	1248.12	0.59	3.42	0.0054	1.2	0.0027	0.57
17823.87	804.48	5384.78	5389.46		5389.62	0.00203	3.83	307.83	860.81	0.36	3.47	0.0020	0.44	0.0027	0.58
17238.95	799.99	5381.27	5386.1		5386.3	0.00201	3.85	242.88	293.99	0.36	3.52	0.0015	0.44	0.0027	0.58
16527.38	800.26	5378.06	5381.78		5382.16	0.00636	5.59	183.17	797.4	0.6	2.59	0.0039	1.03	0.0027	0.43
15829.81	800.09	5371.54	5376.07		5376.33	0.00306	4.41	233.78	471.38	0.43	3.14	0.0031	0.6	0.0027	0.52
15075.9	800.17	5363.69	5368.86		5369.13	0.00220	4.36	214.03	393.5	0.38	3.97	0.0022	0.54	0.0027	0.66
14657.52	799.8	5361.45	5366.43		5366.55	0.00130	3.16	436.03	525.11	0.29	3.64	0.0014	0.29	0.0027	0.60
13349.66	800.24	5354.96	5360.11		5360.15	0.00045	1.96	509.73	1036.14	0.17	3.91	0.0005	0.11	0.0027	0.65
12853.27	799.93	5354.31	5358.24		5358.45	0.00330	4.39	266.15	326.06	0.45	2.95	0.0033	0.61	0.0027	0.49
12202.33	799.19	5347.61	5350.84		5351.06	0.00389	4.17	245.38	626.8	0.47	2.42	0.0032	0.59	0.0027	0.40
11341.18	800.09	5340.7	5343.91		5344.24	0.00519	4.83	205.9	182.45	0.54	2.42	0.0025	0.79	0.0027	0.40
10205.43	800.13	5335.01	5337.89		5338.34	0.00825	5.53	167.81	1185.93	0.67	2.1	0.0039	1.08	0.0027	0.35
9492.8	799.51	5327.89	5331.39		5331.55	0.00256	3.63	373.96	408.29	0.39	2.68	0.0027	0.43	0.0027	0.44
8715.939	799.78	5321.34	5324.63		5324.83	0.00349	4.03	283.12	320.12	0.45	2.49	0.0035	0.54	0.0027	0.41
8284.83	800.22	5316.37	5321.75		5321.87	0.00074	2.78	289.11	238.32	0.23	4.57	0.0007	0.21	0.0027	0.76
7539.836	800.01	5315.05	5317.83		5318.49	0.01211	6.48	123.52	62.97	0.8	2	0.0092	1.51	0.0027	0.33
7021.157	799.93	5304.92	5308.7		5308.83	0.00167	3.15	336.6	172.95	0.32	2.99	0.0017	0.31	0.0027	0.50
6597.772	799.86	5302.25	5305.54		5305.83	0.00460	4.69	239.38	198.35	0.51	2.54	0.0045	0.73	0.0027	0.42
6003.298	799.96	5294.93	5298.94		5299.05	0.00145	3.06	333.99	139.53	0.3	3.19	0.0016	0.29	0.0027	0.53
5397.061	800.04	5291.59	5295.14		5295.28	0.00228	3.34	290.87	119.85	0.36	2.59	0.0023	0.37	0.0027	0.43
4455.757	800.01	5284.05	5287.49		5287.82	0.00553	4.83	190.37	190.79	0.55	2.32	0.0053	0.8	0.0027	0.38
3688.934	800.04	5270.25	5273.89		5274.25	0.00502	4.83	165.69	65.42	0.53	2.48	0.0050	0.78	0.0027	0.41

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft^{2})
3097.111	800.02	5260.86	5266.32		5266.42	0.00075	2.71	348.17	132.63	0.23	4.34	0.0008	0.2	0.0027	0.72
2321.815	800.03	5259.31	5263.26		5263.53	0.00325	4.22	206.23	109.91	0.44	2.81	0.0033	0.57	0.0027	0.47
1608.905	800.1	5252.24	5255.94		5256.16	0.00330	4.01	221.83	91.43	0.44	2.57	0.0028	0.53	0.0027	0.43
1173.305	800.82	5245.91	5254.74		5254.77	0.00012	1.45	570.43	538.4	0.1	6.87	0.0002	0.05	0.0027	1.14
915.5991	800.32	5245.02	5254.02		5254.19	0.00083	3.33	240.59	27.7	0.2	5.48	0.0007	0.28	0.0027	0.91
831.679	799.98	5245	5253.88	5248.13	5253.99	0.00081	2.66	300.64	59.07	0.21	4.01		0.2	0.0027	0.67

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ATTACHMENT B – MEMORANDUM TO FWP FROM APPLIED GEOMORPHOLOGY IN REGARDS TO THE CLARK CANYON CREEK FIELD VISIT, SEPTEMBER 13, 2011

DEQ Comments on Attachment B: This attachment is an independent document that is included here without edit. This attachment is included because it provides significant information that was used to further inform the C factors for the DEQ's *Upland Sediment Source Assessment (***Appendix F***)* BMP cover scenario; and contains recommendations for sediment reductions that may help stakeholders when implementing the TMDL. However, some statements contained herein regarding observations of bank erosion are inconsistent with the results from the DEQ's *Streambank Erosion Source Assessment (***Appendix E***)*. In 2010, the DEQ conducted the *Streambank Erosion Source Assessment* at three 500 ft reaches on Clark Canyon Creek. During this assessment, Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) measurements were collected (bank height, bankfull height, root depth, root density, bank angle, and surface protection). As noted in the memorandum, results from DEQ's bank assessment were not available at the time this memorandum was completed. It is the opinion of DEQ that the DEQ's 2010 Streambank Erosion Source Assessment is a more thorough and accurate characterization of streambank conditions than the one's presented in this Attachment. Additionally, the memo's usage of "point source" language is inconsistent with the DEQ definition of "point source." DEQ defines a point source as a discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or vessel or other floating craft, from which pollutants are or may be discharged "(§75-5-103, MCA). The DEQ's definition of point source should be considered and distinctions made whenever "point source" is encountered while reading this attachment.

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MEMORANDUM

To:	Matt Jaeger, Montana Fish, Wildlife and Parks
From:	Karin Boyd, Applied Geomorphology, Inc.
Date:	September 13, 2011
In Regards To:	Clark Canyon Creek Field Visit

1. Introduction

Clark Canyon Creek is a tributary to the Upper Beaverhead River, entering the Beaverhead approximately 1.5 miles downstream of Clark Canyon Reservoir (Figure 1). The creek is the first major tributary below the dam, entering a robust tailwater fishery at its confluence with the Beaverhead. High sediment loading from Clark Canyon Creek has impacted this fishery due to an occasional imbalance between sediment loads delivered by the creek and transport capacities in the Beaverhead River. The problem has been most pronounced when accelerated sediment delivery on Clark Canyon Creek coincides with low flow releases from Clark Canyon Reservoir. When sediment loading from the tributary is high and flows in the river are low, extensive deposition of fine sediment has occurred in the Beaverhead River, and these events have been associated with declines in fish counts.

The sediment sources within the 11,000 acre Clark Canyon Creek watershed have not been clearly identified. In an effort to identify those sources and develop conceptual sediment management strategies, Applied Geomorphology Inc. (AGI) was retained by Montana Fish Wildlife and Parks (MTFWP) to perform a reconnaissance level site visit and cursory geomorphic assessment. To that end, this document describes observations made during a site visit to Clark Canyon Creek on August 16, 2011. The site visit was attended by myself (Karin Boyd), Matt Jaeger (MTFWP) Katie Tackett (Beaverhead Watershed Committee), Beau Downing (MTFWP), Carl Malesich (Beaverhead Conservation District, BWC Chairman), Tom Miller (R.E. Miller and Sons) and Frank Snellman (Clark Canyon Ranch).

This investigation was reconnaissance in nature and did not include any data collection or analysis. As such, this summary is based purely on field observations, discussions with people familiar with the watershed, and a cursory review of existing information including geologic maps, aerial photography, a Bureau of Reclamation (BOR) sediment transport study, and TMDL-related documents.

Clark Canyon Creek has just over eight miles of mapped channel (MDEQ, 2010). This includes two primary forks, referred to herein as South Fork Clark Canyon Creek and North Fork Clark Canyon Creek (Figure 1). North Fork Clark Canyon Creek drains the flanks of Gallagher Mountain, joining the South Fork approximately four miles upstream of its confluence with the Beaverhead River.

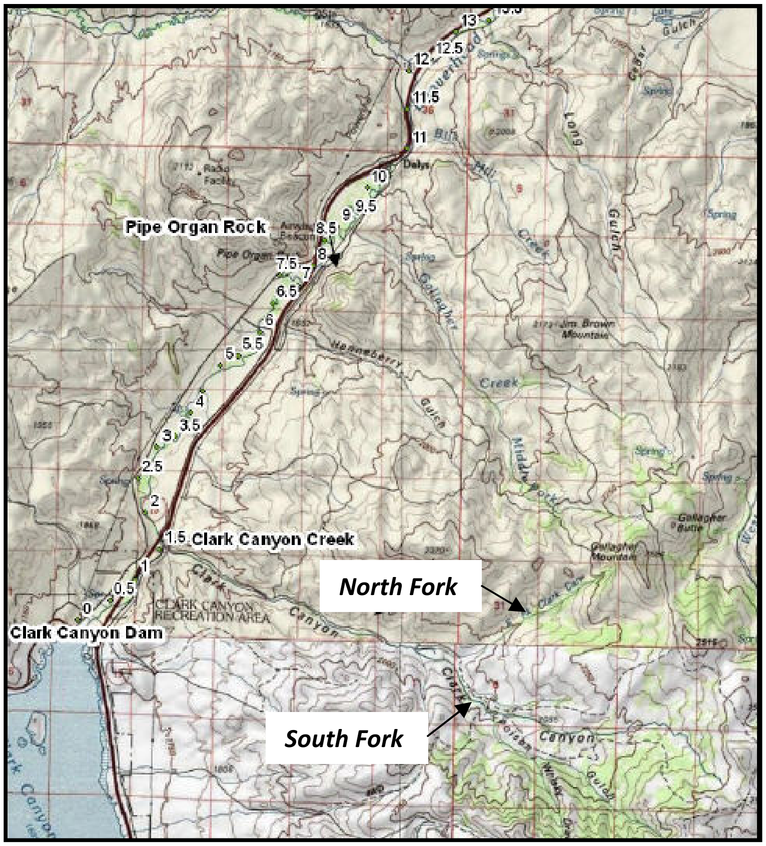

Figure 1. Location map of Clark Canyon Creek with River Miles as distance downstream of dam (BOR, 2010).

Primary findings of this assessment include the following:

- Geologic mapping and field observations indicate that the Clark Canyon Creek watershed is prone to high sediment production rates due to highly erodible source areas and widespread hillslope instability.

- Sediment production is most pronounced from ash-laden Tertiary volcanics. These units are sparsely vegetated, alter to bentonitic clays, and are prone to landsliding and debris flow formation.

- TMDL-related sediment source assessments support the conclusion that uplands are the primary sediment source in the basin. The primary source area appears to be the North Fork of Clark Canyon Creek.

- The ongoing application of BMPs to reduce anthropogenic sediment sourcing from both roads and streambanks should be continued, however these sources are volumetrically minor relative to the hillslope-derived load.

- TMDL source evaluations indicate a potential 50% reduction in hillslope-derived sediment loading with upland BMPs in place, however the BMP condition assumes 85% vegetative cover for scrub/shrub and grassland areas, which may not be achievable on the clay-rich soils.

- Due to the high clay content in the sediment, settling basins are likely not feasible as a sediment control measure.

- Check dams or gully plugs in ephemeral drainages/gullies may help reduce some upland sediment source delivery to Clark Canyon Creek.

- Inducing sediment deposition on a broad fan surface at the mouth of the North Fork may effectively reduce fine sediment loading to the Beaverhead River during flood events.

- Maintaining sufficient flushing flows on the Beaverhead River when Clark Canyon Creek is producing high sediment loads may be the most cost-effective means of minimizing the impacts of these natural inputs on the Beaverhead fishery. Flushing flows should be pursued, and perhaps further evaluated in terms of cross section inundation, to identify the range of flows that result in shallow inundation of the cross section margins. Any flow range that consistently results in shallow inundation of relatively flat channel margin surfaces should be avoided.

2. Geology and Soils

The Clark Canyon Creek watershed straddles two geologic mapping areas, including the Lima 1:100,000 scale map (Lonn and others, 2000), and the Dillon 1:250,000 scale map (Ruppel and others, 1993). Due to the different scales, dates, and authors of the maps, the geologic contacts and rock units are not consistent across the boundary. In order to evaluate the general geology of the area, the two maps were brought into a GIS project, and map units were color coded to match correlative rock types (Figure 2). The results show that the basin consists of the Cretaceous/Tertiary Beaverhead Group (green: Tkb and Tkbq), which consists of massive conglomerate. This unit is overlain by Tertiary-age volcanic rocks (pink and red: Tvu, Trvb and Trvp). Large landslide deposits (cross-hatched) are also mapped in the upper portion of the Clark Canyon Creek basin. The red line on the map is a fault line mapped on the Lima Quadrangle. This northwest trending fault line closely follows the strike of South Fork Clark Canyon Creek.

The geology of the Clark Canyon Creek watershed appears to play a critical role in watershed geomorphology and rates and patterns of sediment production. The Beaverhead Group is exposed in the lower portion of Clark Canyon Creek, where it is locally capped by resistant volcanic rocks, which are mapped as Trvb (Figure 3). Further upstream, relatively erodible layers in the volcanic units are exposed where the valley widens out forming a broad headwaters basin. Large extents of these volcanics have been remobilized as landslides. These landslides locally appear to have formed as debris flows or earth flows, in which a saturated matrix has resulted in gravity-induced mass failure (Figure 4). Bartholomew and others (1999) concluded that late Quaternary landslides, some of which are currently active, have periodically blocked, constricted, or diverted the Beaverhead River in Beaverhead Canyon. They note that “the abundance of landslides in the lower canyon is related to bedrock consisting mostly of mixed volcanic rocks”.

Tertiary-age volcanic rocks are exposed in the valley wall and upland areas within the North Fork of Canyon Creek sub-basin, commonly outcropping as a sparsely vegetated, gullied landform. On the Lima map, which is shown in the southern portion of Figure 2, the primary volcanic unit (pink) is described as air fall and pyroclastic flow tuff and tuffaceous mudstones that are commonly altered to bentonitic clays (Lonn and others, 2000). The authors also note that “landslides commonly develop in this unit”.

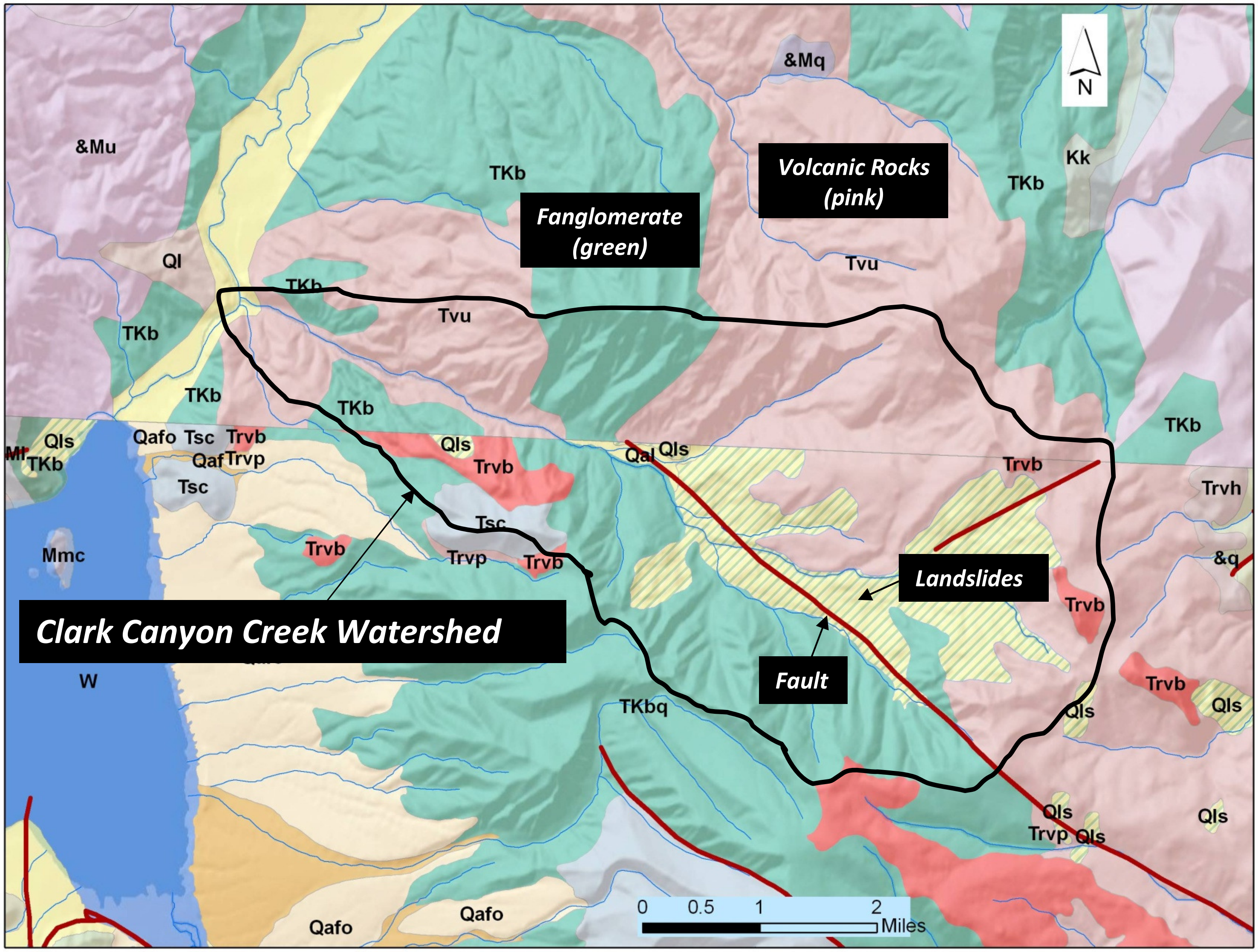

Figure 2. Geologic map of Clark Canyon Creek basin showing major rock types; see text for descriptions.

Figure 3. South valley wall of Clark Canyon Creek showing coarse fanglomerate overlain by a basalt cap.

Figure 4. Landslide/debris flow deposits exposed near confluence of North and South Forks of Clark Canyon Creek.

Figure 5. View upstream of North Fork of Clark Canyon Creek showing exposure of massive fine grained volcanic unit in valley wall.

The fine grained, soft volcanic units appear to create significant slope instabilities in the Clark Canyon Creek watershed. Extensive landslide deposits have been mapped in the upper drainage where the soft volcanic rocks predominate. One such area is shown in Figure 6 where massive instability has resulted in a pinching of the creek between the mass failure and the north valley wall.

2.1 Soils

USDA soils mapping in the Clark Canyon Creek basin support the observations of general hillslope instability associated with the Tertiary-age volcanic rocks. The volcanic exposures within the North Fork Clark Canyon Creek sub-basin are associated with Butchill, Doolittle, and Slagamelt soils, which are described as landslide deposits that are derived from rhyolite (Butchill and Doolittle) or form alluvium and/or debris flow deposits derived from igneous or sedimentary rocks (Slagamelt).

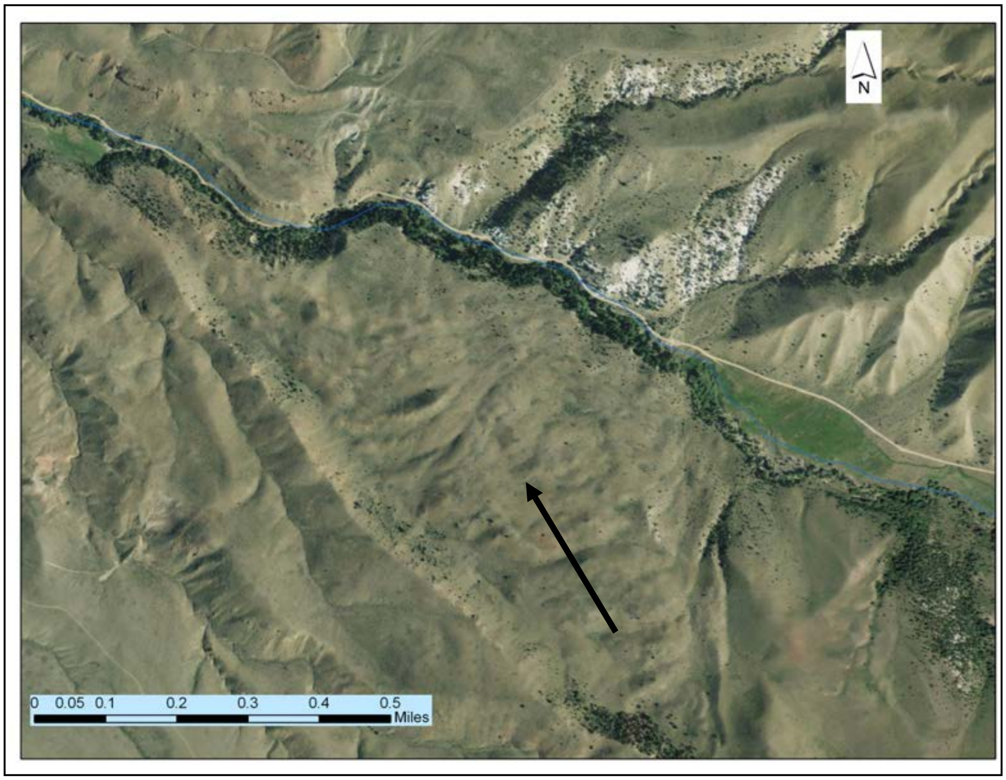

Figure 6. Closeup view of massive earthflow on south valley wall, Clark Canyon Creek; arrow depicts general direction of movement.

3. Sediment Sources in Clark Canyon Creek

One primary objective of this assessment is to consider the sediment sources within the Clark Canyon Creek basin. It is clear from the discussion above that background sediment loading from unstable hillslopes and erodible volcanic units is high. Although hillslopes appear to be a major sediment source in the basin, it is important to consider other potential sources, including streambanks and roads.

3.1 Streambanks

Clark Canyon Creek drains a watershed of approximately 11,000 acres, with a mapped channel length of just over 8 miles (MDEQ, 2010). The main stem of the creek, which extends from the confluence of the north and south forks to the mouth, generally supports a moderately dense woody riparian corridor that is locally confined by the valley wall, a road bed, and/or hillslope failures (Figure 7). Where the valley bottom is relatively wide, it is commonly irrigated for pasture, although during the reconnaissance investigation there was no evidence of accelerated sediment production from streambanks due to livestock. The sediments in the valley bottom are coarse grained and topographically irregular throughout the channel and adjacent floodplain, with local woody debris recruitment and flood deposits evident. Flood deposits are evident as sediment slugs and woody debris accumulations that have locally aggraded the valley bottom and buried the base of cottonwoods. These features indicate that sediment pulses are delivered to the stream corridor during floods.

Figure 7. View upstream of the mainstem of Clark Canyon Creek showing coarse substrate, road bed, and woody vegetation corridor. Photo is taken from recently maintained diversion structure.

As part of the Beaverhead Planning Area TMDL development, a riparian corridor quality assessment was performed by the Montana Department of Environmental Quality. The resulting ratings indicate that on Clark Canyon Creek, 97 percent of the stream length has a “moderately good” to “good” riparian quality (Confluence, 2011). These ratings reflect relatively good riparian conditions on Clark Canyon Creek in relation to the entire Beaverhead Planning Area; out of 20 listed streams in the planning area, 16 were rated as having a majority of stream length classified as a “fair” to “poor” riparian condition.

The only accelerated bank erosion observed in Clark Canyon Creek was where the creek abuts steep valley walls. Even in these areas, however, coarse sediment tended to self-armor the bank toe. The rate of sediment production from these areas has not been quantified, but it appears to be relatively small in comparison to other sources.

3.2 Roads

The mainstem of Clark Canyon Creek is paralleled by a gravel access road that follows the north valley wall. This road has experienced damage during flood events, and multiple culverts have been installed to improve conveyance of both sediment and water from the hillslopes to the valley bottom. In places, the culverts deliver water and sediment to a wide buffer, however in some areas the culverts discharge very close to the stream. Where there is no buffer between the road and the stream, sediment delivery rates from roads are markedly higher.

Although buffer widths are locally narrow such that road sediment is delivered directly to the stream, it is important to consider the overall volume of sediment delivered from roads relative to other sources. The TMDL assessment for the Beaverhead Planning Area included an assessment of sediment delivery from unpaved roads (Atkins, 2011). The results of this assessment indicated that Clark Canyon Creek has 3 road crossings that produce a mean annual load of 0.18 tons of sediment. Two crossings are on private land and one is on BLM property. This is an average of 0.06 tons per crossing, which is equal to the average production rate for assessed crossings throughout the Beaverhead TMDL Planning Area.

For unpaved parallel road segments, the analysis determined that for the entire planning area, approximately 0.0023 tons of sediment are delivered per every 100 ft of road segment located within 150 feet of the stream channel. On Clark Canyon Creek, a 1.25 mile long road segment was identified as contributing, which translates to a mean annual load of 0.15 tons of sediment.

The total mean annual sediment load from unpaved roads in Clark Canyon Creek, which includes both crossings and parallel road segments, is 0.33 tons per year (Atkins, 2011). Atkins estimated that with the application of roads BMPs, this contribution could be reduced by 67% to 0.11 tons per year. The reduction noted in the TMDL document is achieved by "reducing contributing road lengths at unpaved road crossings to 100 feet from either side of the crossing and by reducing contributing road lengths along unpaved parallel road segments to 100 feet" (Atkins, 2011).

At approximately 1.45 tons per cubic yard for rock/soil, the 0.33 tons per year is equivalent to approximately 0.2 cubic yards of sediment per year. For comparison, a standard dump truck has a capacity of 10-12 cubic yards.

3.3 Hillslopes

The TMDL development effort for the Beaverhead Planning area includes an assessment of sediment contributions from hillslope erosion (Confluence, 2011). This assessment consists of a modeling effort using the Universal Soil Loss Equation (USLE) and a sediment delivery ratio to estimate the quantity of hillslope-derived sediment delivered to Clark Canyon Creek, which was modeled as a distinct sub-basin in the analysis. USLE analytical parameters include rainstorm runoff characterization, soil erodibility, slope, overland flow length, vegetative cover, and conservation practices.

Results of the assessment indicate that the upland sediment load for existing conditions in the Clark Canyon Creek watershed is the order of 146.3 tons per year. An evaluation of potential reductions in loading via BMP applications in both upland and riparian areas estimated the potential reduction at 54% of the total load to a total production rate of 67 tons per year. The riparian BMPs apply an improved riparian assessment condition, and the upland BMPs consider improved grazing and cover management.

3.4 Summary of Sediment Sources

The results of the TMDL-related sediment source analysis indicates that the quantity of hillslope-derived sediment delivered to Clark Canyon Creek is several orders of magnitude higher than that derived from unpaved roads (Table 1).

Table 1. Summary of estimated sediment loads to Clark Canyon Creek (Confluence, 2011; Atkins, 2011).

Sediment Source	***Existing Conditions Sediment Production Rate (tons/yr)***	***Sediment Production Rate with BMPs in Place (tons/yr)***
Streambanks	Unknown	Unknown
Roads	0.33	0.11
Hillslopes	146	67

A quantified summary of bank-derived sediment is not yet available for Clark Canyon Creek, however that effort is evidently underway (http://montanatmdlflathead.pbworks.com/w/page/41735489/Beaverhead%20Documents). Field observations and geologic mapping indicate, however, that bank-derived sediment volumes are likely small relative to hillslope-derived sediment. Once the bank erosion inventory analysis is completed by MTDEQ, the results of that investigation can be compared to results of the roads and upland assessments to identify potential opportunities to significantly reduce sediment loading from banks.

In summary, the primary sediment sources to Clark Canyon Creek are highly erodible upland areas that are prone to mass failure and fluvial erosion. These areas appear to be concentrated in the North Fork Clark Canyon Creek sub-basin (Figure 8 and Figure 9). The headwaters of the North Fork contain distinct areas of mass failure. This channel contains evidence of debris flow deposition, with very coarse sediment deposits that are supported by a fine clay matrix (Figure 10). Where these deposits are exposed in the main channel corridor, the fine matrix is commonly eroded out, leaving the coarse material as a distinct depositional form. Additionally, eyewitness accounts of flooding in the basin include observations of very high turbidity in the North Fork flows versus clear water in the South Fork (Frank Snellman, pers. comm.) And lastly, whereas the South Fork of Clark Canyon Creek is reported to support diverse macroinvertebrate populations, the North Fork is largely devoid of macroinvertebrates (Matt Jaeger, pers. comm.). This is likely indicative of high fine sediment loading from the North Fork Clark Canyon Creek sub-basin.

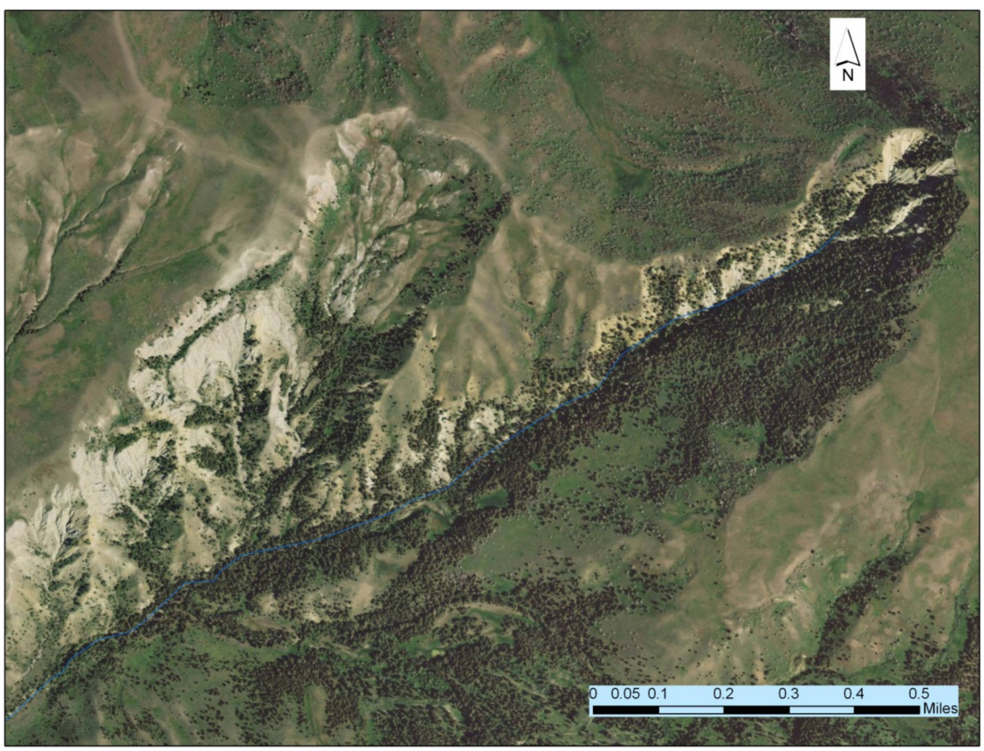

Figure 8. Aerial view of upper basin showing hillslope erosion on North Fork Clark Canyon Creek.

Figure 9. Exposure of Tertiary volcanics in North Fork Clark Canyon Creek (Matt Jaeger).

Figure 10. View upstream of North Fork Clark Canyon Creek showing coarse debris flow deposits.

4. Conceptual Alternatives for Sediment Management

The following section provides a series of conceptual approaches to reducing the impacts of fine sediment loading from Clark Canyon Creek on the Upper Beaverhead River trout fishery. The approaches are highly conceptual in nature and would require more extensive feasibility and engineering analysis to determine feasibility, cost, and anticipated benefit.

There proposed basic approaches to reducing sediment impacts to the Upper Beaverhead River fall into the three following categories:

1. Reduce sediment inputs at their source
2. Trap and/or store sediment en route
3. Flush sediment through the impacted reach

4.1 Reduce Sediment Inputs

The sediment delivered to Clark Canyon Creek is derived from streambanks, roads, and upland areas. Available data indicate that the riparian corridor is in relatively good shape and sediment production from roads is relatively low. BMPs are currently in place on both the roads and in riparian grazing areas. As such, although the implementation of riparian and roads BMPs should be continued, the sediment sources cannot be significantly reduced without addressing upland inputs.

An analysis of sediment contribution from hillslope erosion (Confluence, 2011), estimated that the hillslope-derived load currently delivered to Clark Canyon Creek could be reduced by over 50% with upland and riparian BMPs. This improvement reflects a 10% increase in ground cover for areas classified as grasslands/herbaceous, shrub/scrub, pasture/hay, and woody wetland, and a 20% increase for cultivated crop areas. In the Clark Canyon Creek basin, the primary land cover types are grassland/herbaceous (38%), shrub/scrub (27%) and evergreen forest (33%). The upland BMPs assume no change in cover for the evergreen forest type, but an increase in ground cover from 75% (existing) to 85% (improved) for both the grassland/herbaceous and shrub/scrub cover types.

The National Land Cover Dataset map for the Beaverhead TMDL Planning area indicates that the land cover types associated with the erodible volcanic materials along the North Fork of Canyon Creek are primarily shrub/scrub, with some grassland/herbaceous cover. Due to the geologic and soils conditions in this area, there is some question as to whether these cover types currently support 75% cover, and whether they would support 85% cover in a BMP scenario. Currently, there are numerous areas where vegetative cover on the clay-rich volcanic units and associated mass failures are sparse, with much less than 75% cover (Figure 9). The current BMP status of these areas is unknown, but no other evidence of excessive grazing impacts were noted in the field. It is recommended, however, that the potential for increased vegetative cover on grazing lands be considered as a means to help reduce sediment inputs from sensitive upland areas.

The results of this reconnaissance-level assessment indicate that although the treatment of upland sources through land use BMPs should be considered in any land use plan, it is unlikely that 85% vegetative cover is achievable in this landscape, or that sediment production rates could be reduced by over half with land use modifications.

4.2 Trapping Sediment

The concept of trapping sediment focuses on intercepting upland-derived loads before they reach the Upper Beaverhead River. This can be achieved using in-stream structures such as gully plugs, off-stream structures such as settling basins, or by promoting floodplain aggradation and storage.

When sediment trapping is considered, it is important to note that the sediments that negatively impact the Upper Beaverhead fishery are very fine grained. The description of the Clark Canyon Creek basin soils as derived from rhyolite ash, rich in clay, and prone to alteration to bentonite, suggests that the trapping of this sediment out of the water column would require very long residence times, hence very large basins. Another challenge with sediment trapping lies in the fact that the coarser bedload delivered to the Upper Beaverhead River is beneficial to the fishery, in light of the fact that Clark Canyon Reservoir otherwise traps all bedload entering the reach. So the objective for sediment trapping is to trap fine sediment while allowing coarser bedload (gravel and cobble) to reach the Beaverhead River.

Another important consideration in the evaluation of trapping mechanisms is the fact that the sediment loads are only problematic when Clark Canyon Creek experiences a flood event and Upper Beaverhead flows are too low to effectively transport that material (~350cfs; BOR, 2010). As such, sediment trapping is only necessary when those specific conditions are met.

Check dams and Gully Plugs

The north side of the Clark Canyon Creek watershed is dissected by numerous ephemeral channels that appear capable of producing large volumes of fine sediment during high runoff events (Figure 11). A potentially appropriate sediment control measure for these areas is grade stabilization structures that form check dams, commonly referred to as "gully plugs". These structural measures may be built out of woven-wire, brushwood, logs, logs stone, and boulders; they are typically temporary and used to facilitate the growth of permanent vegetative cover (www.fao.org/forestry). If these treatments are further considered, it would be appropriate to map all major point sources of sediment from such drainages, and survey the drainage to assess the size and number of structural features that would be necessary. One challenge with these features is the potential for plug failure and rapid delivery of sediment slugs downstream.

Figure 11. Gully formation in volcanic rock units (Matt Jaeger).

Riparian Buffers

Riparian zones can be effective at trapping upland sediment before it reaches a stream channel. The amount of sediment trapped is related to the size and condition of the riparian corridor. Confluence (2011) estimated that on Clark Canyon Creek, the total upland sediment load could be reduced by 46% if both riparian and upland BMPs are employed. However, with regard to the riparian BMPs, there is some question as to the potential for significantly increasing riparian vigor or buffer extent in the reach.

The riparian health assessment on Clark Canyon Creek, which was based on an evaluation of air photos, ranked 70% of the corridor as in “moderately good” condition, and 27% as “good” condition. Under a BMP scenario, it is estimated that 97% of the corridor would achieve a “good” rating (Confluence, 2011). This riparian improvement would then reduce sediment loading to the creek by increasing the “Riparian Buffer Sediment Reduction Efficiency” (SRE), as is shown in Figure 12. These SRE values reflect the riparian condition of a “nominal 100-ft wide riparian buffer”, and indicate that whereas a buffer with a good riparian condition will reduce the sediment load by 75%, a poor condition reduces delivery by only 30%. As a result, by improving the condition of a riparian corridor, more upland sediment is trapped in the riparian zone.

As the riparian condition of Clark Canyon Creek was only evaluated at a reconnaissance level for this effort, the potential for major improvement with land use modifications is not clear. Trapping efficiency in the riparian zone is limited by buffer widths, which are commonly less than 100 ft in the narrow stream valley. Locally the valley bottom is irrigated and some clearing has taken place; these areas may provide some opportunities for improved sediment trapping. Overall, however, the existing riparian condition, buffer size, and upland yields indicate that the projected reduction in sediment loading with BMPs is likely overestimated. It is recommended, however, that a riparian specialist be contacted to discuss potential BMP applications in the stream corridor that will improve the sediment trapping efficiency of the riparian area.

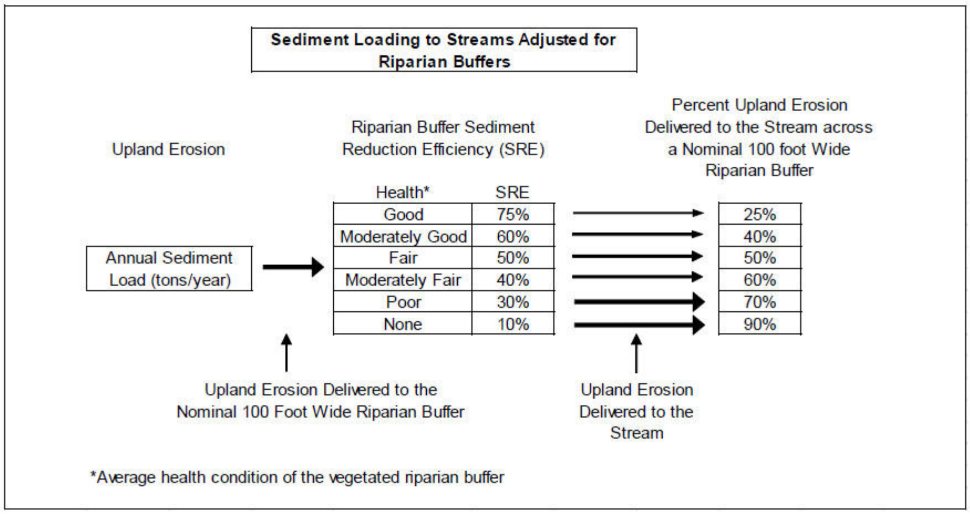

Figure 12. Upland sediment load delivery adjusted for riparian buffer capacity, Beaverhead TMDL Planning Area (Confluence, 2011).

Settling Basins

Settling basins, when properly designed, retain water long enough for coarse suspended solids to settle. Typically, however, in fine grained systems, storm overflows cannot be treated through sedimentation due to the presence of suspended clay particles that require much longer storage times to settle. Typically, sediment basins are only practically effective in removing sediment coarser than fine silt and clay (CASQA, 2003). Systems with a high clay load commonly require chemical treatment in addition to the sediment basin. Even with a silt load, a detention time of 24 to 48 hours is typically necessary to allow 70 to 80% of the sediment to settle (CASQA, 2003). As settling basins do not effectively capture fine silts and clays during storm events, and are expensive to both construct and maintain, the use of these structures in Clark Canyon Creek appears largely unfeasible.

Induced Floodplain Aggradation/Storage

In natural stream systems, floodplains tend to aggrade due to fine sediment deposition. The aggradation occurs during flood events when suspended material is carried out over the floodplain, where shallow water and high roughness create conditions conducive to flow infiltration and fine sediment settling. In the Clark Canyon Creek basin, it is the fine fraction of sediment that is in suspension during flood events that is the target for sediment trapping. As such, it is appropriate to consider induced floodplain aggradation as a potential means of downstream suspended sediment load reduction.

Based on observations made during the field reconnaissance, it appears that the most practical location to consider floodplain sediment storage is in the lowermost section of the North Fork Clark Canyon Creek, just upstream from the gravel road crossing over the North Fork (Figure 13 and Figure 14). This area currently consists of a broad fan-shaped depositional surface that has old spreader dikes, indicating historic irrigation practices. Possible sediment measures on the surface would include managed high flow dispersal into an alluvial fan environment, or potentially dispersal into stepped depressional wetlands. It is not clear as to whether this landform is a deactivated alluvial fan, however the high sediment loads and valley bottom widening in this area suggest that this feature was historically an alluvial fan. No distinct abandoned channel features are visible on the fan surface, however the presence of spreader dikes suggests that land uses may have included topographic modification of the depositional surface.

Alluvial fan restoration is becoming increasingly common in the stream restoration industry. I have personally worked on a proposed fan reactivation project on Hellroaring Creek in the Centennial Valley, in an effort to increase overall channel stability and habitat complexity while reducing sediment delivery downstream. On the Lower Mohawk River in New Hampshire, reactivation of alluvial fan channels was proposed as a means of reducing sediment loading downstream (Field Geology Services, 2007). The concept proposed was to restore flow to abandoned channels on the fan, to spread flow over a wider area and decrease flow velocities within the active main channel. To prevent flow from re-entering the main channel, the proposal included the placement of large woody material in the existing channel. The flow was to be diverted onto the fan through a notch in the existing bank, and partial blockage of the main channel.

The activation of alluvial fan depositional processes at the mouth of North Fork Clark Canyon Creek would require engineering design to assess overall trap efficiency of the surface, and to design outflow points and return flow points. Special attention would have to be paid to the road crossing on the downstream end of the fan, as strategically-placed culverts may be necessary to convey flow towards the South Fork Canyon Creek confluence.

Figure 13. View upstream of lower North Fork Clark Canyon Creek showing potential overflow area.

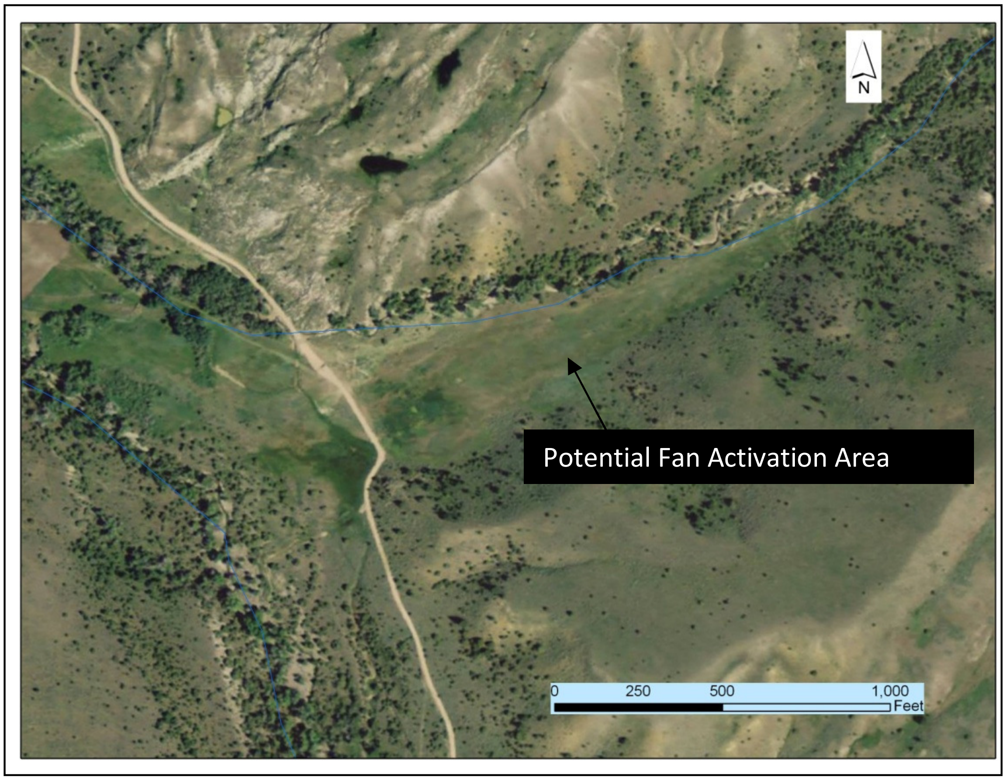

Figure 14. Aerial view of lower North Fork Canyon Creek showing broad fan area south of main channel.

The alluvial fan aggradation concept is different from a settling basin in that the alluvial fan approach relies on a larger surface area, higher roughness, and flow infiltration into the ground surface. Approaches to spreading flows might include structural dispersal of flow across the fan through notched grade controls that are oriented perpendicular to the fan axis, or reactivation of old spreader dikes. Notched grade controls could define overflow areas down the fan surface to prevent channel avulsion, and could be constructed of wood fence, or relatively portable hard structures such as trenched jersey barriers.

4.3 Flushing Flows on Upper Beaverhead River

Clark Canyon Creek has a high natural sediment load due to the presence of fine grained volcanic units that are prone to clay alteration, landslides, massive slope instabilities, and debris flow formation. Due to the extensive exposure of these deposits on the northern portion of the watershed, it is impossible to treat the exposures as point sources. Rather, it may be most appropriate to accommodate the sediment load by ensuring sufficient flushing flows on the Beaverhead River.

The sedimentation problems stemming from Clark Canyon Creek typically occur during the spring, when Clark Canyon Reservoir releases are kept low to optimize storage for irrigation. From 2005 to 2009, the April-May flow releases from Clark Canyon Reservoir have ranged from less than 100 cfs to 900 cfs (BOR, 2010).

The issue of flushing flows has been evaluated by the Bureau of Reclamation. In their analysis, the BOR concluded that a discharge of 350 cfs would mobilize a 20.4mm particle size (based on Shields method), which is larger than the median particle size collected near Clark Canyon Dam (18.3mm). The incipient mobility of bedload was used as a basis for defining conditions at which smaller material was in motion. As stated in the BOR report, "The assumption is that if the underlying bed material will mobilize then it will also carry the smaller size particles downstream allowing flushing of the sediment".

The results of the BOR study (BOR, 2010) indicate that a 350 cfs flushing flow below Clark Canyon Dam should provide effective bedload transport below the Clark Canyon Creek confluence. This will prevent the fine grained channel infilling that is characteristic of very low flows (<~200cfs). Even at 350 cfs, however, the potential for fine sediment accumulation on relatively shallow channel margin areas should be considered. With more detailed cross sections collected in areas prone to deposition, an evaluation of the change in wetted perimeter with increasing discharge would help identify the discharge range that correlates to shallow inundation of channel margin areas. That is, inundation of any low sloping features on the channel cross section would create a rapid increase in wetted perimeter with a small increase in discharge. If shallow inundation of the channel margins occurs at a consistent flow range at multiple cross sections, that flow range could be avoided. Thus the flushing flow could include a minimum discharge, and an optimal range of discharges above that minimum.

A plot of the minimum mean daily discharge measured during the months of April and May on the Beaverhead River at Barretts (downstream of Clark Canyon Creek) shows that minimum flows of less than 350 cfs are fairly common during those spring months. Since 1908, at least one day with a mean daily flow of less than 350cfs was measured at Barretts 73% of the time in April, and 58% of the time in May. Clark Canyon Dam was built in 1964, and flows were commonly less than 350cfs in April and May prior to dam construction, especially during the 1930s and early 1960s. This indicates that sediment transport limitations on the Beaverhead have occurred both prior to and following the construction of Clark Canyon Reservoir.

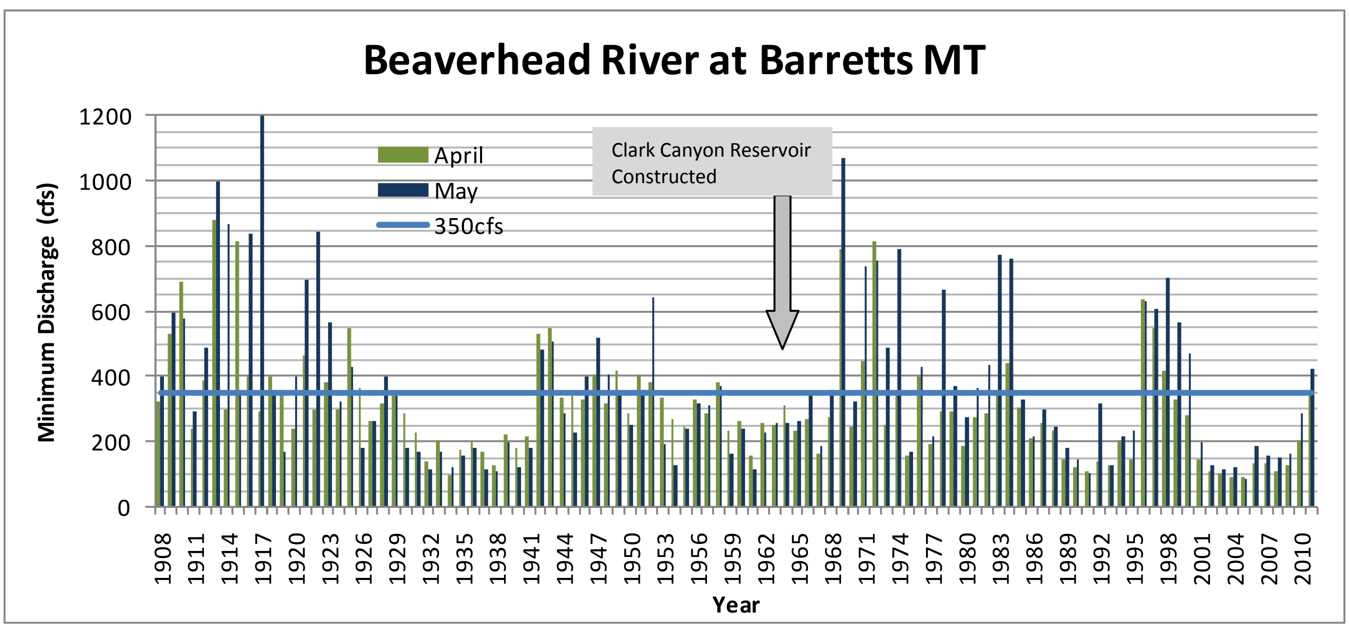

Figure 15. Minimum April and May discharge (mean daily flow) measured since 1908 at USGS Gage 06016000 at Barretts, MT.

5. Summary

Clark Canyon Creek has a high natural sediment load due to inherently unstable aspects of basin geology. Sediment loading is especially elevated during storm events when fine grained volcanic rocks become saturated and prone to surficial erosion or mass failure. If flows in the Beaverhead River are simultaneously low, a sediment transport imbalance occurs and sediment deposition occurs downstream of the mouth of Clark Canyon Creek.

Land uses in the basin include some grazing and road development. BMPs should be continued with these land uses. However, it is apparent that high sediment loads should be expected from the Clark Canyon Creek basin even in the absence of any agricultural land use or road development.

Means of substantively reducing sediment impacts on the Beaverhead include control of point sources, trapping of sediment below the source, and flushing of sediment through Beaverhead Canyon. Any significant control of point sources appears unfeasible due to the sheer extent of hillslope contributions. Additional BMP implementation in either upland or riparian areas may reduce loading, however due to an erodible geology, naturally narrow riparian buffer areas, and existing BMPs, it is unlikely that land use modifications alone will solve sediment loading problems in Beaverhead Canyon. Rather, induced deposition of fine sediment in floodplain areas of Clark Canyon Creek, in combination with flushing flows on the Beaverhead appear to provide the most optimal conceptual alternatives to reduce fine sediment impacts to the Beaverhead fishery. The feasibility and anticipated benefit of induced deposition would require additional analysis related to design requirements and sediment trapping efficiencies in overbank areas. Flushing flows have been evaluated (BOR, 2010), however further analysis of cross section/wetted perimeter relationships may help convert the minimum flow value to an optimal range of flushing flows that will maintain fine sediment transport through Beaverhead Canyon.

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