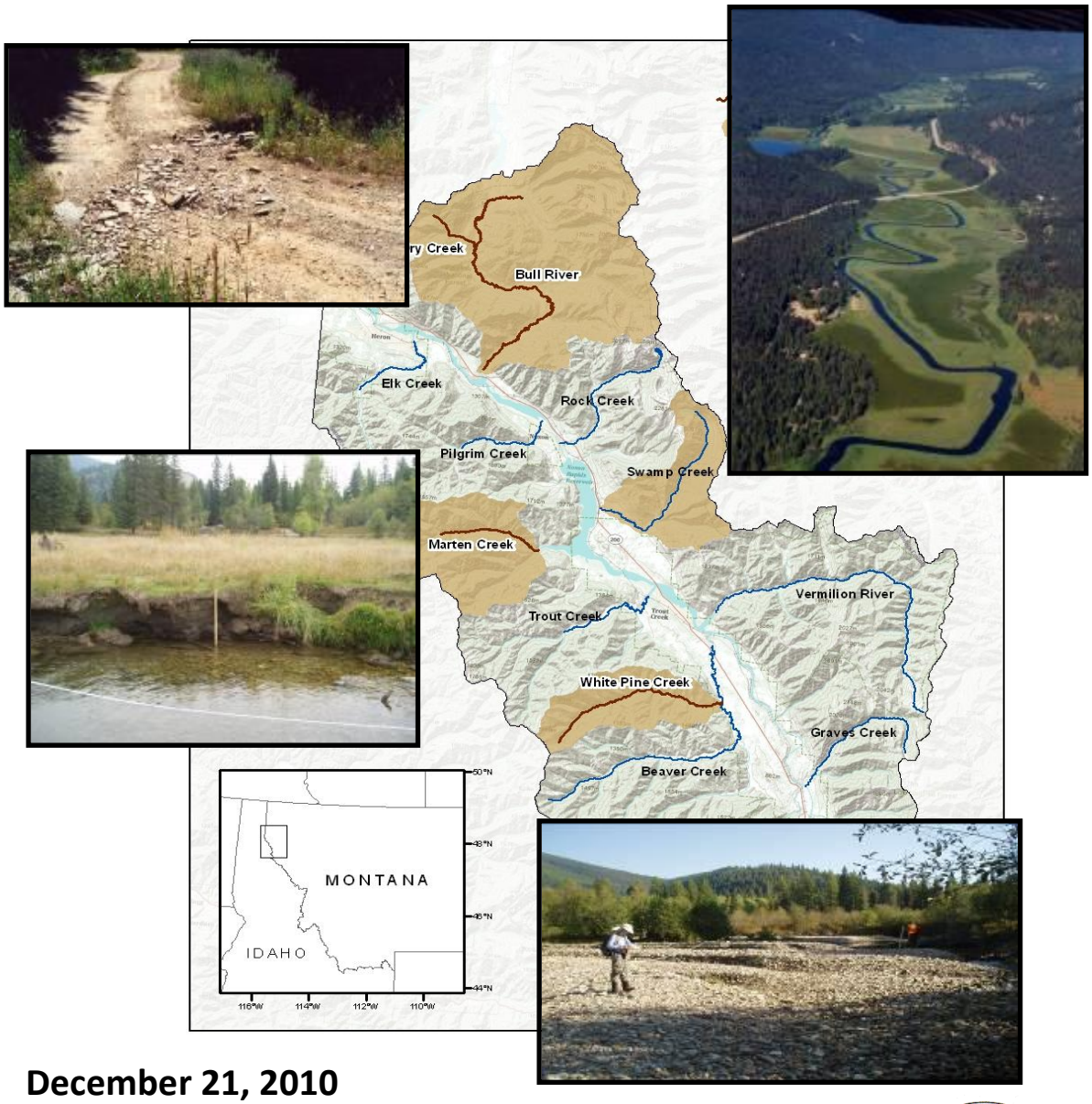
Montana Department of
ENVIRONMENTAL QUALITY

Lower Clark Fork Tributaries Sediment TMDLS and Framework For Water Quality Restoration



December 21, 2010

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ACRONYMS

AFO	Animal Feeding Operation
ARM	Administrative Rules of Montana
BEHI	Bank Erosion Hazard Index
BER	Board of Environmental Review, Montana
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
cfs	Cubic Feet per Second
CNMP	Comprehensive Nutrient Management Plan
CWA	Clean Water Act
DEQ	Department of Environmental Quality, Montana
DLCD	Deer Lodge Conservation District
DNRC	Department of Natural Resources and Conservation, Montana
EMAP	Environmental Monitoring and Assessment Program
°F	Degrees Fahrenheit
ft	feet
FWP	Fish, Wildlife, and Parks, Montana Department of
HRU	Hydrologic Response Unit
HUC	Hydrologic Unit Code
in	inches
LA	Load Allocation
LANDSAT	Land Remote Sensing Sattelite
lbs/day	pounds per day
LCFT-TPA	Lower Clark Fork Tributaries TMDL Planning Area
LWD	Large Woody Debris
MCA	Montana Code Annotated
mg/L	Milligrams Per Liter
mi/sq mi	miles per square mile
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
NBS	Near Bank Stress
NLCD	National Land Cover Dataset
NRCS	National Resource Conservation Service
NRDP	Natural Resource Damage Program
PFC	Proper Functioning Condition
SCD/BUD	Sufficient Credible Data / Beneficial Use Determination
SMZ	Streamside Management Zone
sq/mi	square miles
SSURGO	Soil Survey Geographic
STATSGO	State Soil Geographic [database]
SWAT	Soil and Water Assessment Tool [model]
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
UAA	Use Attainability Analysis
UCFRB	Upper Clark Fork River Basin

U.S. EPA	United States Environmental Protection Agency
USFS	United States National Forest Service
USGS	United States Geologic Survey
USLE	Universal Soil Loss Equation
USFWS	United States Fish & Wildlife Service
WARSEM	Washington Road Surface Erosion Model
WLA	Waste Load Allocation
WQA	Montana Water Quality Act
WRC	Watershed Restoration Coalition of the Upper Clark Fork
WRP	Watershed Restoration Plan

EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality restoration for sediment in five impaired tributaries in the Lower Clark Fork Tributaries TMDL Planning Area (TPA), located in northwest Montana and extending from the mouth of Prospect Creek near Thompson Falls, downstream to the Idaho-Montana state border. The following sections provide details related to the justification, development, and ultimate achievement of sediment TMDLs for Bull River, Dry Creek, Marten Creek, Swamp Creek, and White Pine Creek. DEQ has performed assessments determining that the above listed tributaries do not meet the applicable water quality standards. The scope of the TMDLs in this document address sediment related problems for Lower Clark Fork tributaries (See **Table E-1**). In addition, data for Elk Creek appears within this document to assist with future review of progress toward achieving the 1997 Elk Creek TMDL plan.

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. The goal of TMDLs is to eventually attain and maintain water quality standards in all of Montana's streams and lakes, and to improve water quality to levels that support all state-designated beneficial water uses.

The Lower Clark Fork Tributaries TMDL Planning Area is located entirely in Sanders County and within its boundaries exist the major tributaries of Beaver Creek, Elk Creek, Graves Creek, Pilgrim Creek, Rock Creek, Trout Creek and the Vermillion River, in addition to the tributaries for which TMDLs have been developed; however, it does not include the Lower Clark Fork River channel. Lower Clark Fork tributaries originate in the Cabinet Mountains to the northeast and the Coeur D'Alene Mountains to the southwest. The TPA includes portions of two national forests, the Lolo and Kootenai National Forests, and over half of the Cabinet Mountain Wilderness Area.

Sediment
Sediment was identified as a cause of impairment of aquatic life and coldwater fisheries in Bull River, Dry Creek, Marten Creek, Swamp Creek, and White Pine Creek. Sediment is impacting beneficial water uses in these streams by affecting habitat and other conditions necessary for the success of trout and other aquatic life. Water quality restoration goals for sediment in these stream segments were established on the basis of stream morphology, fine sediment levels in trout spawning areas, pool quality and riparian condition. DEQ believes that once these water quality goals are met, beneficial uses currently impacted by sediment will be restored.

Sediment loads were quantified for natural background conditions and for the following sources: bank erosion, upland/hillslope erosion, and sediment from road crossings. The Lower Clark Fork tributaries sediment TMDLs indicate that reductions in sediment loads ranging from 28% to 43% will result in meeting the water quality restoration goals.

Recommended strategies for achieving the pollutant reduction goals of the Lower Clark Fork Tributaries TMDLs are also presented in this plan. They include best management practices (BMPs) for agriculture, timber harvest, and roads, as well as expanding riparian buffer areas and using other land, soil, and water conservation practices that improve the condition of stream channels and associated riparian vegetation.

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, the TMDL and associated information within this document will be used by a local watershed group and/or other watershed stakeholders as a tool to help guide and prioritize local water quality improvement activities. These improvement activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

It is recognized that a flexible and adaptive approach to most TMDL implementation activities may become necessary as more knowledge is gained through implementation and future monitoring. The plan includes an effectiveness monitoring strategy that is designed to track future progress towards meeting TMDL objectives and goals, and to help refine the plan during its implementation.

Table E-1. Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Lower Clark Fork TPA for Which TMDLs Were Completed in 2010.

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Bull River, the North Fork to the mouth (Cabinet Gorge Reservoir)	MT76N003_040	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Dry Creek, headwaters to the mouth (Bull River) T28N, R33W	MT76N003_180	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Marten Creek, headwaters to the mouth (Noxon Reservoir)	MT76N003_090	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Swamp Creek, Cabinet Mountains Wilderness boundary to the mouth (Noxon Reservoir)	MT76N003_140	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery*
White Pine Creek, headwaters to the mouth (Beaver Creek)	MT76N003_120	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery

* Swamp Creek was not listed on the 303d List for impairment however data suggests that sediment impairment may exist, and impaired uses are similar to other impaired streams in the TPA.

1.0 INTRODUCTION

1.1 BACKGROUND

This document, *The Lower Clark Fork Tributaries Sediment TMDLs and Framework Watershed Water Quality Improvement Plan*, describes the Montana Department of Environmental Quality's present understanding of sediment related water quality problems in rivers and streams of the Lower Clark Fork Tributaries TMDL Planning Area (TPA) and presents a general framework for resolving them. The Lower Clark Fork TPA encompasses the Clark Fork watershed from its confluence with Prospect Creek near Thompson Falls to the Montana-Idaho border; however this document focuses only on sediment TMDLs for Clark Fork tributaries, and excludes the Clark Fork River. **Figure A-1 found in Appendix A** shows a map of waterbodies in the TPA with sediment pollutant listings addressed in this document. Pollutants affecting the Clark Fork River and other pollutants in Lower Clark Fork tributaries will be addressed in future documents.

Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act, in 1972. The goal of this act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Clean Water Act requires each state to set water quality standards to protect designated beneficial water uses and to monitor the attainment of those uses. Fish and aquatic life, wildlife, recreation, agriculture, industrial, and drinking water are all types of beneficial uses designated in Montana. Streams and lakes (also referred to as waterbodies) not meeting the established standards are called *impaired waters*, and those not expected to meet the standards are called *threatened waters*.

The waterbodies with their associated impairment and threatened causes are identified within a biennial integrated water quality report developed by DEQ. Impairment causes fall within two main categories: pollutant and pollution. Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of total maximum daily loads (TMDLs) for impaired and threatened waters where a measurable pollutant (for example, sediment, nutrients, metals or temperature) is the cause of the impairment. The waterbody segments with pollutant impairment causes in need of TMDL development are contained within the 303(d) List portion of the State's integrated water quality report. The integrated report identifies impaired waters by a Montana waterbody segment identification, which is indexed to the National Hydrography Dataset. **Table 1-1** identifies the waterbodies identified as impaired or threatened by pollutants and pollution in the Lower Clark Fork tributaries TPA.

Table 1-1. 2008 Impaired Waterbodies, Impairment Causes, and Impaired Beneficial Uses in the Lower Clark Fork Tributaries TPA.

Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Beaver Creek, headwaters to the mouth (Confluence with the Clark Fork River)	MT76N003_030	Alteration in stream side or littoral vegetation covers	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Bull River, the North Fork to the mouth (Cabinet Gorge Reservoir)	MT76N003_040	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a pollutant*	Aquatic Life, Cold Water Fishery
Dry Creek, headwaters to the mouth (Bull River) T28N, R33W	MT76N003_180	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Graves Creek, headwaters to the mouth (Clark Fork River)	MT76N003_080	Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Marten Creek, headwaters to the mouth (Noxon Reservoir)	MT76N003_090	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a pollutant*	Aquatic Life, Cold Water Fishery
Pilgrim Creek, headwaters to the mouth (Cabinet Gorge Reservoir)	MT76N003_100	Physical substrate habitat alterations	*Not a pollutant*	Aquatic Life, Cold Water Fishery
Rock Creek, headwaters to mouth below the Noxon Dam	MT76N003_190	Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Swamp Creek, Cabinet Mountains Wilderness Boundary to the mouth (Noxon Reservoir)	MT76N003_140	None listed	None listed	Insufficient data to assess
Vermillion River, headwaters to the mouth (Noxon Reservoir)	MT76N003_130	Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
White Pine Creek, headwaters to the mouth (Beaver Creek)	MT76N003_120	Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Temperature, water	*Temperatur e	Aquatic Life, Cold Water Fishery

This document provides TMDLs for those pollutants identified by bold text.
* Temperature TMDL will be developed in a future document.

A TMDL refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. The development of TMDLs and water quality improvement strategies in Montana includes several steps that must be completed for each impaired or threatened waterbody and for each contributing pollutant (or "pollutant/waterbody combination"). These steps include:

1. Characterizing the existing waterbody conditions and comparing these conditions to water quality standards. During this step, measurable target values are set to help evaluate the stream's condition in relation to the applicable standards.
2. Quantifying the magnitude of pollutant contribution from the pollutant sources
3. Determining the TMDL for each pollutant, based on the allowable loading limits (or loading capacity) for each pollutant/waterbody combination.
4. Allocating the total allowable load (TMDL) into individual loads for each source (referred to as the load allocations or waste load allocations).

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

The above four TMDL steps are further defined in **Section 4.0** of this document. Basically, TMDL development for an impaired waterbody is a problem solving exercise. The problem is excess pollutant loading negatively impacting a designated beneficial use. The solution is developed by identifying the total acceptable pollutant load to the waterbody (the TMDL), characterizing all the significant sources contributing to the total pollutant loading, and then identifying where pollutant loading reductions should be applied to one or more sources to achieve the acceptable load.

1.2 WATER QUALITY IMPAIRMENTS AND TMDLS ADDRESSED BY THIS PLAN

As shown by **Table 1-1**, sediment in the predominant TMDL pollutant category in the Lower Clark Fork Tributaries TPA. For each impairment cause, the impaired beneficial uses are also identified and in the Lower Clark Fork include aquatic life and cold water fisheries. TMDL development for each pollutant category will follow a similar process as reflected by the organization of this document and discussed further in **Section 1.3** below.

In addition to those TMDLs identified in **Table 1-1**, data reviewed during this project justified the further development of sediment TMDLs for Swamp Creek, despite the fact that it is not currently listed for sediment impairment on the 2008 303d List. In total, this document addresses 5 sediment TMDLs for the Lower Clark Fork Tributaries TPA.

TMDLs are not required for impairment causes that are not pollutants, and in general, those streams listed solely for habitat alteration causes have not been investigated for TMDL development within the context of this document. However, the sediment targets, pollutant reduction strategies, and restoration principles described herein do apply throughout the TPA and are encouraged to be considered regardless of TMDL status and current water quality condition. Streams listed for impairment causes that are not pollutants are described in **Section 6.0** – **Other Problems and Concerns**.

1.3 DOCUMENT LAYOUT

The main body of the document provides a summary of the TMDL components. Additional technical details of these components are contained in the appendices of this report. In addition to this introductory section which includes the brief TMDL background and identification of TMDLs developed, this document has been organized into the following sections:

Section 2.0 - Lower Clark Fork Watershed Description:
Description of the physical and social characteristics of the watershed.

Section 3.0 - Montana Water Quality Standards:
Discusses the water quality standards that apply to the Lower Clark Fork watershed.

Section 4.0 - Description of TMDL Components:
Defines the components of a TMDL and the process by which they are developed.

Section 5.0 - Sediment TMDL Components, sequentially:
Discusses the pollutant category's impact to beneficial uses, the existing water quality conditions and the developed water quality targets, the quantified pollutant contributions from the identified sources, the determined TMDL, and the allocations.

Section 6.0 - Other Problems/Concerns:
Describes other problems or issues that may potentially be contributing to water quality impairment and how the TMDLs in the plan may address some of these concerns. This section also provides recommendations for addressing these problems.

Section 7.0 - Restoration Objectives and Implementation Plan:
Discusses water quality restoration objectives and presents a framework implementation strategy for meeting 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 Lower Clark Fork Tributaries TMDLs and Framework Watershed Water Quality Improvement Plan.

Section 9.0 - Public Participation and Response to Comments:
Describes the involvement of other agencies and stakeholder groups who were involved with the development of the plan, the public participation process used in review of the draft document, and presents and addresses comments received during the public review period.

2.0 LOWER CLARK FORK WATERSHED DESCRIPTION

This section of the Lower Clark Fork Tributaries TMDL and water quality restoration plan provides general background information about the watershed, and sets the stage for a later discussion of water quality problems, and the underlying historical, current and possible future causes of impairment. It is designed to put the subject waterbodies into context within the larger watershed. The characterization establishes a context for impaired waters, as background for total maximum daily load (TMDL) planning.

The Montana Department of Environmental Quality (DEQ) has identified 5 waterbodies for TMDL development within the Lower Clark Fork River watershed: Bull River, Dry Creek, Marten Creek, Swamp Creek, and White Pine Creek. The impairment listings are detailed in DEQ's Integrated 305(b)/303(d) Water Quality Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, 2009), and information pertaining to the current condition of these streams is located in **Section 5.0**. Impairment listings are summarized in **Section 1.0**.

2.1 PHYSICAL CHARACTERISTICS

2.1.1 Location

The Lower Clark Fork Tributaries TMDL Planning Area (LCFT-TPA) is located in northwest Montana. The planning area encompasses approximately 738 square miles (**Table 2-1**) and includes all tributaries to the Lower Clark Fork River from the mouth of Prospect Creek near Thompson Falls, Montana, downstream to the Idaho-Montana state border (**Figure A-1**). The LCFT-TPA does not include the Lower Clark Fork River channel. Lower Clark Fork tributaries originate in the Cabinet Mountains to the northeast and the Coeur d'Alene Mountains to the southwest. Located entirely within Sanders County, Montana, the LCFT-TPA includes portions of two national forests- the Lolo and Kootenai National Forests, and over half of the Cabinet Mountain Wilderness Area. The Clark Fork River is dammed twice in the LCFT-TPA, forming Cabinet Gorge Reservoir near the Montana-Idaho border and Noxon Reservoir several miles upstream.

Table 2-1. Drainage areas of the Lower Clark Fork Watershed TMDL Planning Area subwatersheds.

Subwatershed	Drainage Area (Square Miles)	Percent of TMDL Planning Area
Beaver Creek✧	90.5	12.3%
Bull River*	142.1	19.3%
Elk Creek†	57.6	7.8%
Graves Creek	28.7	3.9%
Marten Creek	46.1	6.2%
Pilgrim Creek	28.7	3.9%
Rock Creek	33.1	4.6%
Swamp Creek	35.8	4.9%
Vermilion River	105.9	14.4%
White Pine Creek	31.2	4.2%
All other watersheds	137.5	18.6%
Total	738.1	100%

✧Beaver Creek values do not include White Pine Creek watershed area.
*Dry Creek is included in values reported for the Bull River.
†Elk Creek values reported are for the whole watershed. The Montana 303(d) List definition for Elk Creek is for only that portion of the drainage in Montana.

Twelve tributaries in the LCFT-TPA are on the Montana 303(d) List: Graves Creek, Vermilion River, Swamp Creek, Rock Creek, Bull River, Dry Creek, Elk Creek, Pilgrim Creek, Marten Creek, White Pine Creek, and Beaver Creek; although only Bull River, Dry Creek, Marten Creek, and White Pine Creek are currently listed with Sediment as a cause for impairment (**Figure A-1**). In general, watershed characteristics throughout **Section 2.0** are stratified by the Montana 303(d) List of drainage boundaries with two exceptions: 1) Dry Creek, a tributary to the Bull River, is included in the values reported for the Bull River watershed. 2) Elk Creek watershed characteristics are reported for the entire watershed rather than only that portion of the drainage within Montana borders. In addition to these particulars, the Beaver Creek watershed is presented as two parts: White Pine Creek and Beaver Creek. White Pine Creek is the only tributary to Beaver Creek known to be inhabited by bull trout, Salvelinus confluentus, a federally listed threatened species (United States Department of Interior, Fish and Wildlife Service, 1998). Therefore, the White Pine Creek drainage has been separated from Beaver Creek for the purpose of presenting watershed information. Data specific to any 303(d) listed waterbody will be reported as necessary in the following sections.

2.1.2 Topography

Figure A-2 displays topographic relief and the distribution of elevations in the Lower Clark Fork Watershed TMDL Planning Area. Elevations in the LCFT-TPA average 4,270 feet and range from 2,170 feet to 8,690 feet (GEI Consultants, Inc., 2005). Tributaries within the TMDL planning area are characterized by a high percentage of steep terrain in their headwaters and mid-drainages. In the lower drainages, morphology transitions to low gradient alluvial valleys or alluvial fans as the tributaries flow into the Lower Clark Fork River or Noxon Rapids and Cabinet Gorge reservoirs.

2.1.3 Geology

The majority of the LCFT-TPA consists of metasedimentary rock, part of a series known as the Belt supergroup (U.S. Geological Survey, 1955). Deposited over 600 million years ago, rock formations of the Belt series consist generally of shale, sandstone and limestone layers that were deposited by shallow intercontinental seas and lightly metamorphosed during subsequent uplifting processes (GEI Consultants, Inc., 2005). **Figure A-3** displays surface geology of the LCFT-TPA, which includes Belt rocks, alluvial deposits, portions of the Idaho batholith, and isolated deposits from Glacial Lake Missoula. The Vermilion River and Cabinet Mountain Range are known to contain gold, silver and copper deposits.

Glacial Lake Missoula deposits date to the Pleistocene period, between 1.6 million and 10,000 years ago. According to flood deposits in Idaho, Oregon and Washington, the Purcell lobe of the Cordilleran ice sheet dammed the Clark Fork River near the Idaho-Montana border between 40-70 times over approximately 10,000 years (GEI Consultants, Inc., 2005). The ice dams were breached periodically by Lake Missoula, producing large magnitude catastrophic floods. These floods scoured the landscape of the Lower Clark Fork watershed, removing topsoil and exposing bedrock.

Continual advance and retreat of glaciers, in conjunction with the floods of Lake Missoula, have resulted in the shallow soils, compacted glacial tills, fine lacustrine deposits, and highly dissected/high stream density characteristics of Lower Clark Fork tributaries today (GEI Consultants, Inc., 2005). Large glacial till deposits, deep alluvial deposits and shallow soil depths effect perennial flows of Lower Clark Fork tributaries. Intermittent flows, in addition to waterfalls or other geological knick points, act as natural fish barriers in several 303(d) listed streams including Vermilion River, Graves Creek and Rock Creek (GEI Consultants, Inc., 2005).

Detailed Soil Survey Geographic (SSURGO) data are not available for the entire Lower Clark Fork Watershed (Natural Resources Conservation Service, 1995). Two SSURGO scale soil surveys, one each in Lincoln and Sanders Counties, cover the Clark Fork River Basin and most private land areas in the lower watersheds of tributaries to the Lower Clark Fork River. The county soil surveys do not, however, extend to the upper watersheds of several tributaries in the Lower Clark Fork. State Soil Geographic Data Base (STASTGO) data generalize more detailed (SSURGO) soil survey maps and use data on geology, topography, vegetation, climate and Land Remote Sensing Satellite (LANDSAT) images to assemble probable soil classifications for areas lacking SSURGO data (Natural Resource Information System, 2003).

The NRCS recommends using either SSURGO or STATSGO data, but not both, due to the incompatibility of the databases (Natural Resources Conservation Service, 1994). Therefore, soil characteristics presented in the watershed characterization are based on STATSGO data for the sake of continuity.

The Universal Soil Loss Equation (USLE) K-factor is a measure of a soil's inherent susceptibility to erosion by rainfall and runoff. Values of K range from 0 to 1 with higher numbers indicative of greater erodibility. The distribution of K values in the LCFT-TPA can be found in **Table 2-2** below. Almost 77 percent of the Lower Clark Fork TMDL Planning Area has a soil erosion factor between 0.2 and 0.5, which is considered moderate susceptibility to erosion. Soils more resistant to surface erosion (K-factor less than 0.20) constitute 21.6 percent of the LCFT-TPA and soils with high susceptibility to erosion comprise approximately 1.4 percent. **Figure A-4** displays the spatial distribution of K values throughout the Lower Clark Fork watershed.

Table 2-2. Distribution of soil K-factor values in the Lower Clark Fork TMDL planning area (square miles). Blank cells indicate 0 value.

Subwatershed	0.00 – 0.09	0.10 – 0.19	0.20 – 0.29	0.30 – 0.39	0.40 – 0.49	0.50 – 0.59	Total
Beaver Creek✧	---	5.8	32.7	48.0	3.7	---	90.2
Bull River*	---	64.5	7.5	70.1	0.1	---	142.1
Elk Creek†	---	11.7	12.9	19.0	---	8.1	51.7
Graves Creek	---	4.1	6.1	18.5	---	---	28.7
Marten Creek	---	5.9	23.4	16.8	---	---	46.1
Pilgrim Creek	---	3.8	21.2	3.0	0.8	---	28.7
Rock Creek	---	17.6	---	14.1	1.4	---	33.1
Swamp Creek	---	21.0	6.8	5.0	3.0	---	35.8
Vermilion River	---	0.3	34.0	71.7	---	---	105.9
White Pine Creek	---	2.1	10.3	18.8	---	---	31.2
All other watersheds	---	21.2	50.6	58.7	5.0	2.1	137.6
Total	---	158.0	205.4	343.6	13.9	10.2	731.1
Percent of TMDL Planning Area	---	21.6	28.1	47.0	1.9	1.4	100%

✧Beaver Creek values do not include White Pine Creek watershed area.
*Dry Creek is included in values reported for the Bull River.
†Elk Creek values reported are for the whole watershed.

2.1.4 Hydrology and Hydrography

The U.S. Geological Survey (USGS) has maintained seven gauging stations within the Lower Clark Fork periodically throughout the last 30 years. Five of the gauging stations are located on tributaries to the Lower Clark Fork River and two monitor discharge of the Lower Clark Fork River. **Table 2-3** summarizes the data and periods of record for Lower Clark Fork gauging stations. With the exception of two gauging stations on the main stem of the Lower Clark Fork River, there are no stream flow data currently being collected by the USGS within the TMDL planning area. The nearest gauge for which real-time daily discharge is available is Prospect Creek near Thompson Falls, Montana, approximately one-third of a mile upstream of the LCFT-TPA boundary.

Table 2-3. USGS stream gauges in the LCR-TPA
(U.S. Geological Survey, 2008)

Station Number	Station Name	Drainage Area (Square Miles)	Peak Streamflow Period of Record (Calendar Year)	Daily Streamflow Period of Record (Calendar Year)
12391000	Clark Fork River at Thompson Falls, MT	21,113 mi2		1952 – 1959
12391100	White Pine Creek near Trout Creek, MT	8.75 mi2	1974 – 1984	
12391200	Canyon Creek near Trout Creek, MT	8.64 mi2	1972 – 1991	
12391300	Noxon Rapids Reservoir near Noxon, MT	21,833mi2	1959 – Present	1959 - Present
12391400	Clark Fork River below Noxon Rapids Dam	21,833 mi2	1960 – Present	1960 – Present
12391430	Skeleton Creek at Noxon, MT	2.1 mi2	1972 – 1984	
12391525	Snake Creek near Noxon, MT	3.11 mi2	1972 – 1984	
12391550	Bull River near Noxon MT	139 mi2	1973 - 1984	1972 – 1982

The USGS has average daily discharge records in only one Montana 303(d) listed stream in the LCFT-TPA, the Bull River**. Figure 2-1** illustrates a hydrograph for the Bull River gauge and depicts the seasonality of peak flows in the Lower Clark Fork region (U.S. Geological Survey, 2008). During the winter months, the hydrograph rises and falls and various precipitation, rain-on-snow, and snowmelt events increase flows intermittently. In late March/early April, the hydrograph begins to rise as temperature increases causing rapid snowmelt runoff. Stream flows start to taper off in June when warm dry air moves in and the snow pack is depleted. By August, the flows reach their lowest, running near base level for a couple of months through late summer and early fall.

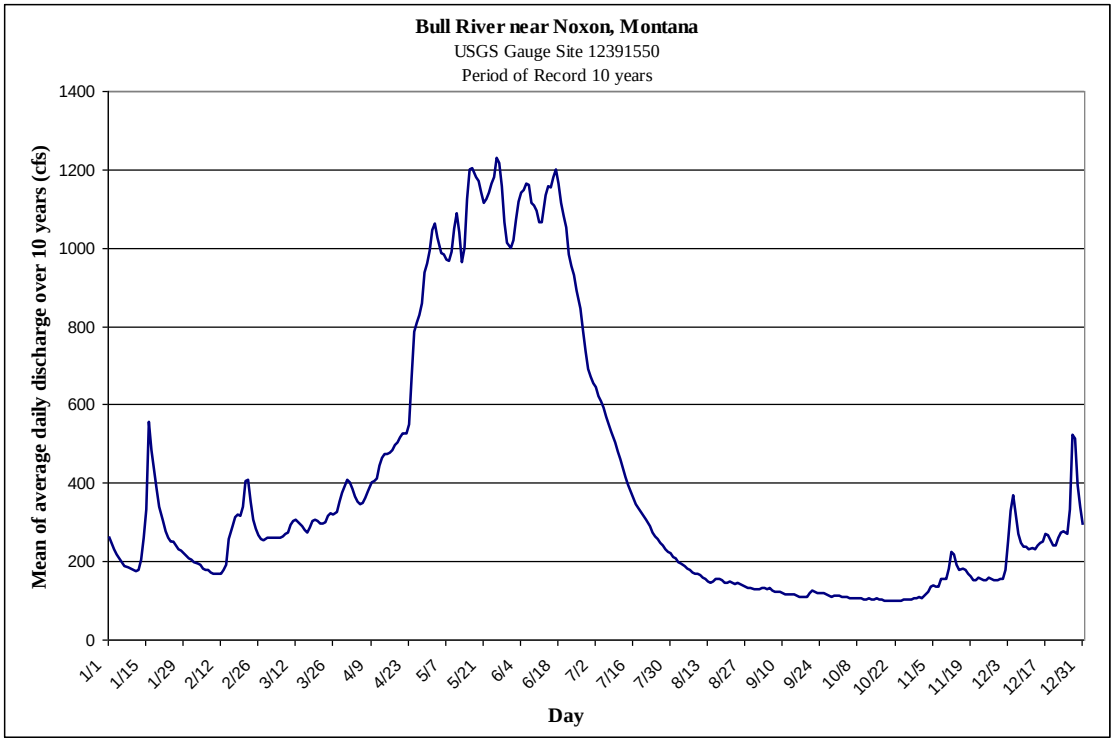


Figure 2-1. The hydrograph for the USGS stream gage stationed on the Bull River near Noxon, Montana displays the mean, in cubic feet per second, of mean daily discharge over a period of 10 years.

Table 2-4 presents predicted flood frequencies based on annual peak discharges through 1998 in White Pine Creek and the Bull River. The USGS stream gage in the Bull River is approximately 1.3 miles upstream of the mouth, representing 139 square miles of the 142 square mile watershed. Flood frequencies based on the Bull River gage data can be assumed to closely represent flows for the entire watershed area. The White Pine Creek Gage is approximately 9 stream miles upstream of the mouth and measures only 8.75 square miles of the 31.2 square mile watershed. Data and calculations based on the White Pine gage do not represent flows for the entire watershed, rather the gage provides information for less than one third of the drainage basin.

Table 2-4. The flood frequencies for White Pine Creek and Bull River USGS gauging stations.
(U.S. Geological Survey, 2008).

Recurrence Interval (Years)	Discharge measured from peak flow record (cfs)	
	White Pine Creek #12391100	Bull River #12391550
Q1.25	137	1,530
Q2	212	2,100
Q5	340	2,900
Q10	442	3,340
Q25	591	4,120
Q50	717	4,630
Q100	858	5,160

For the greater part of the past two decades, the LCFT-TPA has experienced regional drought and below average precipitation, although recently 'wet' years have been recorded in 2008 and 2009 (United

States Geological Survey, 2010). Most notable periods of drought have been from 1992-1994 and 2000-2005. Both 1996 and 1997 were above average precipitation years (United States Geological Survey, 2010). In 1997, rain-on-snow events quickly released water in storage at higher elevations causing flood level flows throughout the Lower Clark Fork region and most of Montana.

The hydrography of tributaries in the LCFT-TPA is approximately a 2:1 ratio of intermittent to perennial channel lengths (**Table 2-5**). Intermittent flows are most likely the result of inherent factors such as climate, geology, and historical geomorphic processes (i.e. glaciations and catastrophic flooding events). With the exception of lower gradient channel sections in Beaver, Elk, Swamp and Trout Creeks, very little surface water is diverted for irrigation (see **Section 2.3.4** for assessment of water use in the LCFT-TPA). The timing, length, and location of intermittent stretches of stream have a direct impact on fisheries abundance throughout the Lower Clark Fork basin (see **Section 2.2.2**).

Table 2-5. Length of perennial and intermittent streams in the Lower Clark Fork TMDL Planning Area* (United States Department of Interior, Geological Survey, 2006)

Flow Regime	Channel Length (Miles)
Perennial	482.4
Intermittent	984.5
Canals, Ditches, or Artificial Pathways	No Designation

* Calculation does not include portion of Elk Creek drainage in the State of Idaho.

2.1.5 Stream Morphology

As part of an effort to consolidate stream channel data, a GIS reach break layer based on stream morphology was created by River Design Group in 2005. Data in this layer came from multiple sources including 1995 USGS aerial imagery assessment, topographic and spatial analysis, incorporation of data from previous studies (Washington Water Power Company, 1996); (Watershed Consulting LLC, 1999); (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000); (Land & Water Consulting, 2001a); (Land & Water Consulting, 2001b); (U.S. Department of Agriculture, Forest Service and River Design Group, 2004); (River Design Group and U.S. Department of Agriculture, Forest Service, Kootenai National Forest, Cabinet Ranger District, 2004); (River Design Group, 2005b); (GEI Consultants, Inc., 2005), and an aerial flight over the study area. The result is a comprehensive summary of Rosgen Level I stream types in the Lower Clark Fork Watershed TMDL Planning Area (**Figure A-5**).

In general, Rosgen type A and B channels dominate the higher elevations and steeper terrain of tributary watersheds (River Design Group, 2005b). At mid-elevations, tributaries typically transition between B, E, C, and D channel types. Rosgen C, E or D types occur primarily in the mid to lower elevations where more gradual terrain is found in the lower watershed areas. Immediately upstream of the mouths of many tributaries in the LCFT-TPA the channel will enter a steep canyon as it drops to the elevation of the Clark Fork River. These short sections are typified by B or F type channels.

Reservoirs in the Clark Fork River formed by the Cabinet Gorge Dam (1952) and Noxon Rapids Dam (1958) have elevated water levels at the mouths of Lower Clark Fork tributaries. An increase in base level elevations can affect an entire drainage profile depending on geology and sedimentation characteristics. To some extent, effects such as upstream migration of channel types, destabilization of banks, and reworking of channel scour and depositional areas can be expected.

2.1.6 Climate

The Lower Clark Fork watershed has an intercontinental/mountain climate, similar to that throughout the Rocky Mountains. Variability in elevation coincides with temperature and precipitation variability. Cumulative data of the subwatersheds in the LCFT-TPA indicates annual precipitation (rain and snowfall) ranges of 21 to 79 inches with an annual mean of 46 inches (GEI Consultants, Inc., 2005). According to monthly precipitation patterns in the towns of Noxon and Thompson Falls, the majority of precipitation falls between November and March as snow. In Noxon, snowfall averages 57 inches per year and rainfall averages 18 inches per year (GEI Consultants, Inc., 2005). Just upstream of the LCFT-TPA, Thompson Falls receives an average rainfall of 20 inches per year. Average monthly temperatures range from 23°F (January) to 64°F (July-August) in Noxon and 27°F (January) to 68°F (July) in Thompson Falls (GEI Consultants, Inc., 2005) (**Table 2-6**).

Table 2-6. Average annual air temperature (°F), average snowfall, and precipitation recorded at four locations in the Lower Clark Fork drainage
(GEI Consultants, Inc., 2005)

Weather Station Location	Years of Record	Average Annual Air Temperature (°F)			Ave. Snowfall (Inches)	Precipitation (Inches)
		Minimum	Mean	Maximum		
Belknap	43	34.7	47	60.6	41.3	23.5
Trout Creek	49	29.4	43	58.5	77.6	30.3
Noxon	104	31.1	45	59.4	57.8	17.9
Heron	87	31.8	44	56.4	85.4	33.7

The Lower Clark Fork drainage is part of a relatively low elevation region that opens onto the Columbia Plateau. As warm, moist air travels from the Pacific Ocean up the Columbia River basin, it can cause occasional rainfalls on existing snowcover, known as rain-on-snow events. The result of rain-on-snow events can be avalanches and rapid flooding. Rain-on-snow events are known to be responsible for some of the largest peak flows ever recorded in some Montana basins (GEI Consultants, Inc., 2005). Since 1974, three of the five largest peak flows on Prospect Creek (Jan. 1, 1974- 5,490 cfs; Feb. 9, 1996- 5,160 cfs; Dec. 26, 1980- 2,960 cfs) occurred between December and February, and were likely rain-on-snow events (United States Geological Survey, 2010). These events appear to occur on a near decadal timeframe on average.

2.2 ECOLOGICAL PARAMETERS

2.2.1 Vegetation

The Gap Analysis Program, sponsored and coordinated by the USGS Biological Resources Division (BRD), is a national- and state-level effort to provide regional assessments of the conservation status of native vertebrate species and natural land cover types (Wildlife Spatial Analysis Lab, 1998). The Montana GAP Analysis was completed in 1998 and has since been updated and standardized to enhance continuity throughout the state. **Table 2-7** summarizes vegetation and natural land cover within the Lower Clark Fork TMDL Planning Area.

Table 2-7. Vegetation classification (GAP) within the LCFT-TPA
(Wildlife Spatial Analysis Lab, 1998). Blank cells indicate a value less than 0.05 units.

Description	Acres	Square Miles	% of LCFT-TPA
Urban or Developed Lands	4	---	---
Low/Moderate Cover Grasslands	3,837	6.0	0.8
Moderate/High Cover Grasslands	1,289	2.0	0.3

Table 2-7. Vegetation classification (GAP) within the LCFT-TPA
(Wildlife Spatial Analysis Lab, 1998). Blank cells indicate a value less than 0.05 units.

Description	Acres	Square Miles	% of LCFT-TPA
Montane Parklands and Subalpine Meadows	4,063	6.3	0.9
Mixed Mesic Shrubs	30,796	48.1	6.6
Mixed Broadleaf Forest	516	0.8	0.1
Lodgepole Pine	23,965	37.4	5.1
Ponderosa Pine	13,232	20.7	2.8
Grand Fir	4,924	7.7	1.1
Western Red Cedar	2,784	4.4	0.6
Western Hemlock	23,632	36.9	5.0
Douglas-fir	50,617	79.1	10.8
Western Larch	8,603	13.4	1.8
Douglas-fir/Lodgepole Pine	8,615	13.5	1.8
Mixed Whitebark Pine Forest	2,730	4.3	0.6
Mixed Subalpine Forest	52,575	82.1	11.2
Mixed Mesic Forest	191,974	300.0	40.9
Mixed Xeric Forest	11,659	18.2	2.5
Mixed Broadleaf and Conifer Forest	2,428	3.8	0.5
Standing Burnt Forest	268	0.4	0.1
Water	386	0.6	0.1
Conifer Riparian	6,595	10.3	1.4
Broadleaf Riparian	300	0.5	0.1
Mixed Broadleaf and Conifer Riparian	242	0.4	0.1
Graminoid and Forb Riparian	164	0.3	---
Shrub Riparian	2,408	3.8	0.5
Mixed Riparian	4,115	6.4	0.9
Rocky Mountain Juniper	13,276	20.7	2.8
Mixed Barren Sites	2,706	4.2	0.6
Alpine Meadows	136	0.2	---
Total	468,840	732.6	100.0

Non-native plants such as spotted knapweed, reed canary grass, St. John's Wort and dalmatian toadflax are known to exist in the LCFT-TPA (GEI Consultants, Inc., 2005; Liermann, Brad, personal communication 2006b). Spotted knapweed grows well in shallow or dry soils, disturbed ground, and upland or riparian areas. Knapweed is often observed on gravel bars and steep channel banks where native plants take longer to become established. Reed canary grass out-competes native riparian species, decreasing species diversity, riparian and stream shade. Non-native plants promote homogeneous upland and riparian zones that may have increased transpiration and/or erosion rates.

2.2.2 Aquatic Life – Cold Water Fish

A recent study of fisheries and habitat in the Lower Clark Fork basin indicates the presence of several native and non-native fish species (**Figure A-6**). Native species known to occur in Lower Clark Fork tributaries include bull trout, westslope cutthroat trout, mountain whitefish, northern pikeminnow, redside shiner, longnose dace, peamouth, suckers, and sculpins (GEI Consultants, Inc., 2005). Nonnative species of concern include brook trout, brown trout and rainbow trout. **Table 2-8** identifies the presence of key native and non-native fish species in 303(d) listed tributaries of the LCFT-TPA.

Table 2-8. Known fish presence in subwatersheds of the Lower Clark Fork Watershed TMDL Planning Area
(GEI Consultants, Inc., 2005).

Subwatersheds	Native Fish Species				Non-native Fish Species		
	Bull Trout	Westslope Cutthroat Trout	Mountain Whitefish	Other fish species*	Brook Trout	Brown Trout	Rainbow Trout
Beaver Creek	x	x	x	x	x	x	x
Bull River	x	x	x	x			
Elk Creek	x		x		x	x	
Graves Creek	x	x	x		x	x	x
Marten Creek	x	x			x	x	
Pilgrim Creek	x	x		x	x	x	x
Rock Creek	x	x			x		x
Swamp Creek	x	x	x	x	x	x	
Vermilion River	x	x	x	x	x	x	x
White Pine Creek	x	x	x	x	x	x	x
All Other Watersheds	x	x	x	x	x	x	x

Bull trout, a federally listed threatened species (United States Department of Interior, Fish and Wildlife Service, 1998), and westslope cutthroat trout recognized by the State of Montana as a Species of Special Concern (Roedel, unpublished), are less numerous today than they were historically in the Lower Clark Fork River system (GEI Consultants, Inc., 2005).

There are several threats to beneficial use support of cold water fisheries (see **Table 2-15**). These include, but are not limited to human land management, presence of non-native fish and vegetation species, and various natural limiting factors (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000; GEI Consultants, Inc., 2005).

Geologic fish passage barriers and intermittent or insufficient channel flows are a barrier to fish movement and spawning activities. A recent assessment of habitat in the Lower Clark Fork basin found approximately 82 miles of stream with detrimentally low flows in streams used by bull trout, westslope cutthroat trout or mountain whitefish (GEI Consultants, Inc., 2005).

2.2.3 Fires

Wild fire has significantly affected natural land cover, runoff rates, and soil erosion in the Lower Clark Fork Watershed. Charred old growth cedar stumps and abundant instream bedload suggest the continued influence of the historic 1889 and 1910 fires, and floods of 1916 that are believed to have altered the stream corridors in the Lower Clark Fork Watershed (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000). **Table 2-9** summarizes wildfire activity in the Lower Clark Fork Watershed TMDL Planning Area.

Table 2-9. Fire history in the LCFT-TPA
(GEI Consultants, Inc., 2005). Blank cells indicate no data available.

Subwatershed		% Watershed Burned Pre-1910	% Watershed Burned 1910	% Watershed Burned Post-1910
303(d) listed	Beaver Creek	23	37	< 0.5
	Bull River	---	8	3
	Elk Creek	---	4	10
	Graves Creek	---	5	0
	Marten Creek	---	24	10
	Pilgrim Creek	---	37	8
	Rock Creek	53	2	5
	Swamp Creek	---	26	1
	Vermilion River	---	20	5
	White Pine Creek	---	16	0
All other tributaries	East Fork Blue Creek	100	41	---
	Dead Horse Creek	99	4	---
	McKay Creek	8	---	15
	Stevens Creek	---	20	---
	Tuscor Creek	---	17	---
	Deep Creek	---	25	2
	Mosquito Creek	---	13	0
	Squaw Creek	---	3	23
	Trout Creek	---	26	5

2.3 CULTURAL PARAMETERS

2.3.1 Population

As of the 2000 Montana census, the population of Sanders County totaled 10,227 people (Natural Resource Information System, 2000; Census and Economic Information Center, 2002). The largest town in the county, Thompson Falls (population 1,319), is southeast of the Lower Clark Fork TMDL Planning Area.

The majority of residences, businesses, and populace are in the low elevation/lower gradient valleys of the LCFT-TPA and along the Lower Clark Fork River corridor (**Figure A-7**). The concentration of population within lower drainage areas of the LCFT-TPA is in stark contrast to virtually uninhabited expanses of land in the middle and upper watershed areas. Approximately 80% of the Lower Clark Fork TMDL Planning Area has less than 2 persons per square mile (**Table 2-10**).

Table 2-10. Distribution of 2000 population density in the Lower Clark Fork Watershed TMDL Planning Area
(Census and Economic Information Center, 2002).*

Population Density (persons / square mile)	2000 (Square Miles)	2000 Percent of LCFT-TPA
0 – 1	327.1	44.7
1 – 2	261.5	35.7
2 – 5	68.0	9.3
5 – 10	34.6	4.7
10 – 25	30.1	4.1
25 – 50	7.2	1.0
50 – 100	2.6	0.4
100 – 150	1.0	0.1
150 – 250	0.3	< 0.05
250 – 350	0.1	< 0.05
Total	732.4	100.0

* Values presented do not include that portion of Elk Creek in the State of Idaho.

Between 1990 and 2000, population in the Lower Clark Fork TMDL Planning Area and the Clark Fork River valley increased 12%, rising from 439 to 490 individuals. In contrast, population increased 21% in the LCFT-TPA tributaries alone, rising from 227 to 274 individuals. While there is an overall increase in population in the Lower Clark Fork Watershed, census data indicates that a greater portion of that growth is occurring in the tributaries to the Clark Fork River than in the main valley.

2.3.2 Land Ownership

The majority of land in the Lower Clark Fork TMDL Planning Area is managed by the U.S. Forest Service (Lolo and Kootenai National Forests) comprising 89.3% or 660 square miles of mostly steep, higher elevation uplands (Natural Resource Information System, 2005). Private lands account for 9.7% (71 square miles) and are located predominantly in the lower watershed areas where wide, low-gradient valleys are conducive to agriculture and development. The Plum Creek Timber Company owns 0.6% (4.6 square miles) of the LCFT-TPA, most of which forms a "checkerboard" pattern with National Forest Lands in the upper Vermillion River drainage. Montana State Trust Lands comprise the least proportion of the basin, accounting for only 0.4% (2.9 square miles) interspersed evenly among private and National Forest lands. For the distribution of land ownership within each 303(d) listed tributary see **Table 2-11** and **Figure A-8**.

Table 2-11. Distribution of land ownership in the Lower Clark Fork TMDL Planning Area
(GEI Consultants, Inc., 2005).

Subwatershed	Percent U.S. Forest Service (USFS)	Percent Private Lands	Percent Plum Creek Timber Company	Percent Montana State Trust (DNRC)
Beaver Creek✧	81.4	17.9	0	0.7
Bull River*	94.0	4.9	1.1	0
Elk Creek†	80.9	18.6	0	0.5
Graves Creek	95.2	4.8	0	0
Marten Creek	99.5	0.5	0	0
Pilgrim Creek	90.7	8.9	0	0.4
Rock Creek	93.0	6.6	0	0.4

Table 2-11. Distribution of land ownership in the Lower Clark Fork TMDL Planning Area
(GEI Consultants, Inc., 2005).

Subwatershed	Percent U.S. Forest Service (USFS)	Percent Private Lands	Percent Plum Creek Timber Company	Percent Montana State Trust (DNRC)
Swamp Creek	87.6	12.4	0	0
Vermilion River	85.4	11.8	2.8	0
White Pine Creek	96.8	3.2	0	0
All other watersheds	89.1	9.7	0	1.2
Total	89.3	9.7	0.6	0.4

✧Beaver Creek values do not include White Pine Creek watershed area.
*Dry Creek is included in values reported for the Bull River.
† Elk Creek values reported are for the whole watershed.

Historically, U.S. Forest Service lands were harvested for timber and minerals. Many roads were built in conjunction with these activities. Currently, forest lands in the LCFT-TPA are used for recreational purposes as well as for resource extraction. Most of the historical roads system is maintained to some degree to supply access for recreation, resource extraction and fire suppression. Other roads are either decommissioned or left in place. Private lands tend to be a mix of agricultural and residential uses. Several tracts of land that were historically grazed or farmed are now subdivided into smaller parcels and have been developed into residential units. Those lands and roads owned by the Plum Creek Timber Co. are maintained for timber harvest as are, generally, the lands managed by the State of Montana's Department of Natural Resources.

2.3.3 Land Cover

In 1992, the USGS and the U.S. Environmental Protection Agency (USEPA) published the National Land Cover Dataset (NLCD), an up-to-date source of intermediate scale land cover data. The information is based primarily on 30 meter resolution Landsat thematic mapper data and provides a coarse outline of land cover and land uses within the conterminous United States (**Figure A-9**). **Table 2-12** presents land uses/land cover in the LCFT-TPA.

Table 2-12. Land uses/land cover in the Lower Clark Fork TMDL Planning Area
(United States Geological Survey, 2000). Blank cells indicate a value of less than 0.05 units.

Land Use / Land Cover	Acres	Square Miles	Percent of LCFT-TPA
Open Water	699	1.1	0.1
Perennial Ice/Snow	122	0.2	---
Low Intensity Residential	1	---	---
Commercial/Industrial/Transportation	382	0.6	0.1
Bare Rock/Sand/Clay	4,588	7.2	1.0
Transitional	4,564	7.0	1.0
Deciduous Forest	584	0.9	0.1
Evergreen Forest	392,534	613.3	83.2
Mixed Forest	2,197	3.4	0.5
Shrubland	29,992	46.9	6.4
Grasslands/Herbaceous	28,902	45.2	6.1
Pasture/Hay	5,792	9.0	1.2
Row Crops	1	---	---
Small Grains	782	0.2	0.2
Fallow	4	---	---

Table 2-12. Land uses/land cover in the Lower Clark Fork TMDL Planning Area
(United States Geological Survey, 2000). Blank cells indicate a value of less than 0.05 units.

Land Use / Land Cover	Acres	Square Miles	Percent of LCFT-TPA
Urban/Recreational Grasses	0	---	---
Woody Wetlands	711	1.1	0.2
Emergent Herbaceous Wetlands	29	---	---
Total	471,856	737.3	100

2.3.4 Water Resources

The Lower Clark Fork River Drainage Habitat Problem Assessment (GEI Consultants, Inc., 2005) identified dewatering of Beaver Creek for irrigation as a potential threat to native fisheries. There are several points of surface water diversion in the TMDL Planning Area (see **Figure A-10**) (Montana Department of Fish, Wildlife and Parks, 2003). The majority of diversions are located in White Pine Creek, Big Beaver Creek and Little Beaver Creek. Elk Creek, Pilgrim Creek, Swamp Creek and the Bull River also have several points of diversion along their tributaries and main stem (Montana Department of Natural Resources and Conservation Water Resources Division, 2003). **Table 2-13** summarizes the means of surface water diversion in the LCFT-TPA.

Table 2-13. Distribution and means of diversion for water rights in the LCFT-TPA
(Montana Department of Natural Resources and Conservation Water Resources Division, 2003).

Subwatershed	Dam	Flowing	Headgate	Livestock Watering Direct From Source	Pipeline	Pump	Other ‡	Total Points of Diversion
Beaver Creek✧	6	1	2	17	1	23	5	55
Bull River*	0	5	5	3	9	6	3	31
Elk Creek†	8	0	12	8	1	13	12	54
Graves Creek	1	0	6	3	0	0	17	27
Marten Creek	1	0	0	0	0	1	0	2
Pilgrim Creek	1	0	4	8	0	6	0	19
Rock Creek	0	0	0	0	4	1	2	7
Swamp Creek	4	6	15	2	3	1	2	33
Vermilion River	0	0	0	0	0	1	2	3
White Pine Creek	1	0	2	10	1	2	0	16
All other watersheds	7	18	19	6	1	6	7	64
Total	29	30	65	57	20	60	50	311

✧Beaver Creek values do not include White Pine Creek watershed area.
*Dry Creek is included in values reported for the Bull River.
† Elk Creek values reported are for the whole watershed.
‡Other category includes the following: gravity flow/direct, dike, diversion dam, fueled pump, instream, multiple, other diversion, pit, pump/flood and dike, pump/gravity flow, pump/headgate with ditch or pipeline.

The **Section 7** Consultation Watershed Baseline: Lower Clark Fork River, Montana report prepared by USFS- Kootenai National Forest in 2000 cites a water right held by the Green Mountain Irrigation District that could potentially divert the entire flow of Swamp Creek into their irrigation system at a diversion upstream of Galena Creek. No mention is made as to how often this diversion has occurred in the past (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000). Currently, no tributaries in the Lower Clark Fork Watershed are active municipal water suppliers ((Montana State Library, 2002); (U.S.Environmental Protection Agency, 2006)) or host wastewater permits (Montana

Department of Environmental Quality, 2000). Ground water is the primary source of municipal drinking water for communities in Sanders County and the Lower Clark Fork Watershed.

2.3.5 Recreational Use

Recreational activities take place on public lands in the Lower Clark Fork Watershed year-round, making use of the road network originally built to meet timber and mineral harvest needs. Popular recreational activities include hunting and fishing, foraging (mushrooms and berries), hiking in upper watershed/headwater areas, snowmobiling and ATV use (Liermann, Brad, personal communication 2006a). The distribution of recreational use is likely to mimic the road network, which facilitates access to public lands. Reservoirs in the Clark Fork River corridor are also popular recreational areas in Lower Clark Fork Watershed.

2.3.6 Harvest History

The majority of timber harvest in the Lower Clark Fork TMDL Planning Area occurred during the latter half of the twentieth century (GEI Consultants, Inc., 2005). Small amounts of timber were extracted between 1910 and 1940 in the Vermilion River and Trout Creek watersheds. Harvest activity began to increase during the 1950s, peaking between 1960 and 1990. All tributaries in the LCFT-TPA have experienced some harvest activity (GEI Consultants, Inc., 2005). **Table 2-14** summarizes the distribution of timber harvest in the Lower Clark Fork basin since 1970. In some watersheds, however, the effect of timber harvest activities prior to 1970 could still be impacting existing stream conditions (e.g. Graves Creek harvest from 1967-1975) (River Design Group, 2005a).

Table 2-14. Harvest history in the LCFT-TPA from 1970 to 2000.

Blank cells indicate incomplete data (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000; GEI Consultants, Inc., 2005).

Subwatershed		Percent Harvested Since 1970	Regeneration Harvest (Acres)*
303(d) listed	Beaver Creek	2.9	
	Bull River	5.5	4,671
	Elk Creek	2.9	
	Graves Creek	0	
	Marten Creek	12.1*	3,707
	Pilgrim Creek	7.2*	1,115
	Rock Creek	12.7*	2,484
	Swamp Creek	2.8*	571
	Vermilion River	6.7*	4,376
	White Pine Creek	15.9*	3,073
All other tributaries	East Fork Blue Creek	3.6	
	Dead Horse Creek	7.5	
	McKay Creek	1.1	
	Stevens Creek	5.1	
	Tuscor Creek	4.3	
	Deep Creek	0	
	Mosquito Creek	12	
	Squaw Creek	0.76	
	Trout Creek	0.4	

* Values reported for USFS managed lands and may not reflect total harvest activity in the watershed.

2.3.7 Natural and Anthropogenic Impacts

Several studies have been done that identify land uses and features that affect fish habitat in the Lower Clark Fork TMDL Planning Area. **Table 2-15** summarizes those land uses and features.

Table 2-15. Distribution of impacts that affect fish habitat in the Lower Clark Fork Watershed TMDL Planning Area

(U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000; GEI Consultants, Inc., 2005).

Feature	Subwatersheds										
	Beaver Creek	Bull River	Elk Creek	Graves Creek	Marten Creek	Pilgrim Creek	Rock Creek	Swamp Creek	Vermilion River	White Pine Creek	All Other Watersheds
Dam											x
Presence of non-native fish	x	x	x	x			x	x	x	x	x
Myxobolus cerebralis	x									x	
Noxious weeds in riparian		x	x			x				x	x
Fire	x		x		x	x	x				
Bridge and road construction			x						x	x	
Upland logging	x		x	x		x					x
Riparian logging	x	x		x		x	x		x	x	x
Riparian vegetation removal						x				x	x
Haying in riparian		x				x					
Floodplain modification	x									x	x
Channel modification	x	x				x					x
Streambank modification									x	x	
Seasonally dry	x				x	x	x	x		x	x
Grazing	x	x				x				x	x
Dewatered for irrigation	x										
Development in the watershed		x	x	x	x						
Mining				x					x		x
Anthropogenic Fish Barrier				x		x	x				x
Natural Fish Barrier (i.e. waterfall)				x			x		x		x

3.0 TMDL REGULATORY FRAMEWORK

3.1 TMDL DEVELOPMENT REQUIREMENTS

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify waterbodies within its boundaries that do not meet water quality standards. States track these impaired or threatened waterbodies with a 303(d) List. The 303(d) List for Montana's waterbodies is within Montana's Water Quality Integrated Report. State law identifies that a methodology for determining the impairment status of each waterbody is used for consistency and the actual methodology is identified in **Appendix A** of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2009).

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 water quality standards (Montana Code Annotated 75-5-103)(11). 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: (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 (MCA 75-5-103(31)). State Law and section 303 of the CWA require states to develop TMDLs for impaired or threatened waterbodies.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable water quality standards to be exceeded. TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources, and need to incorporate a margin of safety and consider seasonality. In Montana, TMDL development is often accomplished in the context of an overall water quality plan. The water quality plan includes not only the actual TMDL, but also includes information that can be used to effectively restore beneficial water uses that have only been affected by pollution, such as habitat degradation or flow modification that are not covered by the TMDL program.

To satisfy the Federal Clean Water Act and Montana State Law, TMDLs are developed for each waterbody-pollutant combination identified on the states list of impaired or threatened waters and are often presented within the context of a water quality restoration or protection plan. State Law (MCA 75-5-703)8)) also directs DEQ to "support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for 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. Montana TMDL laws provide a 5-year review process to allow for an adaptive management approach to update the TMDL and water quality restoration plan.

3.2 WATERBODIES AND POLLUTANTS OF CONCERN

Recently, a court ruling and subsequent settlements have obligated the U.S. EPA and the State of Montana to use pollutant/waterbody combinations from the Montana's 1996 List of impaired waters. State and federal guidance indicates that the most recent list be used for determining the need for TMDLs. Sediment pollutants that have appeared on the 2008 list are addressed in the impairment status review, TMDLs, or watershed restoration plans presented in this document. Most pollutants identified on the 2008 list are addressed, however the 2008 temperature listing for White Pine Creek is not addressed at this time due to project budget and time constraints. This listing will be identified in a follow up monitoring strategy and addressed within a timeframe identified in Montana's law (MCA 75-5-703). **Table 3-1** provides a summary of waterbody listings and their beneficial use support status for the 2008 303(d) Lists for the Lower Clark Fork tributaries TPA. Specific probable causes of impairment for each of the impaired waterbodies is found in **Table 1-1,** in **Section 1**.

Table 3-1. Lower Clark Fork impaired waterbody segments and beneficial use support status for which TMDLs were developed

Waterbody & Stream Description	Waterbody #	Use Class	Aquatic Life	Fisheries - Cold	Drinking Water	Primary Contact (Recreation)	Agriculture	Industry
Bull River, the North Fork to the mouth (Cabinet Gorge Reservoir)	MT76N003_040	B-1	P	P	X	F	F	F
Dry Creek, Minnesota Gulch to mouth (German Gulch)	MT76N003_180	B-1	P	P	F	F	F	F
Marten Creek, headwaters to mouth (Clark Fork River)	MT76N003_090	B-1	P	P	X	X	F	F
Swamp Creek, the headwaters to the mouth (Warm Springs Creek)	MT76N003_140	A-1	X	X	X	X	X	X
White Pine Creek, the national forest boundary to the mouth (Clark Fork River)	MT76N003_120	B-1	P	P	F	F	F	F

Legend: **F**= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X**= Not Assessed (Insufficient Credible Data)

Impairment status and impairment list reviews are provided for each of the above waterbodies in **Sections 5.0**.

3.3 APPLICABLE WATER QUALITY STANDARDS

Water quality standards 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 water quality restoration plan, 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**. Sediment is the only pollutant addressed in this Water Quality Restoration Plan. This section provides a summary of the applicable water quality standards for sediment.

3.3.1 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 (WQA) directs the Board of Environmental Review (BER, i.e., the state) 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 (ARM 17.30.607-616), and to adopt standards to protect those uses (ARM 17.30.620-670).

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. All classifications include multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that 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 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 mis-classified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet U.S. EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

All tributaries included in this document have been designated as B-1, except Swamp Creek, which is designated as A-1. A description of Montana's applicable surface water classifications and designated beneficial uses for Lower Clark Fork tributaries are presented in **Table 3-2**.

Table 3-2. Montana Surface Water Classifications and Designated Beneficial Uses Applicable to the Upper Clark Fork Tributaries.

Classification	Designated Uses
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; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply
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

3.3.2 Standards

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

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (Montana Department of Environmental Quality, 2008). 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., life long) exposure by water consumption, 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 that include 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.

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

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface water quality standards. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a 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 list of pollutants addressed in the Lower Clark Fork TPA are summarized below.

Sediment

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

Table 3-3. Applicable Rules for Sediment Related Pollutants.

Rule(s)	Standard
17.30.622(3)	No person may violate the following specific water quality standards for waters classified A-1.
17.30.622(3)(d)	No increase above naturally occurring turbidity or suspended sediment is allowed except as permitted in 75-5-318, MCA.
17.30.622(3)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is five nephelometric turbidity units except as permitted in 75-5-318, MCA.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602(19)	“Naturally occurring” means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(25)	“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.

4.0 DESCRIPTION OF TMDL COMPONENTS

A TMDL is the pollutant loading capacity for a particular waterbody and refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. Therefore, when a TMDL is exceeded, the waterbody will be impaired.

More specifically, a TMDL is the sum of the allowable loading from all sources to the waterbody. These loads are applied to individual sources or categories of sources as a logical method to allocate water quality protection responsibilities and overall loading limits within the contributing watershed(s). The allocated loads are referred to as waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. Natural background loading is considered a type of nonpoint source and therefore represents a specific load allocation. In addition, the TMDL includes a Margin of Safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. The inclusion of a MOS results in less load allocated to one or more WLAs or LAs to help ensure attainment of water quality standards.

TMDLs are expressed by the following equation which incorporates the above components:

$$TMDL = \sum WLA + \sum LA + MOS$$

The allowable pollutant load must ensure that the waterbody being addressed by the TMDL will be able to attain and maintain water quality standards for all applicable seasonal variations in streamflow, and pollutant loading. **Figure 4-1** is a schematic diagram illustrating 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.

The major components that go into TMDL development are target development, source quantification, establishing the total allowable load, and allocating the total allowable load to sources. Although the way a TMDL is expressed may vary by pollutant, these components are common to all TMDLs, regardless of pollutant. Each component is described in further detail below.

The following section of the document (**Sections 5**) describes the analysis of sediment in the Lower Clark Fork Tributaries TPA. **Section 5** includes a discussion on the waterbody segments of concern, how sediment is impacting beneficial uses, the information sources and assessment methods to evaluate stream health and pollutant source contributions, water quality target development along with a comparison of existing conditions to targets, quantification of loading from identified sources, the determination of the allowable loading (TMDL) for each waterbody, and the allocations of the allowable loading to sources.

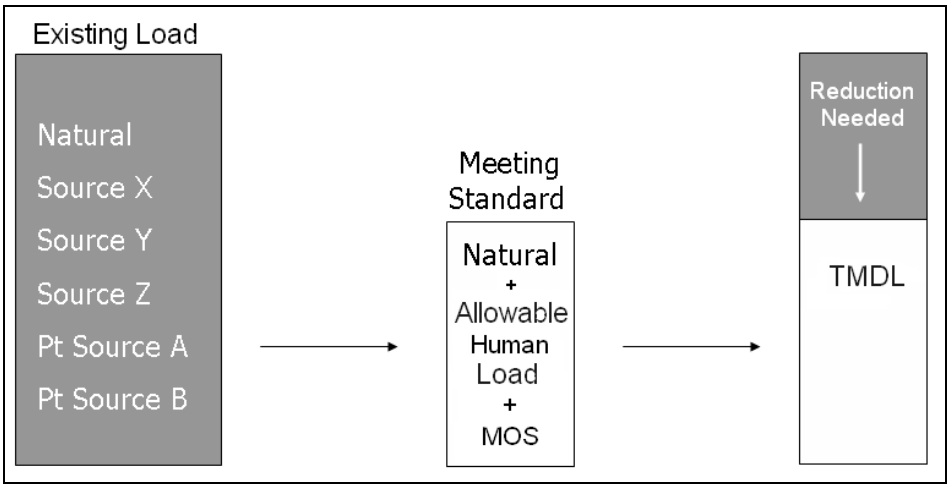


Figure 4-1. Schematic example of TMDL development

4.1 TARGET DEVELOPMENT

Because loading capacity is evaluated in terms of meeting water quality standards, quantitative water quality targets are developed to help assess the condition of the waterbody relative to the applicable standard(s) and to help determine successful TMDL implementation. This document outlines water quality targets for sediment in the Lower Clark Fork Tributaries TPA. TMDL water quality targets help translate the applicable numeric or narrative water quality standards for the pollutant of concern. For pollutants with established numeric water quality standards, the numeric value(s) within the standard(s) are used as TMDL water quality targets. For pollutants with only narrative standards, such as sediment, the water quality targets provide a site-specific interpretation of the narrative standard(s), along with an improved understanding of impairment conditions. Water quality targets typically include a suite of in-stream measures that link directly to the impacted beneficial use(s) and applicable water quality standard(s). The water quality targets help define the desired stream conditions and are used to provide benchmarks to evaluate overall success of restoration activities. By comparing existing stream conditions to target values, there will be 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. Source assessments often have to evaluate the seasonal nature and ultimate fate of the pollutant loading since water quality impacts can vary throughout the year. The source assessment usually helps to further define the extent of the problem by putting human caused loading into context with natural background loading.

A pollutant load is usually quantified for each point source of the pollutant permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Most other pollutant sources, typically referred to as nonpoint sources, are quantified by source categories such as unpaved roads and/or by land uses such as crop production or forestry. These source categories or land uses can be further divided by ownership such as Federal, State, or private. Alternatively, a sub-watersheds or tributaries approach can be used, whereby most or all sources in a sub-watershed or tributary are combined for quantification purposes.

The source assessments are performed at a watershed scale because all potentially significant sources of the water quality problems must be evaluated. The source quantification approaches may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques 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 and sensible time period necessary to comply with the applicable water quality standard(s). Although the concept of allowable daily load is incorporated into the TMDL term, a daily loading period 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 using a time period consistent with the application of the water quality standard(s) and consistent with established approaches to properly characterize, quantify, and manage pollutant sources in the watershed. For example, sediment TMDLs may be expressed as an allowable yearly load whereas the TMDL to address acute toxicity criteria for metals will include a near-instantaneous loading requirement calculated over a time period of one second (based on standard methods for evaluation flow in cubic feet per second).

Where numeric water quality standards exist for a stream, the TMDL or allowable loading, typically represents the allowable concentration multiplied by the flow of water over the time period of interest. This same approach can be applied for situations where a numeric target is developed to interpret a narrative standard and the numeric value is based on an in-stream concentration of the pollutant of concern.

For some narrative standards such as those relating to sediment, there is often a suite of targets based on stream substrate conditions and other similar indicators. In many of these situations, it is difficult to link the desired target values to highly variable and often episodic in-stream loading conditions. In these situations, 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 Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period as discussed above.

4.4 DETERMINING ALLOCATIONS

Once the loading capacity (i.e. TMDL) is determined, that total must be partitioned, or allocated, among the contributing sources. In addition to basic technical and environmental considerations, this step introduces economic, social, and political considerations. The allocations are often determined by quantifying feasible and achievable load reductions associated with the application of reasonable land, soil, and water conservation practices. Reasonable land, soil, and water conservation practices generally include Best Management Practices (BMPs), but additional conservation practices may be required to

achieve compliance with water quality standards and restore beneficial uses. It is important to note that implementation of the TMDL does not conflict with water rights or private property rights. **Figure 4-2** contains a schematic diagram of 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.

Under the current regulatory framework for development of TMDLs, flexibility is allowed in the expression of 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, such as a percent increase in canopy density for temperature TMDLs.

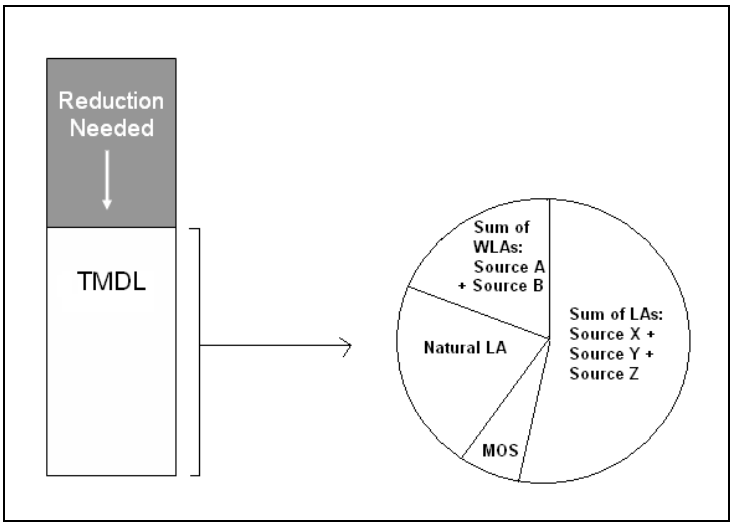


Figure 4-2. Schematic diagram of TMDL and allocations

Incorporating a margin of safety (MOS) is a required component of TMDL development. 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 sustain conditions that will 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 COMPONENTS

This portion of the document focuses on sediment as an identified cause of water quality impairment in the Lower Clark Fork TPA. It describes: 1) the mechanisms by which sediment impair beneficial uses of those streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to sediment impairments in the watershed, 4) the various contributing sources of sediment based on recent data and studies, and 5) the sediment TMDLs and allocations.

The term sediment is used in this document to refer collectively to several closely-related factors associated with the sediment pollutant, including suspended sediment, stream channel geometry that can affect sediment delivery and transport, and sediment deposition on the stream bottom.

5.1 MECHANISMS OF EFFECTS OF EXCESS SEDIMENT TO BENEFICIAL USES

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Streams in particular are dynamic systems that are dependent on a balance between stream flow and sediment input for their natural function. However, human influence may alter or prohibit the ability of a stream to achieve equilibrium between flow and sediment, which in turn may lead to detrimental effects to the proper form and function of the stream, and may change habitat and water quality conditions.

Erosion and sediment transport and deposition are a function of the natural balance between flow and sediment. Regular flooding allows sediment deposition to build floodplain soils and prevents excess scour of the stream channel. Riparian 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 erosion is taking place due to altered channel morphology or reduced riparian vegetation, excess sediment is transported through the channel and may be deposited in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

Increased sediment beyond what is typically present in a naturally occurring condition often has detrimental effects on streams and the aquatic communities living within them. High suspended sediment levels reduce light penetration, which may cause a decline in primary production. As a result, aquatic invertebrate communities may also decline, which may then cause a decline in fish populations. Deposited particles may also obscure sources of food, habitat, hiding places, and nesting sites for invertebrates.

Excess sediment may also impair biological processes of individual aquatic organisms. When present in high levels, sediment may clog the gills of fish and cause other abrasive damage. Abrasion of gill tissues triggers excess mucous secretion, decreased resistance to disease, and a reduction or complete cessation of feeding (Wilber, 1983); (McCabe and Sandretto, 1985); (Newcombe and MacDonald, 1991). High levels of benthic fine sediment can also impair reproductive success of fish. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. An accumulation of benthic fine sediment reduces the flow of water through gravels harboring salmonid eggs, hindering emergence of newly hatched fish, depleting oxygen supply to embryos, and causing metabolic wastes to accumulate around embryos, resulting in higher mortality rates (Armour et al., 1991).

As described in **Section 3**, sediment as a pollutant is addressed via narrative criteria that do not allow for harmful or other undesirable conditions related to increases in sediment above naturally occurring levels. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a waterbody's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental or injurious to beneficial uses.

5.2 STREAM SEGMENTS OF CONCERN

The **Table 5-1** presents streams and stream segments that have been listed for sediment impairment on the 2008 303(d) List.

Table 5-1. Waterbody segments in the Lower Clark Fork TPA with sediment related pollutant and pollution listings on the 2008 303(d) List

Waterbody ID	Stream Segment	2008 Probable Causes of Impairment
MT76N003_040	**BULL RIVER**, the North Fork to the mouth (Cabinet Gorge Reservoir)	**Sedimentation/siltation,** *Physical Substrate Habitat Alterations*
MT76N003_180	**DRY CREEK,** headwaters to the mouth (Bull River) T28N, R33W	**Sedimentation/siltation**
MT76N003_090	**MARTEN CREEK**, headwaters to the mouth (Noxon Reservoir)	**Sedimentation/siltation**, *Physical Substrate Habitat Alterations*
MT76N003_120	**WHITE PINE CREEK**, headwaters to the mouth (Beaver Creek)	**Sedimentation/siltation***, Alteration in stream-side or littoral vegetation covers*

Pollution listings are presented in *italics*

At the time of the 2008 field investigation, two additional Lower Clark Fork TPA streams were included for data collection and analysis as a result of their appearance on earlier 303(d) Impaired Waters Lists or due to pollution listings that are frequently associated with sediment. This inclusion of additional sites within the Lower Clark Fork TPA helped provide the foundation for target development, and give a broader representation of sediment issues throughout the watershed. In the case of Swamp Creek, which at the time of the field effort had not undergone an impairment determination, the data collected helped further characterize the condition in that stream which led to its inclusion in TMDL development. In the case of Elk Creek, a TMDL had been completed in 1997 and significant work has been completed since that time to improve its conditions and address TMDL requirements. In addition to supporting overall target development in the TPA, the inclusion of Elk Creek in the 2008 field effort provides data to local resource managers to evaluate the stream condition since the time of the TMDL. Streams not listed for sediment, but included in this report are listed in **Table 5-2**.

Table 5-2. Additional waterbody segments in the Lower Clark Fork TPA included for TMDL related investigation

Waterbody ID	Stream Segment	Previous Probable Causes of Impairment Listings
MT76N003_140	**SWAMP CREEK,** Cabinet Mountains Wilderness boundary to the mouth (Noxon Reservoir)	*Insufficient information to assess*
MT76N003_060	**ELK CREEK**, headwaters to the mouth (Cabinet Gorge Reservoir)	**Sedimentation/Siltation**

5.3 INFORMATION SOURCES AND ASSESSMENT METHODS

Existing data specifically related to sediment conditions for listed tributaries is mixed in the Lower Clark Fork. Where data may exist, varying methods in data collection between agencies and across the watershed, as well as qualitative assessment rather than quantitative data, make sediment impacts difficult to define and compare throughout the planning area. The main information source used to assess sediment and habitat conditions for the Lower Clark Fork tributaries of interest are from the DEQ 2008 field effort (subsequent report included as **Appendix B**), and where available and applicable, data from land management agencies such as the US Forest Service, US Natural Resource & Conservation Service, Green Mountain Conservation District, and various reports related to the Lower Clark Fork and its tributaries, along with field notes, "windshield surveys" from DEQ personnel, and information contained within DEQ Sufficient Credible Data/Beneficial Use Determination (SCD/BUD) files were used to supplement the 2008 DEQ field data.

5.3.1 DEQ Longitudinal Field Method for Sediment and Habitat Impairment

In the summer of 2008, 22 sites on six streams throughout the Lower Clark Fork TPA were selected for sediment and habitat data collection. (**Appendix C**). Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes: stream order, valley gradient, valley confinement, and ecoregion. These four categories represent the main factors that are not influenced by the presence of human activity, and thereby allow for comparisons among those reaches of the same characteristics. However land management practices as a result of the presence of man may have an impact on the way a stream responds, and because of this, reaches were stratified further based on anthropogenic influence, to allow for the observance of natural versus anthropogenic effects. Reaches were then chosen for assessment to allow for a representation of various reach characteristics and anthropogenic influence.

Sediment and habitat related information that was collected includes: width/depth ratio, entrenchment ratio, riffle cross section, riffle pebble count, riffle grid toss, grid toss in pool tails, pool frequency, residual pool depth, riparian green line, and eroding bank analysis. Detailed methodology and procedure for reach classification and field methods can be found in Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments (DEQ, 2010) and data from the field effort is presented in **Appendix B**.

5.3.2 United States Forest Service – Pacfish/Infish Biological Opinion Effectiveness Monitoring Program (PIBO)

PIBO was initiated in 1998 to provide a consistent framework for monitoring aquatic and riparian resources on most Forest Service and Bureau of Land Management land within the upper Columbia River basin. The goal of PIBO is to implement a monitoring program with the capability of determining whether the aquatic conservation strategies within PACFISH and INFISH (USFS Fisheries management units), or revised land management plans, are effective in maintaining or restoring the structure and function of riparian and aquatic systems. As such, each PIBO site has a suite of data collected to characterize stream morphology, substrate composition, pool and habitat quality, riparian condition and more.

PIBO data comparable to DEQ targets and relatable to DEQ data and methods includes width/depth ratios, percent fines less than 6mm, percent fines less than 2mm, residual pool depths, pool frequency, and large woody debris counts.

Where it occurred, PIBO data from the streams of interest was used for comparison to DEQ targets. In addition, PIBO data from 46 sites within the Cabinet ranger district in the Kootenai National Forest, and the Plains-Thompson Falls ranger district in the Lolo National Forest was analyzed for target value development.

5.4 WATER QUALITY TARGETS

5.4.1 Targets

In order to ascertain the relative impact of sediment on a stream and its beneficial uses, comparison of stream conditions to a suite of numeric water quality targets is used. One single water quality target is often not sufficient for determining the condition of a stream, however, when viewed in combination measures of instream siltation; morphological characteristics that contribute to loading, storage, and transport of sediment or that demonstrate those effects; and biological response to increased sediment provide a good representation of current condition as it relates to sediment. The linkages between sediment, habitat, and fish and aquatic life is well documented in scientific studies, examples of which are (Cover et al., 2008; Bryce et al., 2010)

In developing these targets, consideration must be made to account for natural variation throughout the river continuum. Specifically, some reaches will have a natural tendency for storage of sediment and others will be more efficient at sediment transport. Therefore, targets follow stratifications employed in the data analysis, such that they can be applied appropriately.

The water quality targets presented in this section (see **Tables 5-3, 5-4**) are based on the best available science and information available at the time this document was written. However, targets will be addressed during future TMDL reviews for their applicability and may be modified under situations such as a better understanding of reference conditions or procedure improvements including new or modified field methods. In some situations, new targets may be added in the future to better characterize sediment conditions.

Furthermore, the exceedence of one target value does not necessarily equate to a determination of impairment. The degree to which one or more targets are exceeded is taken into account, and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. A brief description and justification of the target parameters used in the analysis is included in the sections that follow, and rationale and development of target values is included in **Appendix D**.

Table 5-3. Lower Clark Fork Tributaries TPA Sediment and Habitat Targets; Does NOT include Bull River

Sediment and Habitat Water Quality Target	High Gradient Reaches*		Low Gradient Reaches*	
Morphology				
Width/Depth Ratio	≤20		≤25	
Entrenchment	Rosgen literature values			
Substrate Composition				
Pebble Count, % <2mm	≤5		≤5	
Pebble Count, % <6mm	≤5		≤10	
Pool Habitat				
Pool Frequency (per 1000 feet of stream)	>9		>9	
Residual Pool Depth	**Bankfull Width 20-29 feet**	**Bankfull Width 30-39 feet**	**Bankfull Width 40-49 feet**	
	≥1.2	≥1.6	≥1.7	

* In general, high gradient reaches for these purposes refer to the equivalent of Rosgen A and B stream categories. Low gradient reaches refer to the equivalent of Rosgen C stream types. These types classify the majority of conditions that would be encountered in the Lower Clark Fork. For stream types outside of this range (such as Rosgen E), analysis may need to be conducted on a site by site basis using literature values and counsel with local resource management professionals.

Table 5-4. Lower Clark Fork Tributaries TPA Sediment and Habitat Targets; Bull River*

Sediment and Habitat Water Quality Target			
Morphology			
Width/Depth Ratio	Within expected values for appropriate Rosgen stream type; (Width/Depth guidelines: C types <30, B types <25, E < 12)		
Entrenchment			
Substrate Composition			
Pebble Count, % <2mm	≤20		
Pebble Count, % <6mm	≤20		
Pool Habitat			
Pool Frequency (per mile)	>20		
Residual Pool Depth	**Bankfull Width 30-39 feet**	**Bankfull Width 40-49 feet**	**Bankfull Width >50 feet**
	≥1.6	≥1.7	≥1.9

*It was deemed that the size and character of the Bull River, in comparison to the other tributaries in the planning area, warrants targets specific to the Bull River to be developed independent of the other tributary targets. Details are included in **Appendix D**.

5.4.1.1 Morphology

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

Width Depth Ratio

Width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). 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 in 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."***

Width/depth ratio is one of several standard measurements used to classify stream channels (Rosgen, 1996), making it a useful variable for comparing conditions on reaches within the same stream type. Comparison of observed and expected width/depth ratio is a useful indicator of channel overwidening and aggradation, which are often linked to excess streambank erosion or acute or chronic erosion from sources upstream of the study reach. Higher width/depth ratios than those expected indicate streams that may not be properly functioning or have higher sediment loads. Channels that are overwidened often are associated with excess sediment deposition and streambank erosion, contain shallower, warmer water, and provide fewer deepwater habitat refugia for fish.

Entrenchment Ratio

Stream entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen 1996). Entrenchment ratio is used to help determine if a stream shows departure from its natural stream type. It is an indicator of stream incisement, and therefore indicates how easily a stream can access its floodplain. Streams are often incised due to detrimental land management or may be naturally incised due to landscape characteristics. A stream that is overly entrenched (entrenchment ratio <1.4) generally is more prone to streambank erosion due to greater energy exerted on the banks during high flow periods. Greater scouring energy in incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incisement are historic in nature and may not currently be present, although sediment loading may continue to occur. Entrenchment ratio is an important measure of channel condition as it relates to sediment loading and habitat condition, due to the long-lasting impacts of incisement and large potential for sediment loading in incised channels.

5.4.1.2 Substrate Composition

Percent surface fines provide a good measure of the siltation occurring in a river system and serve as an indicator of stream bottom aquatic habitat and its ability to support aquatic life. Although it is difficult to correlate percent surface fines with loading in mass per time directly, the Clean Water Act allows "other applicable measures" for the development of TMDL water quality restoration plans. Percent surface fines and their effect on biological communities has been quantitatively shown in a number of studies (Suttle et al., 2004; Irving and Bjornn, 1984; Kondolf, 2000) and applied successfully in other TMDLs in western Montana addressing sediment related to stream bottom deposits, siltation, and aquatic life uses.

Percent Fines <2mm

Surface fine sediment measured in the Wolman pebble count is one indicator of aquatic habitat condition and can indicate excessive sediment loading. Studies have shown that increased substrate fine materials less than 2mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan, 1991). As well, the TMDL for the Flathead Headwaters TMDL (Environmental Research Laboratory-Duluth et al., 2004) describes work completed in the Boise

National Forest in Idaho, which showed a strong correlation between the health of macroinvertebrate communities and percent surface fines defined as all particles less than two millimeters.

Percent Fines <6mm

As with surface fine sediment smaller than 2mm diameter, an accumulation of surface fine sediment less than 6mm diameter may indicate excess sedimentation. The size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and incubation. Excess surface fine substrate smaller than 6.35 mm may have detrimental impacts on aquatic habitat. Weaver and Fraley observed a significant inverse relationship between the percentage of material less than 6.35 mm and the emergence success of west slope cutthroat trout and bull trout (Weaver and Fraley, 1991).

5.4.1.3 Pool Features

Pools are morphological features that are characterized by slow moving, deep sections of the stream. These important components aid in the balance between flow and sediment load by reducing stream velocity and storing water and sediment. Pool features also play an important role for the aquatic life and fisheries by providing refuge from warm water, high velocity, and terrestrial predators. However, when sediment loads are excessive, pool habitat quality and frequency is often diminished as pools fill with sediment. As this happens, velocities increase, stream channels widen, and sediment is transported to other areas of the stream where it is sometimes deposited in areas that have an additional impact on fisheries and aquatic life. The measure and comparison of pool features can have direct links to sediment load increases and its affect on stream form and function, as well as biological integrity.(Kershner et al., 2004; Riggers et al., 1998)

Residual Pool Depth

Residual pool depth, defined as the difference between pool maximum depth and crest depth, (end of the pool depth), is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Essentially it represents the depth of water that would remain in a pool if water ceased to flow through the channel, and only where pools occur remained filled. Deep pools are important resting and hiding habitat for fish, and provide refuge during temperature extremes and high flow periods. Pool residual depth is also an indirect measurement of sediment inputs to listed streams. An increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Pool Frequency

Pool frequency is a measure of the availability of pool habitat to provide rearing habitat, cover, and refuge for fish. 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 affected adversely by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

5.4.2 Supporting Information/Supplemental Water Quality Parameters

Although the following categories are not a direct measure of sediment, they do provide insight into the condition of the stream and streambanks, and of the overall riparian quality which is often associated with factors that may be leading to increased sediment loads and the reduction of habitat. (Castelle and Johnson, 2000; Ellis, 2008)

During the 2008 DEQ sediment and habitat data collection, a riparian assessment method (ie, Greenline) (DEQ, 2010) was used to conduct a coarse survey of the riparian corridor and its general vegetation composition. The results of which can be used to infer riparian corridor health and bank stability.

Understory Shrub Cover along Green Line

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 main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are an important food source for fish.

Based on a general review of riparian shrub cover results from Greenline studies conducted during the 2008 DEQ field efforts, a goal of 90% or greater shrub cover for high gradient reaches, and 60% or better shrub cover for low gradient reaches should be considered under most conditions for streams in the Lower Clark Fork watershed.

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.

Based on a general review of riparian shrub cover results from Greenline studies conducted during the 2008 DEQ field efforts, a goal of 0% bare ground should be considered under most conditions for streams in the Lower Clark Fork watershed.

Large Woody Debris

Large woody debris in the form of branches, trunks, rootwad, and other manner of downed wood within the active stream channel is a vital component of most western Montana stream ecosystems. Large wood in the channel provides multiple benefits for fish and other aquatic life by creating cover and habitat, encouraging scour resulting in pool development and sediment transport, and being a component in the overall foodweb for the various lifeforms in and around the stream. In addition, large

woody debris may also be an indicator of riparian community health and maturity, which also has impacts on the overall form and function of a stream ecosystem (Hauer et al., 1999).

Although large woody debris does not, by itself, suggest impairment from sediment, because of the common linkages that large woody debris has on stream health, it is commonly reviewed in combination with other sediment parameters to provide a better picture of the overall issues affecting a stream. Large woody debris discussion within the context of this document is used for that purpose and is not suggested as a target value per say; but simply to provide a stronger weight of evidence when discussing the condition of streams in the Lower Clark Fork. A value of 40 large wood pieces per 1000' is suggested as an appropriate indicator of a health system for Lower Clark Fork tributary systems.

5.4.3 Comparison of Listed Waters to Targets (by stream segment)

5.4.3.1 Bull River, the North Fork to the mouth (Cabinet Gorge Reservoir); MT76N003_040

Review of the DEQ assessment files for Bull River indicates moderate impairment to the Bull River, with fisheries being limited by low habitat complexity, limited spawning areas, and low large woody debris, partially as a result of land management activities along the river. Macroinvertebrate communities indicate 'fair' conditions. High fines were also identified in some parts of the lower river.

Although reaches from the Bull River were included in the 2008 DEQ sampling effort, it was found that in general, the character of the sites sampled on the Bull River, were considerably different from the sites in the rest of the data set, and therefore the data included from the Bull River sites was not included when developing targets for the Lower Clark Fork tributaries. Instead, TMDL targets from other, nearby, larger stream systems such as the St. Regis River and Prospect Creek were reviewed, and targets specific to the Bull River were developed to assess its condition; these targets are described further in **Table 5-4** and **Section D.3** of **Appendix D**.

General stream morphology parameters (see **Table 5-5**) such as width/depth and entrenchment for all three DEQ sites appear to be within the range of what might be expected for this system. Substrate composition in reach 3-2 is very much within the range of the overall Lower Clark Fork tributary targets; however reach 3-3 has very high percent fines, and reach 5-1 also displays elevated fines **(Table 5-6**). Although designated as Rosgen C stream types in BULL 3-3 and BULL 5-1, these reaches may be borderline E reaches, which typically have higher percent fines, and therefore comparison to the C reach based targets may be misleading, (although percent fine values in 3-3 are considerably high, even for an E type system). Pool frequency for all reaches (**Table 5-6**) is somewhat low however the residual pool depths are very well defined in all three reaches. Large woody debris appear to be acceptable throughout the sampled reaches in the Bull River.

The PIBO site occurs on the East Fork Bull River (see **Table 5-7**), which is more akin to the other tributaries in the Lower Clark Fork in terms of size and Rosgen stream type, and therefore is compatible with the designated targets described in **Section 5.4.1**. Percent fines <6mm are slightly elevated and pool frequency is not meeting the target at this site.

Table 5-5. Bull River – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
BULL 3-2	15q	3-U-0	61.5	C4/E4	28	4.20
BULL 3-3	15q	3-U-0	61.3	C5/E5	19.3	5.90
BULL 5-1	15q	3-U-0	62.7	E5	**14.1**	7.10

Values in **BOLD** indicate an exceedence of the target value.

Table 5-6. Bull River – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000'	Large Wood #/1000'
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
BULL 3-2	1	6	4.0	2.8	8.0	**19.0**
BULL 3-3	**30**	**55**	**61.0**	3.5	**4.0**	**11.0**
BULL 5-1	14	**24**	12.0	3.5	**3.0**	22.0

Values in **BOLD** indicate an exceedence of the target value.

Table 5-7. Bull River - PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
East F. Bull	2152	5.0	16.8	4	**13**	1.7	**2**	139

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ Bull River reaches further:

BULL 3-2 – There was moderate bank erosion occurring within the reach. Streambanks on outside meanders with poor vegetation and rooting conditions typically experienced the greatest erosion. Streambanks are comprised of sandy, gravelly unconsolidated materials lending to its erosive nature. The understory is dominated by reed canary grass, alder, and some willow and grass/forbs. Overstory consists of patchy conifers with spruce and cedars along the channel margins. The entire riparian zone is still recovering from 1990s stand replacement wildfire. Riparian zone likely logged prior to 1990 wildfire as evidenced by cedar and spruce stumps. This reach was historically used for log drives when western red cedars were logged. No current active human impacts to the reach, although there are private residences upstream and downstream of survey reach. Throughout the reach, mid-channel and transverse bars present alluding to high sediment (coarse) supply from North Fork and South Fork Bull River. This is a transitional reach between the upper watershed transport reaches (typically B), and downstream depositional E stream type reaches. Abundant sediment deposits occur downstream of the surveyed reach where the gradient is lower, and sinuosity and bed material fines are higher.

BULL 3-3 – Streambanks were mostly stable. The silt-clay bank material is cohesive and seemingly more resistant to scour although some sloughing of upper bank occurs. Reed canary grass dominates the riparian zone with drier grasses intermixed, and willow and red osier dogwood forming narrow bands adjacent to streambanks with some debris inputs. Human impacts in this reach related to the historic clearing and conversion of riparian vegetation (woody shrub community conversion to reed canary grass). Stream channel with plane bed, dune-ripple bedforms indicating increased sediment deposition. Channel bed sediment is mostly sand/silt with some small gravel content.

BULL 5-1 – Streambanks are primarily composed of sands and other fine materials, overlain by extensive vegetative cover of reed canary grass, and sparse shrubs and scattered cedar roots, but root mats are moderately undercut and slumping on several banks, with the underlying materials eroded. The riparian zone may have been historically affected by agricultural operations (conversion of valley land), but does not appear to have any current and active anthropogenic influences throughout this reach. Slow-moving water, low gradient riffles and few, long pools characterize the habitat in this reach.

As a result of the high fines in BULL 3-3 and BULL 5-1, reduced pool frequency and historic human impacts witnessed in the Bull River reaches, a TMDL will be developed.

5.4.3.2 Dry Creek, headwaters to the mouth (Bull River) T28N, R33W; MT76N003_180

Review of the DEQ assessment files for Dry Creek indicates a lack of macroinvertebrates and significant sources of sediment present including roads and sensitive land types. 100% pure resident westslope cutthroat are present, however the stream also displays intermittency which may limit connectivity to the Bull River. Sediment produced from landslides and road fill have provided a significant sources of mostly course gravel to cobble size material. Logging in the riparian areas coupled with the fire of 1910 have exacerbated channel instability in the transitional areas causing significant braiding and bank erosion potential. Comparison of recent photos with pre-management photos shows dramatic increases in the number of slope failures throughout the watershed, although most roads are now closed and USFS initiated a basin-wide road reclamation project in 2001. Based on the available data, the severe impairment indicated by the macroinvertebrates and identification of sources of sediment (non-natural) has lead to the impairment listing.

Only one reach was assessed in the Dry Creek watershed and of the parameters reviewed only pool frequency was below the target value, and only slightly (**Tables 5-8 and 5-9**). Two sites were assessed through the USFS PIBO data (**Table 5-10**) however both of those sites had an incomplete suite of data with information pertaining only to large wood and width/depth. For the PIBO data, only one of the two sites had w/d data, and that site was well above the w/d target for B streams. Large wood was meeting the target at one site, and slightly below the target at the other.

Table 5-8. Dry Creek – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
DRY 9-2	15q	2-U-0	36	B3	12.4	6.10

Values in **BOLD** indicate an exceedence of the target value.

Table 5-9. Dry Creek – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000’	Large Wood #/1000’
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
DRY 9-2	1	2	3.0	1.7	**8.0**	116.0

Values in **BOLD** indicate an exceedence of the target value.

Table 5-10. Dry Creek – PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
Dry	4802	3.8	**-**	-	-	-	-	**35**
Dry	142	3.8	**41.9**	-	-	-	-	53

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ Dry Creek reaches further:

DRY 9-2 – Streambank material is dominated by course cobbles and boulders in this reach, covered with a mat of forest roots and associated understory shrubs. However, high bank height ratios, shallow rooting depths, and high near bank stress values lead to high erodibility. Although the reach was dry when assessed, this reach and channel corridor are subject to major debris torrents in addition to active channel headcuts and avulsions; fresh coarse sediment lag deposits with material up to 4' in diameter were observed. Channel headcuts and avulsions are common. No current anthropogenic activities appear to be actively influencing the channel however there is evidence of historic logging practices such as an abandoned road along the north side of the valley that was relocated mid-slope due to chronic road failures. Erosion and sediment production is also influenced by the alluvial fan that forms the bed geomorphic surface. Conifer species dominate the riparian area, and extensive large woody debris jams are prevalent, resulting in gradient increases and knickpoints, which lead to frequent channel shifts and destabilized banks.

Although meeting most targets at the assessment site, the unstable banks as a result of historic anthropogenic activities and actively eroding nature of this reach undoubtedly is contributing significant sediment loads in low gradient reaches and to the receiving Bull River. As such, a TMDL will be developed for Dry Creek.

5.4.3.3 Marten Creek, headwaters to the mouth (Noxon Reservoir); MT76N003_090

Review of DEQ assessment files for Marten Creek described slight to moderate impairment with high levels of percent fines in spawning gravels; values of 29% and 41%; and Riffle Stability Index values indicating an unstable streambed. The assessment file also referenced a 1998 USFWS document – *ESA Determination for Bull Trout*, that states >17% fines in spawning gravels is considered to be 'Functioning at Unacceptable Risk for bull trout'.

Multiple sites were assessed in the Marten Creek watershed as part of the 2008 DEQ field study (**Tables 5-11 and 5-12**). In the two branches that eventually join to make Marten Creek (South Branch and North Branch); the North Branch site NBMC 8-1 was not meeting the target for residual pool depth and large wood. The South Branch site SBMC 3-1 was slightly above the target for width/depth, but met all other targets. Both sites on the mainstem of Marten Creek saw values for pool quality and quantity, and large wood slightly outside of the target, and site MC 9-1 also was well outside of the expected target value for width/depth ratio.

In addition, two PIBO sites in the Marten Creek watershed were also reviewed (see **Table 5-13**). Similar to Dry Creek, both sites had incomplete data sets and only a few parameters were able to be compared to targets. One site occurred on the South Fork of Marten Creek; only width/depth and large wood were measured; width/depth somewhat exceeded the target, and large wood was well below the target value. The second site occurred on the mainstem of Marten Creek; and again only width/depth and large wood were reviewable. Width/depth values at the mainstem PIBO site were just slightly above the target, and large wood numbers were well below.

Table 5-11. Marten Creek – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
NBMC 8-1	15o	2-U-4	21.4	B3	12.5	1.70
SBMC 3-1	15o	2-C-4	31.4	B4	**26.6**	1.70
MC 6-2	15o	3-U-2	30.7	C3	16.2	5.00
MC 9-1	15k	3-U-0	48.9	C3	**41**	7.40

Values in **BOLD** indicate an exceedence of the target value.

Table 5-12. Marten Creek – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000'	Large Wood #/1000'
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
NBMC 8-1	1	4	2.0	**1**	16.0	**30.0**
SBMC 3-1	3	5	5.0	1.3	28.0	149.0
MC 6-2	6	8	5.0	**1.5**	**6.0**	**26.0**
MC 9-1	7	8	4.0	**1.4**	**8.0**	**20.0**

Values in **BOLD** indicate an exceedence of the target value.

Table 5-13. Marten Creek – PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
South F. Marten	1801	1.4	**31.5**	-	-	-	-	**12**
Marten	1805	1.6	**26.7**	-	-	-	-	**29**

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ Marten Creek reaches further:

NBMC 8-1 – Streambanks are generally stable with some discrete eroding banks located along meander outcurves and constrictions. Bank substrate contains a large cobble-boulder matrix which provides some natural bank protection. Overall, there is low supply from eroding streambanks, and high vegetative cover prevents erosion of the thin forest topsoil and provides moderate potential for large wood recruitment, although there is evidence of past logging activities within the channel migration zone. The stream interacts with USFS road hillslope in part of the reach, but the fillslope appears stable with grasses/shrubs and there is low sediment delivery potential. The channel is characterized as having a plane bed, riffle/step (forced) pool morphology. There is limited pool development and depths due to armored bed and lack of coarse large wood.

SBMC 3-1 – Dense vegetation, a rocky hillslope and coarse bank materials result in minimal to moderate bank erosion. Numerous large woody debris jams and boulder deposits dissipate energy and prevent scouring, as well as influencing channel morphology and habitat. There does not appear to be any recent impacts in the reach other than a fire. The riparian zone is intact with no signs of logging. Series of log steps store sediment and provide upstream deposition and downstream scour. There is a multi-story riparian zone with a mature conifer canopy dominated by hemlock.

MC 6-2 – In the lower reach, there is a bedrock outcrop on the southern bank and forms much of the southern channel margin. There is minor bank erosion on the north bank and bank erosion occurs on most streambanks lacking bedrock. Eroding banks are commonly 3-4 feet high where they occur. No obvious current human impacts. Downstream end of reach has intermittent conditions partially caused by large sediment deposits in the channel, influenced by large wood. Water flows upstream and downstream of the intermittent reach. Steeper reaches have coarser bed material including boulders that are unlikely to move except in uncommon flood events. Large trees including cedars and mature cottonwoods provide the in-channel debris.

MC 9-1 – Bank erosion is pervasive with most outside banks affected by scour. Flood-deposited coarse material on channel margins is semi-colonized by shrubs and weeds and most of these surfaces are not stable enough to resist erosion. Eroding banks range from 2ft to 4ft in height. Loose sediment suggests a dynamic system with a mobile bed and lack of larger material and large woody debris for channel stability. Channel changes may be relatively frequent based on overflow channels, moderately fresh deposition, and bank erosion. Stream habitat is generally homogeneous with limited pools and long riffles. The canopy is less contiguous compared to upstream reaches and consists of cottonwoods as the primary overstory species, with infrequent conifers. No current anthropogenic influences were identified at this site.

Current anthropogenic impacts are rare in the Marten Creek sites selected for assessment. In general, pool depths and pool frequency are only slightly lower than target values. Although not a direct indicator of sediment itself, large woody debris was consistently below the target which may indicate more of an issue with riparian community development and historic disturbance than any present activity. Additionally, the bank instability and high width/depth ratio at the lower reach (MC 9-1) indicates a disturbed floodplain and stream corridor that will likely require active channel restoration to stem the pervasive bank erosion. Because of this, a TMDL will be pursued despite the marginal and limited exceedence of sediment targets in the other reaches.

5.4.3.4 Swamp Creek, Cabinet Mountains Wilderness Boundary to the mouth (Noxon Reservoir); MT76N003_140

Four reaches were assessed on Swamp Creek during the 2008 Lower Clark Fork field assessment (**Tables 5-14 and 5-15**). Data throughout the reaches was variable in relation to meeting the various targets. Two reaches had width/depth ratios well above the target for that parameter indicating some reaches with unstable channel form. In addition, while not well above the targets for percent fines, three of the four sites were in some slight exceedence of the target values for both size classes. Residual pool depths in SWP 18-1 was also considerably below the target for residual pool depth, while SWP 22-3 was also somewhat below the target. Large wood was also well under the target in reach SWP 18-1, and slightly below in reaches SWP 21-1 and SWP 22-3.

Additionally, one site on West Fork Swamp Creek was included in the PIBO dataset (**Table 5-16**). This site met all targets except pool frequency. Large wood data did not exist for this site.

Table 5-14. Swamp Creek – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
SWP 18-1	15q	2-U-2	33.5	C3	18.7	4.50
SWP 20-1	15q	3-U-0	47.7	C4	**43.4**	6.20
SWP 21-1	15k	3-U-0	45	C4	**47.8**	9.50
SWP 22-3	15q	3-U-0	40.1	C4	19.8	2.90

Values in **BOLD** indicate an exceedence of the target value.

Table 5-15. Swamp Creek – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000'	Large Wood #/1000'
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
SWP 18-1	4	7	1.0	**0.6**	13.0	**20.0**
SWP 20-1	**11**	**14**	5.0	1.7	14.0	71.0
SWP 21-1	**11**	**14**	1.0	1.8	11.0	48.0
SWP 22-3	**12**	**15**	4.0	**1.3**	11.0	40.0

Values in **BOLD** indicate an exceedence of the target value.

Table 5-16. Swamp Creek – PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
West F. Swamp	1812	3.4	19.8	0	3	1.3	**3**	-

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ Swamp Creek reaches further:

SWP 18-1 – Some erosion of floodplain areas and minimal streambank erosion has occurred as a result of flood scour but dense shrub cover including willow communities and forest understory anchors most of the streambanks while scattered cedar groves provide additional root cover. Some signs of livestock grazing exist but no other identifiable current anthropogenic impacts. Minimal habitat exists in the form of shallow pocket pools in channel margins. The channel is dynamic with floodplain overflow channels and coarse alluvium deposits and large woody debris scattered throughout. Bed material is limiting in spawning habitat and is comprised of coarse material and minimal gravels. Beavers are active on the floodplain and influence the vegetation community, especially along the channel and broader floodplain areas, but riparian vegetation is dense and diverse, consisting of a cedar, cottonwood, aspen, and spruce overstory, and willow, dogwood, snowberry, and alder in the understory.

SWP 20-1 – The channel appears to be unstable and actively shifting in the upstream portions, with relic point-bars, lack of vegetative cover and abandoned channels. Considerable bank erosion is contributing sediment to the channel and most of the fine sediment (remnant of glacial Lake Missoula silts) is in the lower portion of the reach, especially downstream of a floodplain channel that joins the creek in toward the head of the reach. Swamp Creek Reach 20-1 currently exhibits a Rosgen D4 channel morphology. Based on the valley morphology, floodplain, and vegetation characteristics, the probable historical stream type was likely a Rosgen C4. Grazing has significantly contributed to stream erosion and may be furthering the system's susceptibility to periodic disturbance, as evidenced by hoof shear and vegetation cropping. Past and present beaver activity also appears to play an important role influencing channel

morphology, sediment storage, water storage and the vegetation community. Riparian community is described as a diffuse overstory with infrequent spruce, larch and cedar.

SWP 21-1 – Bank erosion is common at this site. Accelerated erosion is related to livestock grazing, hoof shear, vegetation removal and attempts at bank stabilization through riprap. The most severe erosion was due to bank toe failure and bank slumping. The channel morphology was characterized by long pools/glides and short riffles. Alder clumps and large wood from upstream influence pool scour and habitat. The channel appears to be over-widened through much of the reach due to grazing impacts and the upstream end of the reach is split into two channels.

SWP 22-3 – Erosion is moderate at this site. Failing banks, dominated by reed canarygrass are fairly common. However, a good and diverse off-channel riparian shrub community limits the extent of lateral bank retreat and bedrock limits erosion in the upper portion of the reach. Bedrock is either exposed at the channel surface or is covered by a thin veneer of sediment ranging from sand to boulders. Historic anthropogenic influence is apparent from the previously logged uplands and the current irrigation withdrawls and reservoir operations affecting flows. The channel is relatively homogeneous with few moderate to large pools. Numerous fish were stranded in the remaining pools. A narrow floodplain separates the channel from adjacent hillslopes.

Swamp Creek will undergo sediment TMDL development, largely as a result of the known historic influences of stream and landscape disturbance in the watershed, and the resultant affects, as seen in width/depth ratios and higher than average percent fines. The present day anthropogenic influences on bank stability and sediment load in the lower reaches also support the pursuit of TMDL for this stream.

5.4.3.5 White Pine Creek, headwaters to the mouth (Beaver Creek); MT76N003_120

Review of the DEQ assessment files indicates that upper White Pine Creek supports a pure, small yet viable westslope cutthroat fishery but it may be threatened from competition and genetic introgression from non-native species. Bull trout are also though to have been distributed throughout the drainage historically, but only 1 fish has been captured in 2000. Subpopulation size, growth and survival, life history diversity and connectivity all “functioning at risk” for bull trout. Persistence and genetic integrity “functioning at unacceptable risk.” Macroinvertebrates indicate that habitats are mostly intact, but demonstrate disturbance, and index scores suggest partial support of aquatic life. Much of the sediment issues in White Pine Creek appear to be a result of habitat instabilities; historic, natural catastrophes such as the large, landscape fires in 1889 and 1910, and the large flood of 1916, along with past and present detrimental land use practices including road construction, riparian and upland timber harvest, and stream modifications. The increased sediment loads resulted in accumulation of sediments, increased bank instability, erosion, and stream braiding, which are still visible on the landscape. Comparison of White Pine Creek to Kootenai National Forest reference data sets shows large, high quality pools with good habitat complexity are lacking and reduce the quality of overwintering habitat for fish. In addition, Wolman pebble counts and McNeil core sampling have demonstrated that there are areas that have excess fines, and are most likely affecting fish spawning success.

Three sites on White Pine Creek were included during the 2008 field assessment (**Tables 5-17 and 5-18**). Percent fines less than 2mm exceeded the target at all three sites, and was either at the target or barely above for percent fines less than 6mm. Residual pool depths were also below the target at two of the three reaches, as was pool frequency. Width/depth ratio and large wood did not meet the target at WPC 9-2.

In addition, one PIBO site on White Pine Creek was included for review (**Table 5-19**). This site did not meet the target for width/depth, both classes of percent fines, and residual pool depth. Large wood data was not available for this site.

Table 5-17. White Pine Creek – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
WPC 8-3	15k	2-U-2	31.9	C3	21.3	7.70
WPC 9-2	15k	2-U-0	35.3	C4	**32.4**	5.20
WPC 9-5	15k	2-U-0	37.7	C4	24.8	5.50

Values in **BOLD** indicate an exceedence of the target value.

Table 5-18. White Pin Creek – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000'	Large Wood #/1000'
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
WPC 8-3	**9**	10	1.0	**1**	**6.0**	56.0
WPC 9-2	**7**	**11**	3.0	**1.5**	12.0	**33.0**
WPC 9-5	**6**	10	1.0	1.7	**8.0**	57.0

Values in **BOLD** indicate an exceedence of the target value.

Table 5-19. White Pine Creek – PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
White Pine	1810	0.5	**29.7**	**9**	**23**	**1.1**	11	-

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ White Pine Creek reaches further:

WPC 8-3 - Most streambanks exhibit erosion. There is considerable sediment, generally coarser substrate, generated within the reach from streambank and floodplain erosion. There are signs of large material mobilized by larger flood events indicating strong forces during high flow events. Multiple braided channels show evidence of scouring during floods and subsequent abandonment. Portions of the reach have multiple channels and an intermittent reach with substantial bedload. The reach resembles fan morphology with poor habitat conditions and limited pools. Large wood present but infrequently influences channel morphology. Most of the large wood is in the form of single pieces with a few aggregates. No obvious current anthropogenic impacts to the site however a road does intersect the stream at the top and bottom of the reach. The riparian zone is characterized by a multi-species canopy of fir and cottonwood. There are limited shrubs, mainly small conifers.

WPC 9-2 - Considerable streambank erosion contributes sediment ranging from silts to medium cobble. Most erosion is occurring on outside streambanks with extreme bank heights. Alders provide some streambank stability but most eroding banks are dominated by grasses and knapweed. Inside banks are characterized by point bar deposits and sparse vegetative cover. Reaches upstream and downstream are influenced by a forest road, active evulsions and shifting channel braids. Most observable impacts are related to historical logging, past grazing, agriculture and on-going road maintenance. Large stumps suggest historical canopy and past logging. Algae is common throughout channel which may suggest high nutrient levels. The channel is actively migrating with an abundant sediment load as evidenced through meander cut-offs, floodplain scrolls, and extensive depositional bars. Shallow pools are located

where the stream interacts with large wood and alder bunches. The channel profile includes pools, long glides and abrupt riffles. The vegetation community is characterized by an alder overstory with an understory including grasses, knapweed, and willows. Other shrubs include alder which are regenerating throughout the site. Sedges are common on depositional features parallel to channel. Areas of significant weed infestation include knapweed, oxeye daisy, purple loosestrife, and Canada thistle.

WPC 9-5 - Bank erosion is relatively common at outside streambanks with excessive bank heights. The entrenched channel has a relatively low sinuosity planform characterized by short riffles and long pools and glides. Some large wood and numerous alder thickets promote channel scour and pool diversity where they interact with the stream. Fine to medium gravels predominate the channel bed material and fine sediment and flocculant cover the channel bed in most slow water areas. Current anthropogenic impacts are easily seen throughout this reach; the streambank has been anthropogenically altered (bulldozed and graded) on river-left near the downstream end of the reach. Haying is a dominant influence on river-left, which extends from the floodplain to the channel margin. There is a recent subdivision on surrounding uplands. Riparian vegetation has been mowed to the top of bank. A newer bridge and low water ford have introduced fine sediment to the stream. Tractor tracks are apparent on the floodplain and equipment was used to manipulate the channel, potentially resulting in an active avulsion. Alder dominate the overstory and reed canary grass dominates the understory. Alders are located on the floodplain as well as on the streambanks of the entrenched bankfull channel. No mature overstory canopy exists above the alders. Reed canary grass is common, displacing sedges and rushes from low depositional areas and witnessed on failed streambank blocks and point bars. Limited other shrubs are present in the reach, including spirea.

Current and historic anthropogenic activity in the watershed, and exceedence of targets in each of the assessed reaches supports the development of TMDLs for this stream.

5.4.4 Data Review for Elk Creek

In 1998, a TMDL was developed for the Elk Creek watershed. Since that time, numerous improvement efforts have been completed, and more are in development, to try to achieve the recommendations in that TMDL and meet water quality standards. Elk Creek was included in the sampling and analysis plan for the 2008 Lower Clark Fork study to broaden the representativeness of data from tributaries within the TPA, and to provide additional information for the benefit of those who wish to review current conditions in Elk Creek, and assess progress since the 1998 TMDL was completed.

Seven sites in all were included from the Elk Creek watershed; one from West Fork Elk Creek, four from East Fork Elk Creek, and two from the mainstem of Elk Creek (**Tables 5-20 and 5-21**). The West Fork reach, WFELK 8-1 met the targets for stream morphology, and were barely exceeding the targets for both classes of percent fines. Additionally, residual pool depths were somewhat low in comparison to the target. The East Fork reaches saw some exceedence of target values for 3 of 4 width/depth ratios, with the most significant exceedence at EFELK 10-3. Residual pool depths and pool frequency targets were also not met in 3 of 4 reaches, as was large woody debris. Mainstem Elk Creek met most targets however a slight exceedence in width/depth ratio at ELK 11-3 was observed, as well as a deficiency in large wood at ELK 11-6. Although the target for percent fines was based on the wolman pebble count results, the target value of <10% less than 6mm showed slight exceedence via the grid toss method. These values are likely within the range of acceptability and are compatible with the percent fines as determined through the pebble count.

Three PIBO sites in the Elk Creek watershed were also identified; two on East Fork Elk Creek and one on West Fork Elk Creek (**Table 5-22**). The West Fork Elk Creek site had incomplete data; however, it was slightly below the target for large woody debris. Of the two East Fork Elk Creek sites only one had percent fines data, which was well above the target values for both classes. In addition, large wood and pool frequency was not meeting the target values at both sites. The residual pool depth target was met at one site, but not the second site.

Table 5-20. Elk Creek – DEQ 2008 Morphology Data

Reach	Ecoregion	Reach Type	Bankfull Width	Rosgen Stream Type	Width/Depth Ratio	Entrenchment
WFELK 8-1	15o	2-U-0	20.3	C3	23.5	7.40
EFELK 7-2	15k	2-U-4	28.5	B3	16.6	2.60
EFELK 8-1	15k	2-U-2	24.8	B4	**21.4**	4.60
EFELK 9-1	15k	2-U-0	27.5	B4	**26.9**	3.00
EFELK 10-3	15k	3-U-0	36.7	C4	**38.7**	3.30
ELK 11-3	15k	4-U-0	43.8	C4	**26.4**	7.00
ELK 11-6	15k	4-U-0	39.4	C4	17.4	2.60

Values in **BOLD** indicate an exceedence of the target value.

Table 5-21. Elk Creek – DEQ 2008 Habitat Data

Reach	Wolman Pebble Count		Grid Toss	Residual Pool Depth	Pools #/1000'	Large Wood #/1000'
	Percent Fines <2mm	Percent Fines <6mm	Percent Fines <6mm			
WFELK 8-1	**6**	**11**	7.0	**1.3**	10.0	43.0
EFELK 7-2	1	5	5.0	**1.1**	**7.0**	**26.0**
EFELK 8-1	2	5	3.0	1.3	**3.0**	**20.0**
EFELK 9-1	5	7	10.0	**1.1**	**4.0**	**37.0**
EFELK 10-3	5	9	8.0	**1**	9.0	56.0
ELK 11-3	3	7	**12.0**	2.7	9.0	62.0
ELK 11-6	4	8	**18.0**	3.2	9.0	**31.0**

Values in **BOLD** indicate an exceedence of the target value.

Table 5-22. Elk Creek – PIBO Data

Stream	Reach ID	Gradient	W/D	%<2mm	%<6mm	Pool D	Pool Frq	LWD
East F. Elk	145	0.6	24.1	-	-	**1.2**	**5**	**46**
East F. Elk	2149	0.7	**35.1**	**19**	**29**	1.6	**2**	**16**
West F. Elk	2156	2.9	19.1	-	-	-	-	**41**

Values in **BOLD** indicate an exceedence of the target value.

Field notes from the 2008 field assessment describe the conditions of the DEQ Elk Creek reaches further:

WFELK 8-1 – Limited bank erosion occurs primarily near cedar stumps, roots, trunks, or large woody debris knick points. The stream is intermittent in this reach. Where and when water exists, there are deep pools and runs, with smaller sections of riffle throughout. Deep, curving, and pool forming bends also result in limited erosion at corners. Small material gravel dominant at pool crests and depositional sections of stream with large size cobble (90-128 mm) frequent in stream bottom with some embeddedness of larger cobble from finer material. Evidence of historical logging includes cedar stumps throughout the reach however, stream channel and riparian zone appear to be relatively stable and no recent anthropogenic influences exist. Past logging may have been limited and there is no sign of recent

activity, this reach occurs in a predominantly natural setting. Large diameter wood interspersed along stream channel helping to create pools and redirect flow. Some large cedars exist throughout and vegetation including small woody shrubs comprise the understory. Although old stumps are visible, a sparse but mixed age class in cedar composition with interspersed deciduous trees indicates a recovering riparian community. Good vegetation cover for the shaded, cedar sections of the reach.

EFELK 7-2 – The armored channel exhibits minimal erosion, and no current anthropogenic influences are present at this reach, although there is some logging approximately 2-3 miles upstream. Despite this, the logged area is small, and there is not much noticeable logging effect. Vegetation along the reach extends to the channel margin, completely covering the mixed sizes of substrate material that comprise the streambank. Intermittent flow through the reach appears to be due to high sediment bedload. Pool habitat is lacking with low wood frequency with marginal quality pools. The riparian zone is characterized by a grass, forbs and shrub understory with an overstory of conifers and patchy cottonwoods. Riparian condition looks good with stable vegetation and multiple age classes.

EFELK 8-1 – Naturally occurring eroding banks, very limited in size and frequency are usually at outside meanders. The streambanks are armored with large cobble, with a mat of shrub and tree cover on top with moderate rooting density. One large eroding hillslope with a stable toe is eroding about 8 feet up the bank. Previous increased sediment loads are evident by mature cottonwoods buried up to 3 feet and flood lag deposits intercepted by the channel, possibly deposited during the 1964 flood. The reach is intermittent. A homogeneous mixture of sediment size, dominated by coarse particles, is the primary source of material to the channel and armors the channel bed. Pools lack complexity and cover and are not well developed. The few pools that exist typically occur at meanders and are small in size. There is a limited amount of in-channel coarse large woody debris possibly reflecting riparian age class and past disturbance regimes. The stream is intermittent in the reach. Similar to EFELK 7-2, there is very little evidence of current human impacts in the reach. Limited logging occurred a number of years ago about 3 miles upstream, but no evidence of logging in the study reach. A forest fire approximately 20 years ago affected the vegetation community. There are relatively young age classes, 12-16” max diameter at breast height on floodplain and limited large wood recruitment potential. However, young riparian zone is diverse and dominated by conifer with some interspersed deciduous trees.

EFELK 9-1 – Some areas of sand and small fines dominated substrate, easily eroding where channel shape shifts due to large in-stream wood or at bends, however not much bank erosion witnessed outside of these erosive soil type areas. Extensive vegetation cover appears to be successfully mitigating erosion and providing cover. Long riffles and few pools, with pools typically influenced by large woody debris. The stream bed is elevated with deep channels along the edge of stream bottom. Excessive bedload and a shifting thalweg with channel bars forming midstream in some areas near large wood or upstream of bends suggests the reach is aggrading. Minimal evidence of human impacts near the stream however barbed wire was found along streambanks and within the channel suggesting previous fencing, possibly for livestock. Gabion basket was also found in the streambank in part of the reach. Conifer-dominated forest although size class is uniform indicating past disturbance. Good riparian buffer width although vegetation density and diversity are average.

EFELK 10-3 – Most streambanks in this reach are actively eroding. High stream energy and bedload deposits occur at meanders, influencing channel morphology. The riparian vegetation is dominated by reed canary grass and alder rather than historically dense species such as willow and dogwood, and limited root density coupled with sandy soils results in streambank instability. Large woody debris redirects flow into streambanks which is also affecting stability. Stream habitat consists of moderately

deep pools and interspersed riffles. In general, there is limited trout habitat, mainly provided by pools formed by alders slumping from eroding banks. The bedload material is very mobile (smaller cobbles dominate) with abundant fine sediment in pool bottoms, slow areas and at meanders. Historically, valley bottoms similar to EFELK 10-3 in the Lower Clark Fork tributaries were dominated by western red cedar. Channel and floodplain instability is largely due to vegetation changes from cedar to alder. Other vegetation changes include shifts from stable cedar to reed canary grass. Past agricultural practices and livestock grazing have also affected vegetation conditions. The current landowner fences livestock from the stream and maintains a buffer, but woody vegetation is sparse and relatively ineffective for bank stabilization. Some streambank stabilization projects have been installed in this reach including two engineered log jams and one rip-rap bank. The narrow riparian zone includes reed canary grass and alder and virtually no conifers.

ELK 11-3 – Large, long sandy streambanks are unstable due to lack of good riparian vegetation. Minimal riparian vegetation remains on eroding banks aside from reed canary grass and small patches of alder. Historically, valley bottoms like this were dominated by western red cedar. Channel and floodplain instability is due to vegetation changes from cedar to alder, or cedar to reed canary grass via human influence of agricultural practices and livestock grazing. Channel substrate and depositional bar substrate are dominated by similar small cobble substrate indicating very mobile, shifting materials. Mid-channel bars and long depositional benches occur throughout the reach. As a result, riffles are uncommon and the channel appears to be relatively unstable and aggrading, however deep pools are located through some meanders. Nearby, local haying and agricultural practices occur but does not seem to be affecting the streambanks themselves. The current adjacent landowner fences livestock from the stream and maintains a buffer of approximately 5 feet on average, but woody vegetation is sparse and relatively ineffective for bank stabilization. Some deciduous species, but mainly alders with a reed canarygrass understory. River right (opposite streambank from the hayfield) has more established riparian vegetation, but again limited in vegetation quality and diversity.

ELK 11-6 – Streambanks are generally comprised of fine gravel and lacustrine silt and clays. The rooting depth is relatively shallow and knapweed dominates several droughty terraces resulting in high erosion potential. The outside streambanks are characterized by a low and middle terrace, and are prone to erosion. Streambank heights are approximately 2 ft to 3 ft above the bankfull stage. The channel bed sediment distribution is bi-modal with coarse gravel surface material and high embeddedness with interstitial fines in the sub-surface bed material. The stream has a pool-riffle morphology, with the bed coarsening in a downstream direction. Riffles are underdeveloped with long glide features and associated pools generally lacking in cover, complexity and depth however, some deep lateral scour pools exist associated with large wood, mature alders, or the natural channel morphology. Undercut streambanks provide the primary cover through the reach. The 1997 flood appears to have affected the channel morphology. Past grazing and other land uses may have also affected channel stability. The channel generally downcut into the valley fill by as much as 2 feet relative to the low terrace which is the abandoned floodplain surface. The channel has limited meander belt width and is actively expanding the floodplain through erosion and accretion. Channel over-widening appears to be mainly from channel mobility and the confluence of two channel threads. Some residences and horses located near the stream, but livestock fenced from channel. At the upper end of the reach, the left floodplain and streambank is mowed and outdoor furniture is present. Floodplain riparian vegetation primarily consists of grass and forbs, reed canary grass, and pole-sized alders which replaced the historical western red cedar cover type. The cedars were most likely logged in the early 1900s similar to practices in other tributaries. The understory vegetation, from 5 ft to 15 ft in height, is comprised of mature and decadent alder. No overstory canopy exists with the exception of mature alders. Past and present vegetation

conversion is due primarily to channel instability and resultant increased sediment loading to the channel.

Based on the data reviewed, it appears that past disturbance to the riparian corridor continues to affect the Elk Creek watershed. Slightly elevated fines, active bank erosion, and increased width/depth ratios in the lower reaches, as well as low numbers of large woody debris indicate the affects of a disturbed riparian area. However, it is noted that current land use practices witnessed along the stream in some stretches of the lower Elk Creek valley have fenced off the riparian corridor in an attempt to allow stabilization of banks. It will likely take more time, and potentially additional stream restoration BMPs, before true riparian recovery is witnessed.

5.4.5 TMDL Development Summary

Based upon the results of **Sections 5.4.3**, the following streams will be included for TMDL development for sediment (**Table 5-23**). Sediment sources and estimates of sediment loads from those sources are investigated in **Section 5.5**, and the TMDLs and allocations of sediment load are presented in **Section 5.6**.

Table 5-23. Lower Clark Fork TPA waterbodies included in sediment TMDL development

Waterbody ID	Stream Segment	2008 Probable Causes of Impairment
MT76N003_040	**BULL RIVER,** the North Fork to the mouth (Cabinet Gorge Reservoir)	**Sedimentation/Siltation***; Physical Substrate Habitat Alterations*
MT76N003_180	**DRY CREEK**, headwaters to the mouth (Bull River) T28N, R33W	**Sedimentation/siltation**
MT76N003_090	**MARTEN CREEK**, headwaters to the mouth (Noxon Reservoir)	**Sedimentation/siltation,** *Physical Substrate Habitat Alterations*
MT76N003_140	**SWAMP CREEK**, Cabinet Mountains Wilderness boundary to the mouth (Noxon Reservoir)	*Insufficient data to assess*
MT76N003_120	**WHITE PINE CREEK**, headwaters to mouth (Beaver Creek)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetation covers*

5.5 SOURCE QUANTIFICATION FOR ALL WATERBODIES

Three major source categories of sediment have been identified in the Lower Clark Fork TPA. When developing TMDLs, sediment loads must be quantified for each significant source category, and where appropriate, strategies for reducing those loads from human caused sources must be developed such that streams meet all applicable water quality standards. This section describes the methodology, rationale, and assumptions in sediment load quantification and load reduction that is used as the basis for TMDLs for the tributaries of concern in the Lower Clark Fork.

5.5.1 Bank Erosion

Rivers and streams are dynamic, ever changing systems that are constantly seeking equilibrium with its surrounding environment. The size, force, and shape of these flowing waters fluctuate throughout the seasons, and over the years. As streams shift across the landscape, they inevitably cut a new path by which to flow, sometimes very slowly and subtly, and sometimes very dramatic and obvious. The resultant sediment load from the erosion enters the stream and becomes a component of the equation by which the stream tries to find its balance. Sediment from eroding banks may alter channel shape, alter the erosive properties of the stream itself, prohibit or encourage aquatic life and fisheries, and affect water chemistry and quality.

Bank erosion as a result of these shifts in direction and energy is a natural and necessary function of an active stream channel. However, in some cases bank erosion can be exacerbated or accelerated by human activities that result in altered bank stability or stream morphology. In investigating bank erosion as one source of the total watershed sediment load to derive the TMDL, methods were used to quantify sediment loads from eroding banks, identify the cause and effects of the eroding banks and therefore differentiate between existing and desired conditions (under all applicable land, water, and soil best management practices), and apply loads across the landscape to derive appropriate bank erosion loads at the watershed scale.

5.5.1.1 Quantifying Pollutant Sources

In 2008, a field study was conducted throughout the Lower Clark Fork watershed that investigated the sediment and habitat conditions in selected reaches for the streams of interest. In preparation for that study, an aerial assessment and GIS exercise was conducted to characterize the streams into representative reaches categorized by geomorphologic constraints independent of the influence of man, and sub-categorized further by the apparent influences land use, land cover, and local activities may have on an individual reach. From this assessment, sites were chosen for study to represent the variability in natural and anthropogenic influences throughout the watershed. For each site that was selected as part of the 2008 field study, an assessment of eroding banks was conducted for the entire length of the study site (generally 1000' in length). The data from this effort forms the basis for quantifying loads from individual banks and their associated conditions, and the extrapolated bank erosion load as a component of the Total Maximum Daily Load for sediment.

5.5.1.2 Bank Erosion Assessment

For each monitoring reach selected in the aerial photo assessment, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), in accordance with the Watershed Assessment of River Stability and Sediment Supply guidelines (Rosgen, 2006). BEHI evaluates the susceptibility to erosion for multiple erosional processes. The process integrates multiple variables that relate to "combined" erosional processes leading to annual erosion rates. Erosion risk is then established for a variety of BEHI variables and is eventually used to establish corresponding streambank erosion rates. (Rosgen, 2006)

As part of the field analysis, in addition to the information recorded for the physical character of the eroding bank and the near bank stress, each bank is categorized as either actively/visually eroding or slowly eroding/vegetated. Each bank is also assigned percent influence contributing to the erosion of the bank and distributed among natural and anthropogenic causes such as transportation, grazing, timber harvest, etc. Once sediment loading is generated for each analyzed bank in a given site, the sum of the bank loads is calculated to derive the total load for the sampled site.

5.5.1.3 Bank Erosion Sediment Loading

In order to determine sediment loading from bank erosion, information from the sites assessed in the field is used and a process developed to provide reasonable estimates to represent the total sediment loads from bank erosion for each watershed.

In the Lower Clark Fork, the sediment load for each eroding bank in a sampled reach was calculated, and then the total sediment load for that reach was summed. Sampled reaches were sorted by their Level IV ecoregion and stream order, and the average sediment loads (tons/1000') from these representative

groupings determined. Sediment loads were then applied to each of the delineated reaches in a given stream, according to its associated reach Level IV ecoregion and stream order, and normalized by the distance of the reach. For individual reaches where the sampled data existed, those loads were applied instead of the average reach category load. For reaches with a stream order of one, or a gradient greater than 4%, no sediment load was applied as it was assumed that these reaches, in most cases, were very steep, head water reaches that typically exhibited little to no bank erosion. All reach loads were then summed for each stream to produce the estimated existing sediment load based on field data.

The Bull River provided a challenge during this analysis and extrapolation effort. The stratification of reaches was based on ecoregion, stream order, valley confinement, and valley gradient. In general, these four categories provide enough information by which to group reaches, and provide reasonable assurance that similarly characterized reaches will exhibit a similar sediment loading character. In large part, this appears to hold true with many of the tributaries in the Lower Clark Fork. However, this method does not account for additional differences in stream character as described through the Rosgen stream classification system. Namely, the differences in character between Rosgen C and E types, which take into account meander patters (sinuosity) and width/depth ratios. Upon review of the data and through observations in the field, it was determined that E type reaches generally seemed to show higher bank erosion trends than B or C reaches in the Bull River watershed, and therefore should be distinguished with a different loading rate. Of the three reaches on the Bull River surveyed, one reach was considered an E channel, and two others were considered borderline C/E channels. None of the three reaches were deemed appropriate to represent a true Bull River B/C channel. As a result, it was determined that the average bank erosion load from the sampled Bull River reaches would represent the load associated with E type reaches, and the average load from the Swamp Creek sites exhibiting the associated reach grouping would represent B/C stream types. But, as the original stratification did not include Rosgen stream classification, another source of information was necessary to extrapolate the bank erosion sediment loads. A watershed characterization completed in 2004 by RDG contained information on Rosgen types for the Bull River, and was therefore used as the reference by which to apply the existing sediment loading rates (River Design Group, 2006).

Table 5-24 provides the average reach load information that was used to develop existing bank erosion sediment loads in the Lower Clark Fork tributaries.

Table 5-24. Average Streambank Erosion Sediment Load by Reach Grouping

Reach Grouping (Level IV ecoregion-stream order)	Sampled Reaches	Average Streambank Erosion Sediment Load per 1000' (tons/year)
15k-2	ELK 7-2, EFELK 8-1, EFELK 9-1, WPC 8-3, WPC 9-2, WPC 9-5	15.1
15k-3	EFELK 10-3, MC 9-1, SWP 21-2	10.6
15k-4	ELK 11-3, ELK 11-6	17.9
15o-2	NBMC 8-1, SBMC 3-1, WFELK 8-1	16.2
15o-3	MC 6-2	40.2
15q-2	SWP 18-1, DRY 9-2	8.3
15q-3	SWP 22-3, SWP 20-1, BULL 3-2, BULL 3-3, BULL 5-1	16.5/40.9*

* 16.5 tons/year is the average sediment load from the Swamp Creek sites (22-3, 20-1) which are used to represent B/C stream type loads in the Swamp and Bull River subwatersheds. 40.9 tons/year is the average sediment load from only the three Bull River sites (3-2, 3-3, 5-1) which are used to represent loads from E stream types in the Bull River system.

5.5.1.4 Establishing the Total Allowable Load

Once the existing bank erosion sediment load has been derived, the allowable load must be established by which to determine the target conditions and allocation of sediment reductions.

In some cases, establishing the total allowable load is done by simply comparing the results from those areas clearly influenced by human activities to those areas where conditions are in a more natural or properly managed 'reference' condition. In the Lower Clark Fork, a legacy of historic forest fires and widespread timber harvest had at one time significantly altered the landscape and in particular, changed the riparian character and bank stability such that these affects are still evident today, despite there being relatively limited current anthropogenic influence in most drainages. Although as many as 100 years have passed since some of these activities have occurred, the soils, geology, climate and hydrology of the region have made recovery from these impacts a very slow process, and as a result, the historic anthropogenic influences, particularly the logging and riparian harvest of cedars throughout the watershed, are the focus of the sediment reduction strategy from bank erosion.

Due to the widespread nature of the riparian harvest and historic anthropogenic affects, as well as the historic forest fires of the region, simple designation between anthropogenic influence, and natural or 'reference' conditions proved difficult. As such, in order to determine the allowable load and target condition for bank erosion, the overall length of bank erosion occurring within the sampled reaches was investigated. For each reach sampled, the percent of eroding streambanks was calculated, and the median percent eroding banks of all reaches determined to be 9%. The median was chosen because the sample set included a mix regarding the severity of bank erosion impact, and represents reaches both which were stable and functioning, and those obviously unstable and contributing to increased 'unnatural' sediment loading. Since in any stream environment, the dynamic nature of stream migration inherently is erosive and creates both slowly eroding and actively eroding banks, some bank erosion is expected, and indeed necessary for the balance and health of the overall system. As such, the 9% eroding banks was deemed an appropriate, allowable, and expected degree of bank erosion for stream systems in the Lower Clark Fork.

For each individual stream of interest, the average percent eroding banks for the sampled reaches of that stream was determined. The average percent eroding banks of the stream was then compared to the median percent eroding banks (9%) of the total sample population. For each stream, the existing load was then reduced by the percent reduction necessary for that stream to achieve an equivalent of 9% eroding banks, the result of which is the desired sediment load from eroding banks, or the allowable load. **Table 5-25** shows the results for each stream.

Table 5-25. Extrapolated Bank Erosion Loads and Reductions

Stream	Existing Bank Erosion Load	Average % Eroding Bank per sampled reach	Percent Reduction to Achieve Equivalent of 9% Eroding Bank	Resultant Load
Bull River	4689	29.1	69	1454
Dry Creek	93	16.7	46	50
Marten Creek	870	18.5	51	426
Swamp Creek	534	19.6	54	299
White Pine Creek	818	32	72	229
Elk Creek	1375	10	10	1238

5.5.1.5 Allocations and achievement

Since the sediment loading from bank erosion is a gross estimate based on limited data, the allocation is simply described as the percent reduction necessary to achieve the 9% eroding bank equivalent. This allocation thereby encompasses all adjacent land use categories and land management practices, and expects all land owners in the Lower Clark Fork TPA to manage their land with all applicable and reasonable land, water, and soil conservation practices that will protect, improve, and restore stable and healthy streambanks and riparian corridors. Also, because much of the instability in banks, and therefore the resultant sediment loads, is presumed to be due to historic land management practices, it is not anticipated that current land owners bear the full responsibility for immediate recovery to the desired conditions. Rather, it is acknowledged that recovery to stable banks and improved and established riparian vegetation communities may take many decades to achieve. It is encouraged that, in addition to managing current activities with all reasonable land, soil, and water conservation practices, management decisions to promote floodplain functionality and native vegetation establishment throughout the riparian corridor will be reviewed and implemented wherever and whenever possible.

Historic influences on current bank erosion may be a large factor in the current condition of stream banks throughout the Lower Clark Fork TPA; however it is certainly not the only factor. Although it may be difficult to use aerial photography and GIS methodology to discern between bank erosion influenced from historic practices, and bank erosion as a result of natural processes, it is possible to identify potential present-day influencing factors with these methods. Through the stratification process used as part of the Lower Clark Fork assessment method, information on adjacent land use and potential current influences on bank erosion was collected. This data can be used to help assist land managers with prioritizing areas, or focusing on issues to be addressed to expedite sediment load reduction and eventually achieve the TMDL. This data is presented in **Table 5-26** below. It is acknowledged that the developed sediment loads and the method by which to attribute anthropogenic and historic influence are estimates based on aerial photography, best professional judgment, and limited access to each stream reach. The assignment of bank erosion loads to the various causes is not definitive; however it does provide helpful guides for directing focus and efforts at reducing the loads from those causes which are likely having the biggest impacts on the investigated streams. Complete TMDLs and allocations are presented in **Section 5.6**.

Table 5-26. Percent Adjacent Land Uses as Identified through GIS/Aerial Imagery with Potential Influence on Bank Erosion

Watershed	Natural/Historic	Transportation	Grazing	Cropland	Mining	Timber Harvest
Bull	35	18	40	-	-	7
Dry	87	9	-	-	-	4
Marten	60	22	6	-	-	12
Swamp	74	8	16	2	-	-
White Pine	73	-	9	-	1	1
Elk	56	12	31	-	-	2

5.5.1.6 Assumptions and Considerations

- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies developed in Colorado. While the predominant geologies between the Colorado research sites and the Lower Clark Fork are different, they are similar enough in character to warrant their application.

- The bank erosion data collected during the 2008 field effort is representative of conditions throughout the Lower Clark Fork watershed.
- The present day erosion has been, and continues to be, affected by the historic clearing of cedars and other past riparian harvest activities, in addition to other disturbances to the riparian corridor (both anthropogenic and natural, in the case of fires).
- Most tributaries in the LCF-TPA typically exhibit A, B, or C Rosgen stream types, however the Bull River is the only stream that exhibits a significant amount of E channel character to warrant a specific loading extrapolation scenario to account for this.
- The target of 9% eroding bank is a reasonable expectation of normal, natural conditions assuming riparian corridor vegetation was mature and stable.

5.5.2 Sediment from Roads

Roads located near stream channels can impact stream function through a degradation of riparian vegetation, channel encroachment, and sediment loading. The degree of impact is determined by a number of factors including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of Best Management Practices (BMPs). In the Lower Clark Fork watershed, sediment from roads has been identified as one of three major source categories potentially affecting sediment loads in impaired tributary streams.

In 2009, DEQ estimated sediment loads for unpaved road crossings and parallel segments in the Lower Clark Fork through a combination of GIS analysis, field assessment, and computer modeling. The results of that effort were used to develop load calculations and load reduction allocations for sediment listed streams. The report from that effort is presented here as **Attachment 1**.

5.5.2.1 Quantifying Sediment From Roads

In order to determine the amount of sediment from roads, computer models are often used that simulate road surface erosion response to the hydrology and climate for a given area. These models take into account weather, road condition, road shape, road orientation, topography, buffering vegetation, and other factors. Most models require a certain amount of known field evaluation to use as input parameters to derive the loads from discrete locations, however depending on the size of the watershed, a subset of the sediment load from roads may be based on real data, with the results of the model extrapolated to the remaining roads.

In 2009, using road information provided by the Kootenai National Forest (KNF), crossings and parallel segments in the road network were identified and classified relative to 6th code subwatershed (with the separation of Dry Creek from Upper Bull River), land ownership, soil erosion hazard class, and road type. Then, a total of 43 unpaved crossings and 19 parallel segments were evaluated in the field to provide a subset of data related to these road attributes. **Table 5-27** provides a summary of road statistics for each assessed 6th code subwatershed.

Assessment of data from the field evaluation was conducted using the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length,

road width, fill grade, fill length, buffer grade, and buffer length). In addition, supplemental data was collected on vegetation condition of the buffer, evidence of erosion from the road system, and potential for fish passage failure.

Table 5-27. Road Statistics for Streams in the Lower Clark Fork TPA

Watershed	Watershed Area (sq mi)	Road Density (mi/sq mi)	Number of Crossings	Road Miles	Stream Miles	Unpaved Road Length Within 100' of the stream
Dry Creek	14.1	1.9	17	26.4	31.7	0.8
Bull River	203.8	1.1	111	218.9	408.1	6.9
Marten Creek	71.1	1.9	82	134.0	143.5	4.9
Swamp Creek	54.7	0.6	15	31.2	98.2	1.0
White Pine Creek	36.2	3.3	62	118.0	70.9	4.1
Elk Creek	84.4	1.9	98	162.5	160.0	6.8

5.5.2.2 Sediment from Road Crossings

Often, the majority of sediment loading from roads occurs at road crossings. Road crossings may act as a direct conduit to the stream since these intersections of road and stream are natural drainage locations and often have limited capacity for buffering or diverting sediment laden runoff from the road. The contributing sediment load at road crossings is a function of the road length and condition that leads directly to the crossing, and the other physical and hydrologic characteristics of the immediate area. Addressing road/stream crossings and their contributing sediment load is an important component to managing the sediment load from road networks.

For the purposes of estimating the sediment load from each road crossing in the Lower Clark Fork TPA, the average of all field sites by ownership category assumes that the random subset of crossings assessed as part of this study is representative of the road crossing conditions in each of the six watersheds. Due to accessibility issues, unpaved privately-owned road crossings were not assessed in the Bull River and White Pine Creek watersheds, and one privately-owned crossing was selected in the field in the Marten Creek watershed that was not randomly chosen in the original Sampling and Analysis Plan. The average result from stream crossings on privately owned land in the Swamp Creek and Elk Creek watersheds was used to represent the sediment load on private land.

The road network was classified by major landowner within each watershed, as various entities and administrative controls direct operation and maintenance of the road network. Three major landowner classifications were identified: Federal lands, State of Montana, and private landowners. Mean sediment loads from field assessed sites were used to extrapolate existing loads for each ownership class in each listed watershed. Extrapolation of these results to the remainder of road crossings assumes that the random subset of crossings assessed as part of this study is representative of each of the six watersheds.

5.5.2.3 Sediment from Parallel Segments

Sediment from road/stream crossings addresses the sediment contributed from discrete locations in a watershed where the road and stream intersect. However, road sediment as a result of erosion from those sections of road which may not have a direct entry point to the stream channel is also considered in many source assessment studies and included with the overall sediment load quantification.

Mean sediment loads were calculated for parallel road segments in White Pine Creek watershed, Marten Creek watershed, and Elk Creek watershed. These segments constituted a subset of the overall

parallel segments and, as with the road crossing assessment, were classified by land ownership, (however no discernable difference was noted in loading rates between private and Federal segments).

The annual sediment load from each parallel segment was normalized to a per mile sediment load; the normalized results were averaged to represent the six watersheds. Extrapolation of these results to the remainder of parallel segments assumes that the random subset of parallel segments assessed as part of this study is representative of the larger watershed.

In addition to the sediment that is produced from the surface erosion of native or gravel roads, winter maintenance of roads of all surface types may produce an additional sediment load. The quantity of traction sand applied to the roads in the Lower Clark Fork TPA was estimated as 10 cubic yards for 85 lane miles (42.5 road miles, 0.28 tons/mile). The Sanders County Road Department usually plows and re-applies traction sand every day (depending on snowfall) for four to five months in the winter. This would equate to 28 tons/mile/year assuming a five day work week, for five months. The Noxon Section, Montana Department of Transportation (MDT) estimates that, in the past, 10 cubic yards of sand was applied to 15 miles of road along the Bull River (0.83 tons/mile); however MDT has discontinued the use of sand in favor of using salt.

The Blackfoot Headwaters TMDL Unpaved Roads assessment assumed a delivery rate of 10% for roads within 100 feet of surface water, and 5% for those roads within 200 feet. Using this as a guideline, watersheds with paved roads where traction sand is applied were assumed an additional sediment load based on 5-10% of the Sanders County traction sand application rate and miles of paved road within proximity to the stream.

5.5.2.4 Establishing the Total Allowable Load

In order to determine the reductions necessary to achieve a desired condition, or total allowable load from roads, a scenario was developed to simulate the application of Best Management Practices (BMPs) on the unpaved road network. In this case, BMP sediment reduction was evaluated based on a reduction in contributing road length.

The resultant sediment loads from the BMP scenario for estimating sediment load reductions was calculated by assuming a uniform reduction in contributing road length to 200 feet for each unpaved road crossing, and 400 feet for each parallel segment. For those sites assessed with less than 200 feet contributing length for crossings, and 400 feet for parallel segments, the original sediment load derived was retained. Average annual reduced mean sediment loads were then extrapolated to the entire watershed in the same manner in which the existing loads were calculated. Estimated summary load reductions by watershed are shown in **Table 5-28**.

Table 5-28. Sediment Loads from Roads and BMP Reductions

Watershed	Ownership	Existing Road Crossing Load	BMP Road Crossing Load	Existing Parallel Segment Load	BMP Parallel Segment Load	Total Existing Load	Total BMP Load
Bull	Federal	12.2	3.5	3.6	2.0	15.8	5.5
	State	0.1	0.1	0.5	0.3	0.6	0.4
	Private	4.4	1.3	1.0	0.4	5.4	1.7
	Total	16.7	4.9	5.1	2.7	21.8	7.6
Dry	Federal	2.4	0.7	0.7	0.4	3.1	1.1

Table 5-28. Sediment Loads from Roads and BMP Reductions

Watershed	Ownership	Existing Road Crossing Load	BMP Road Crossing Load	Existing Parallel Segment Load	BMP Parallel Segment Load	Total Existing Load	Total BMP Load
Marten	Federal	11.2	3.2	4.0	2.2	15.2	5.4
	Private	0.5	0.1	0.1	0.0	0.6	0.1
	Total	11.7	3.3	4.1	2.2	15.8	5.5
Swamp	Federal	0.8	0.2	0.2	0.1	1.0	0.3
	Private	2.1	0.6	0.6	0.2	2.7	0.8
	Total	2.9	0.8	0.8	0.3	3.7	1.1
White Pine	Federal	8.1	2.3	3.3	1.8	11.4	4.1
	Private	0.9	0.3	0.1	0.0	1.0	0.3
	Total	9.0	2.6	3.4	1.8	12.4	4.4
Elk	Federal	7.3	2.1	3.3	1.8	10.6	3.9
	Private	10.6	3.2	2.4	0.9	13.0	4.1
	Total	17.9	5.3	5.7	2.7	23.6	8.0

Due to the extent of the unpaved road network and the resulting inability to assess it in its entirety, generalized assumptions are necessary for modeling the effects of BMPs. On average, it was found that a 71% reduction in sediment from road crossings could be achieved based on the contributing road length reduction results. For parallel segments, on average a 45% reduction could be achieved from State or Federal roads, and a 64% reduction could be achieved from private road segments. Restoration efforts would need to consider site-specific BMPs that, on average, would be represented by the modeling assumptions. Other management issues that will impact BMP scenarios are the ability to perform restoration work within different land ownership categories.

5.5.2.5 Determining Allocations

Allocations for the reduction of sediment from roads in the Lower Clark Fork are presented as a percent reduction as a function of land ownership, by watershed. It is expected that the maintenance of roads and ultimate achievement of the allowable load is the responsibility of those individuals or entities that control and manage the roads. As stated previously, although the WEPP model does not specifically model BMPs, the reduction in contributing road length allows a simulation in the sediment reduction that would occur if some BMPs were installed. These management practices may be accomplished through a variety of measures that would lead to reduced sediment loading from the road network, such as the installation of structural BMPs (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.

It is recognized that in reality, in some cases the majority of the sediment load may come from only a few discrete locations within a watershed, or some roads may currently have some or all of their roads addressed with appropriate BMPs and the allocations may already have been met. It is expected however, that the derived sediment load and expected reductions in this document serve as a starting point for road management investigations, and a guideline for where to begin additional studies to improve and refine these estimates. Complete TMDLs and allocations are presented in **Section 5.6**.

5.5.2.6 Assumptions and Considerations

- The sites assessed are representative of conditions throughout the Lower Clark Fork watershed.

- The contributing road length reduction as simulated in WEPP represents the likely achievable reductions in sediment load that can be gained from Best Management Practice application throughout the watershed.
- GIS identification of parallel segments and road crossings is reasonably accurate.
- Focusing on road/stream crossings and their associated approaching road lengths will effectively reduce the majority of the sediment load from roads.
- BMPs may have already have been implemented on roads but have not been accounted for in the GIS information used in this analysis and therefore the reductions necessary by land owner may be less than described in this document.

*At the time of production of this public review document, information regarding road obliteration projects that may not have been accounted for in the GIS road layers used for this analysis was brought to the attention of DEQ that may reduce the reductions necessary, and alter the summary statistics for some subwatersheds. This information will be reviewed and updated, if necessary, for the final TMDL document.

5.5.3 Upland Sediment

Nonpoint source pollution is pollution that originates over many varied and diffuse sources, where as pollution delivered directly from a specific point or outlet, such as an end of pipe or chimney stack, is known as point source pollution. Typically, non point source pollution is carried to streams and lakes through erosion via surface water (in the form of rainfall or snowmelt), ground water, or wind. It is often difficult to accurately quantify pollutant loads from the landscape when so much variability exists in weather, vegetation, land use practices, soil types, geology, and riparian condition occurs throughout a watershed. However, while many complex processes are intertwined that determine this load, models with varying levels of complexity can be employed to represent the landscape and simulate the processes that occur that allow us to reasonably estimate sediment loads, identify where on the landscape those loads are coming from, and intimate how those loads could be reduced.

In the Lower Clark Fork, three main categories of pollution sources for sediment have been identified: sediment from roads, sediment from bank erosion, and sediment from upland sources. As sediment from bank erosion and sediment from roads have been addressed via alternative methods, a USLE model is used to determine sediment from upland sources, and refers to the sediment from the landscape that is delivered to the stream via overland runoff from rainfall and snowmelt.

5.5.3.1 Quantifying Sediment from Upland Sources Using USLE

Upland sediment loading due to hillslope erosion was modeled using an application of the Universal Soil Loss Equation (USLE) with GIS. In addition, a sediment delivery ratio was incorporated to better simulate the relationship between downslope travel distance and ultimate delivery to the stream. Further, 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, riparian zone health and its effect on sediment delivery was also incorporated into the sediment delivery ratio. This model provided an assessment of existing sediment loading from upland sources, an assessment of potential sediment loading through the application of BMPs and riparian improvement, and an additional scenario to simulate potential sediment loading before human alterations of the land cover.

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

ArcGIS and available data sources were used to develop the appropriate USLE factor values to estimate upland sediment loading. Typically, the ability to modify change to vegetation cover or field practices is the only real way to simulate landscape or land management alterations using USLE. As the P-Factor (field practices) generally relates to specific agricultural plots and at a scale much less than the watershed-scales we are dealing with, the C-Factor is the main variable to represent existing conditions and the potential for improvement. For the Lower Clark Fork TPA, the 2001 National Land Cover Dataset, NRCS C-Factor tables, and the assistance and input of local NRCS and USFS employees served as the basis for establishing the C-Factors for the Lower Clark Fork tributary watersheds.

The riparian corridor quality assessment used to modify sediment delivery to the stream, is taken from the report, "Lower Clark Fork River Drainage Habitat Problem Assessment" (GEI Consultants, Inc., 2005). Riparian corridors are referred to as having low (marginal/limited), moderate (some good, some marginal), or high (majority adequate for aquatic resources) quality and the buffering capacity of the riparian corridor is based on the percent condition for each stream of interest. Existing condition upland sediment loads are presented in **Table 5-29** below. Full details of the upland sediment modeling effort are documented in the report, Lower Clark Fork Tributaries Watershed Sediment Contribution from Hillslope Erosion, (Confluence, Inc., 2009) the text of which is included in **Attachment 2**.

5.5.3.2 Establishing the Total Allowable Load

From the model output, an average annual sediment load delivered to the stream is determined for each subwatershed, (or listed stream watershed). This sediment load represents the best estimation of current conditions resulting in sediment from upland sources.

The initial model outputs represent an estimate of current conditions and practices that result in the upland sediment load. To determine the total allowable load from upland sources, land use/land cover categories where management practices may be improved are modified (through an alteration to the C-Factor, or vegetative condition) to represent those changes on the landscape, and the USLE model is run again to simulate the resultant sediment loads that exist when all reasonable land, soil, and water conservation practices are employed.

For the purposes of this assessment, only a few land use categories were modified. These include grassland/herbaceous, pasture/hay, transitional, and cultivated crops. It is assumed that in the Lower Clark TPA, these land use categories have real potential for improvement and are often not meeting all applicable land, soil, and water conservation practices. The sediment contributions from the other land uses in the Lower Clark Fork TPA are presumed to be either negligible in their contribution, or with little potential for altering the current management to reduce sediment contribution from the existing load. In addition, riparian corridor buffering efficiency was altered to reflect an increase from moderate quality riparian health to high quality, and from areas with low quality riparian health to an improved moderate quality.

For the purposes of TMDL development, three scenarios were run in the model. The existing condition scenario (Scenario 1) represents the current sediment loads for the watersheds of interest in the Lower Clark Fork TPA. Scenario 2 represents the reduction in sediment load if only riparian condition were improved. Scenario 3, the improved condition scenario, represents the changes that would occur with improved land management practices, including restoration of the riparian buffers to filter sediment from the landscape. The improved condition scenario provides the desired, or allowable, sediment load from upland erosion which is used in combination with the allowable loads from bank erosion and roads to develop the TMDL. The results and estimated sediment reductions necessary from upland erosion are presented in **Table 5-29**.

Table 5-29. Upland Modeling Results

Watershed	Scenario 1*	Scenario 2**	Percent Change From Existing	Scenario 3***	Percent Change From Existing
Bull River	8118.8	6053.4	25%	5796.3	29%
Dry Creek	482.7	331.5	31%	330.5	32%
Marten Creek	5282.0	3256.2	38%	3214.2	39%
Swamp Creek	2618.9	2095.4	20%	2008.9	23%
White Pine Creek	1977.7	1404.6	29%	1346.4	32%
Elk Creek	4257.4	2626.5	38%	2595.2	39%

*Upland Erosion Sediment Load for Existing Conditions

**Upland Erosion Sediment Load for Existing Upland Conditions and BMP Riparian Health

***Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (All BMPs)

Lastly, a historical condition scenario was run. The last scenario was completed not as a target condition, but simply to compare the existing condition to the historical condition to investigate the effects historic timber harvest and fire may have had on past sediment loads. Some observations of the historic scenario results include:

- The 1910 fire affected the most subwatersheds and represented the largest area of disturbance for the 1910-1919 time periods.
- From 1910-1939, the predominant transitional polygon type was fire. After 1960, the predominant transitional polygon type was timber harvest.
- The Marten Creek watershed has experienced a large fire or harvest impact in almost every decade reviewed, except 1940-49, and 1980-89.
- Most events in most subwatersheds have marginal estimated effect on total sediment delivered from upland sources. Severe events such as the 1910 fires are estimated here to have resulted in a 20-30% increase in annual sediment delivery.

The complete results of the historic scenario are presented in **Attachment 2**.

5.5.3.4 Determining Allocations

The upland sediment loads are estimations based on the land uses that exist within a watershed, and combination of climate, geology, geography and other related factors that drive sediment production as described earlier in this section. Further assumptions are made regarding the riparian condition and the ability for improved riparian conditions to effectively reduce sediment loading to the stream. For the purposes of allocating the load amongst the sources, sediment loads from upland erosion are investigated by the land use/land cover classification as identified by the NLCD information. In addition, while only a few land cover classifications were selected to simulate reductions through BMPs, it should be noted that the potential for riparian improvement occurs throughout the watersheds regardless of

land cover classification, and that typically riparian improvement constitutes the greatest potential for upland sediment reduction in the Lower Clark Fork, as well as a significant role in stabilizing banks and improving sediment loading from bank erosion as was discussed in **Section 5.5.1**. Complete TMDLs and allocations are presented in **Section 5.6**.

5.5.3.5 Assumptions and Considerations

As with any modeling effort, and especially when modeling at a watershed scale, there are a number of assumptions that must be accepted. For the Lower Clark Fork, the following points serve as some of the more significant considerations:

- The input variables used in the USLE calculations are representative of their respective land use conditions.
- The land management practices (grazing duration, hay cutting, etc) for certain land use categories that define the vegetative cover are relatively consistent and representative of practices throughout the watershed.
- The riparian condition as estimated through the aerial assessment is representative of on-the-ground conditions.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.
- The USLE model provides an appropriate level of detail and is sufficiently accurate for developing upland sediment loads for TMDL purposes.
- The data sources used are reasonable and appropriate to characterize the watershed and parameterize the model.
- The riparian health assessment is of sufficient accuracy, resolution and coverage to serve as the basis for a sediment delivery ratio.
- Megahan and Ketchesons dimensionless equation is appropriate to relate travel distance and delivered volume as the basis for a sediment delivery ratio (Megahan and Ketcheson, 1996).

5.6 TMDL AND ALLOCATIONS (BY STREAM)

The sediment TMDLs for all streams and stream segments presented in **Tables 5-30 – 5-34** 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. These reductions address both coarse and fine sediment loading to ensure full protection of beneficial uses. The allocations are based on information provided from the source assessment analyses used within this document, and a determination that these approximate source load reductions for each stream or segment of interest, and its contributing tributaries, will cumulatively account for the total percent reduction needed to meet the TMDL, and is achievable by addressing the major human caused sources described in this section. The sediment load allocations and associated rationale behind the allocations are described in **Section 5.5** and **Appendices D-G**. Due to the uncertainty and assumptions associated with the methods used to determine sediment loads, the specific annual loads should not necessarily be recognized as an exact quantification. However the percent reductions presented offer a valuable and more conceivable goal for watershed restoration planning purposes and an accurate representation of the *degree* of sediment reduction that would result from the implementation of this plan. As required by EPA, TMDLs must also be expressed as actual daily loads. Information on interpreting these values into “daily” sediment loads is presented in **Appendix E**.

Sediment from upland erosion in the following tables is represented as the sum of upland sediment load from each of the land uses within that watershed. This category, by default, incorporates both sediment loads influenced by anthropogenic activities and natural loads. However, within the context of TMDL development and Montana state law, we can interpret the natural load to be the load that results when all reasonable land, soil, and water conservation practices are applied, which in this case, also equates to the sediment load allocation.

A TMDL is determined by the sum of the Waste Load Allocation (WLA), Load Allocation (LA), and Margin of Safety (MOS). Waste Load Allocations are derived for specific point sources, often which require local, state, or federal permits that put limits on the amount of a particular pollutant that a nearby waterbody can receive. There are no WLAs identified in the Lower Clark Fork tributaries of interest.

5.6.1 Bull River

Table 5-30. Bull River Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion		4689	1454	69%
Roads	Federal	18.8	6.6	
	State	0.6	0.4	
	Private	5.4	1.7	
Total Road		24.8	8.7	65%
Upland Load	Urban	12.5	7.2	
	Forest	5869	4257.3	
	Wetland	12.1	7.2	
	Shrub/Scrub	1412.2	1082.8	
	Transitional	136.1	46.9	
	Grassland/Herbaceous	668.1	388.1	
	Barren land	5.0	4.8	
	Pasture/Hay	2.5	1.4	
	Cultivated Crops	1.3	0.6	
Total Upland Load		8118.8	5796.3	29%
Total Sediment Load		12,832.6	7259	41%

5.6.2 Dry Creek

Table 5-31. Dry Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion		93.2	55.9	40%
Roads	Federal	3.1	1.1	
Total Road		3.1	1.1	66%
Upland Load	Forest	453.8	313.9	
	Wetland	0.1	0.1	
	Shrub/Scrub	23.7	14.7	
	Grassland/Herbaceous	5.2	1.9	
Total Upland		482.7	330.5	32%
Total Sediment Load		579.0	387.5	33%

5.6.3 Marten Creek

Table 5-32. Marten Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion		869.5	469.5	46%
Roads	Federal	15.2	5.4	
	Private	0.6	0.1	
Total Road		15.8	5.5	65%
Upland Load	Urban	1.2	0.6	
	Forest	4227.5	2628.1	
	Wetland	6.4	4.0	
	Shrub/Scrub	890.0	534.1	
	Transitional	114.4	35.4	
	Grassland/Herbaceous	42.5	12.1	
Total Upland		5282.0	3214.2	39%
Total Sediment Load		6167.3	3689.2	40%

5.6.4 Swamp Creek

Table 5-33. Swamp Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion		533.7	272.2	49%
Roads	Federal	1.0	0.3	
	Private	2.7	0.8	
Total Road		3.7	1.1	70%
Upland Load	Urban	0.7	0.5	
	Forest	1779.0	1428.5	
	Wetland	2.7	2.2	
	Shrub/Scrub	534.4	420.5	
	Transitional	10.8	4.1	
	Grassland/Herbaceous	282.4	148.4	
	Barren Land	0.1	0.1	
	Pasture/Hay	6.8	3.6	
	Cultivated Crops	2.0	0.9	
Total Upland		2618.9	2008.9	23%
Total Sediment Load		3156.3	2282.2	28%

5.6.5 White Pine Creek

Table 5-34. White Pine Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Bank Erosion		817.9	253.6	69%
Roads	Federal	11.4	4.1	
	Private	1.0	0.3	
Total Road		12.4	4.4	65%

Table 5-34. White Pine Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Upland Load	Forest	1628.8	1617.1	
	Wetland	1.4	0.9	
	Shrub/Scrub	160.4	107.0	
	Transitional	124.5	42.9	
	Grassland/Herbaceous	60.9	27.6	
	Pasture/Hay	0.3	0.2	
	Cultivated Crops	1.5	0.7	
Total Upland		1977.7	1346.4	32%
Total Sediment Load		2808	1604.4	43%

5.7 SEASONALITY AND MARGIN OF SAFETY

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Lower Clark Fork TPA tributary sediment TMDL development process.

5.7.1 Seasonality

The seasonality of sediment impact to aquatic life is taken into consideration in the analysis within this document. Sediment loading varies considerably with season. For example, sediment delivery increases during spring when snowmelt delivers sediment from upland sources and the resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportion of deposited fines in critical areas for fish spawning and insect growth. While fish are most susceptible to fine sediment deposition seasonally during spawning, fine sediment may affect aquatic insects throughout the year. Because both fall and spring spawning salmonids reside in the Lower Clark Fork TPA, streambed conditions need to support spawning through all seasons. Additionally, reduction in pool habitat, by either fine or coarse sediment, alters the quantity and quality of adult fish habitat and can, therefore, affect the adult fish population throughout the year. Thus, sediment targets are not set for a particular season, and source characterization is geared toward identifying average annual loads. Annual loads are appropriate because the impacts of delivered sediment are a long-term impact—once sediment enters the stream network, it may take years for sediment loads to move through a watershed. Although an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation, to meet EPA requirements daily loads are provided in **Appendix E**.

5.7.2 Margin of Safety

Incorporating a margin of safety (MOS) is a required component of TMDL development. 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 sustain conditions that will support beneficial uses. 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 help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (see **Section 5.4.1**).
- By using supplemental indicators to help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during supplemental indicator development (see **Section 5.4.1**).
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and road and agricultural BMP effectiveness (see **Appendices B**, **D, E, and F**).
- By considering seasonality (discussed above).
- 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 and in **Section 6.0** and **7.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) to establish the TMDLs and allocations. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.

5.7.3 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes related to sediment. The assessment methods and targets used in this study to characterize impairment and measure future restoration are each associated with a degree of uncertainty. This TMDL document includes monitoring and adaptive management strategies to account for uncertainties in the field methods, targets, and supplemental indicators. For the purpose of this document, adaptive management 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. Adaptive management addresses important considerations, such as feasibility and uncertainty in establishing targets. For example, despite implementation of all restoration activities (**Section 7.0**), the attainment of targets may not be feasible due to natural disturbances, such as forest fires, flood events, or landslides.

The targets established in the document are meant to apply under median conditions of natural background and natural disturbance. The goal is to ensure that management activities achieve loading approximate to the TMDLs within a reasonable timeframe and prevent significant excess loading during recovery from significant natural events. Additionally, the natural potential of some streams could preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluations. Supplemental indicators are used to help with these determinations. In these circumstances, it is important to recognize that the adaptive management approach provides the flexibility to refine targets and supplemental indicators as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

Sediment limitations in many streams in the Lower Clark Fork TPA relate to both coarse and fine sediment. In general, roads and upland sources produce mostly fine sediment loads, while streambank erosion can produce all sizes of sediment. Because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each watershed. Instead, source assessment model results should be considered used as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources.

Cumulatively, the source assessment methodologies address average sediment source conditions over long timeframes. Sediment production from both natural and human sources is driven by storm events. Pulses of sediment are produced periodically, not uniformly, through time. Separately, each source assessments methodology introduces different levels of uncertainty. For example, the road erosion method focuses on sediment production and sediment delivery locations from yearly precipitation events. The analysis did not include an evaluation of road culvert failures, which tend to add additional sediment loading during large flood events and would, therefore, increase the average yearly sediment loading if calculated over a longer time period. The bank erosion method focuses on both sediment production and sediment delivery and also incorporates large flow events via the method used to identify bank area and retreat rates. Therefore, a significant portion of the bank erosion load is based on large flow events versus typical yearly loading. The hillslope erosion model focuses primarily on sediment production across the landscape during typical rainfall years. Sediment delivery is partially incorporated based on distance to stream. The significant filtering role of near-stream vegetated buffers (riparian areas) was incorporated into the hillslope analysis, resulting in proportionally reduced modeled sediment loads from hillslope erosion relative to the average health of the vegetated riparian buffer throughout the watershed.

Because the sediment standards relate to a waterbody's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses, the percent-reduction allocations are based on the modeled upland and riparian BMP scenarios for each major source type. The allocations reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. However, if new information becomes available regarding the feasibility or effectiveness of BMPs, adaptive management allows for the refinement of TMDLs and allocations.

Additionally, as part of this adaptive management approach, shifts in the amount or intensity of land use activities should be tracked and incorporated into the source assessment to determine if allocations need to be revised. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

6.0 OTHER PROBLEMS/CONCERNS

6.1 POLLUTION 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 Lower Clark Fork Tributaries TPA may appear on the 303(d) List but may not always require TMDL development for a pollutant, but do have pollution listings such as "alteration in stream-side or littoral vegetation covers" that could be linked to a pollutant. These habitat related pollution causes are often associated with sediment issues, or potential sediment 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 attempting to improve water quality conditions in individual streams, and the Clark Fork watershed as a whole. In some cases, pollutant and *pollution* causes are listed for waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the pollution listings. **Table 6-1** presents the *pollution* listings in the Lower Clark Fork Tributarues TPA, and notes those streams listed that do not have any associated pollutant listings.

Table 6-1. Waterbody segments in the Lower Clark Fork Tributaries TPA with pollution listings related to the 2008 303(d) List pollutants of concern addressed in this document

Waterbody ID	Stream Segment	2008 Probable Causes of Impairment
MT76N003_030	**Beaver Creek*,** headwaters to the mouth (Confluence with the Clark Fork River)	*Alteration in stream side or littoral vegetation covers*
MT76N003_040	**Bull River,** the North Fork to the mouth (Cabinet Gorge Reservoir)	*Physical substrate habitat alterations*
MT76N003_080	**Graves Creek*,** headwaters to the mouth (Clark Fork River)	*Alteration in stream side or littoral vegetation covers*
MT76N003_090	**Marten Creek,** headwaters to the mouth (Noxon Reservoir)	*Physical substrate habitat alterations*
MT76N003_100	**Pilgrim Creek*,** headwaters to the mouth (Cabinet Gorge Reservoir)	*Physical substrate habitat alterations*
MT76N003_190	**Rock Creek*,** headwaters to mouth below the Noxon Dam	*Alteration in stream side or littoral vegetation covers*
MT76N003_130	**Vermillion River*,** headwaters to the mouth (Noxon Reservoir)	*Alteration in stream side or littoral vegetation covers*
MT76N003_120	**White Pine Creek,** headwaters to the mouth (Beaver Creek)	*Alteration in stream side or littoral vegetation covers*

* Streams listed for *pollution* only, and have no associated sediment pollutant listings.

6.2 POLLUTION CAUSES OF IMPAIRMENT DESCRIPTIONS

Pollution 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 pollution categories are linked and appear together in the cause listings, however a pollution category may appear independent of a pollutant listing. The following discussion provides some rationale for the

application of the identified pollution causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteratation in Stream-side or Littoral Vegetation Covers
Alteration in stream-side or littoral vegetation covers refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the stream-side vegetation, destabilized banks from loss of vegetative root mass could lead to over-widened stream channel conditions, elevated sediment loads, and the resultant lack of canopy cover can lead to increased water temperatures.

Physical Substrate Habitat Alterations
Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from anthropogenically 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.

6.3 MONITORING AND BMPS FOR POLLUTION AFFECTED STREAMS

Streams listed for *pollution* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment and temperature information where data is minimal and the linkage between probable cause, pollution listing, and affects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 7** and **8** are presented to address pollutant and issues for Lower Clark Fork tributaries, are equally applicable to streams listed for the above pollution categories.

7.0 FRAMEWORK WATER QUALITY RESTORATION STRATEGY

7.1 SUMMARY OF RESTORATION STRATEGY

This section provides a framework strategy for water quality restoration in the Lower Clark Fork watershed, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document. This section identifies which activities will contribute the most reduction in pollutants for each TMDL. Limited information about spatial application of each restoration activity will be provided.

This section should assist stakeholders in developing a more detailed adaptive Watershed Restoration Plan (WRP) in the future. The locally-developed WRP will likely provide more detailed information about restoration goals and spatial considerations within the watershed. The WRP may also encompass broader goals than the focused water quality restoration strategy outlined in this document. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, sequences of projects, prioritizing types of projects, and funding sources towards achieving local watershed goals, including water quality improvements. Within this plan, the local stakeholders would identify and prioritize streams, tasks, resources, and schedules for applying Best Management Practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, this strategy could be adapted and revised by stakeholders based on new information and ongoing improvements.

Although no formal TMDL document or WRP has been developed for the Lower Clark Fork tributaries previously, it should be noted that the Lower Clark Fork Tributaries TPA has seen a considerable amount of restoration activity over the years. Some of the practices outlined in the sections below have been or are currently being implemented throughout the LCFT-TPA, and focused management strategies have been written independently for multiple drainages. The TMDL document provides a broad watershed assessment for specific streams and specific pollutants or water quality/stream habitat issues. The TMDL document should be used in combination with other assessments and resources that provide information at a further detailed scale to assist in the identification of specific areas of concern and potential restoration projects that will ultimately lead to the achievement of the TMDL. These resources, along with the TMDL, should form the basis for the development of the WRP, such that restoration efforts are developed into the most efficient and effective strategies possible. The following documents are examples of assessments that have been completed which should be considered to develop a greater understanding of the issues affecting the Lower Clark Fork Tributaries TPA:

- *Green Mountain Watershed Project Implementation Plan*. GMCD, 1998
- *A Stream Habitat Inventory of Pre and Post Restoration Conditions of the Elk Creek (Heron) Drainage, 1997 and 1998*. Watershed Consulting, 1998
- *West Fork Elk Creek/Deer Creek/Beaver Creek Assessment Report*. (Watershed Consulting LLC, 1999)
- *Draft Phase 1/Phase 2 Total Maximum Daily Load Report for Pilgrim Creek, Northwest Montana*. USFS/River Design Group, 2003
- *Pilgrim Creek Watershed Assessment and Conceptual Design Report*. USFS/River Design Group, 2004
- *Lower Clark Fork River Drainage Habitat Problem Assessment*. (GEI Consultants, Inc., 2005)
- *Vermillion River Watershed Assessment and Preliminary Restoration Plan*. USFS, 2006

7.2 ROLE OF DEQ, OTHER AGENCIES, AND STAKEHOLDERS

The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help 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 Lower Clark Fork Watershed Group, Green Mountain Conservation District, USFS, USFWS, NRCS, DNRC, FWP, Avista, EPA and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Trust, Montana Water Center, University of Montana Watershed Health Clinic, and MSU Extension Water Quality Program.

7.3 WATERSHED RESTORATION GOALS

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 Lower Clark Fork TPA by improving sediment related water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
  - water quality targets,
  - pollutant source assessments, and
  - general restoration guidance which should meet the TMDL allocations.
- Assess watershed restoration activities to address significant pollutant sources.

A WRP is a locally-derived plan that can be more dynamic and detailed than the TMDL document. It can be refined as activities progress and address more goals than those included in this TMDL document. The following elements may be included in a stakeholder-derived WRP in the near future:

- Support for implementing restoration projects to protect water conditions so that all streams in the watershed maintain good water quality with an emphasis on waters with TMDLs completed.
- More 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.
- Weed control initiatives
- Other local watershed based issues.

Specific water quality goals (i.e. targets) for sediment are detailed in **Section 5.** These targets serve as the basis for long-term effectiveness monitoring for achieving the above water quality goals. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Lower Clark Fork Tributaries TPA. Section 8 identifies a general monitoring strategy

and recommendations designed to track implementation water quality conditions and restoration successes.

7.4 OVERVIEW OF MANAGEMENT RECOMMENDATIONS

Sediment TMDLs were completed for 5 waterbody segments. Other streams in the watershed may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL formation at this time. In general, sediment loading can be greatly reduced by focusing restoration efforts on streamside riparian restoration and long term riparian zone and floodplain recovery management. Stream channel restoration may be necessary in areas that have lost channel integrity due to long term riparian vegetation impacts. Other sediment restoration actions include unpaved road erosion control near streams, application of Best Management Practices in agriculture and timber harvest operations, and sound and conscientious future planning for growth and development.

7.4.1 Sediment Restoration Approach

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

Riparian disturbance has occurred throughout the Lower Clark Fork TPA as a result of many influencing factors. Historic forest fires, riparian timber harvest, and 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 recovery through the application of timber harvest best management practices, improved grazing management (including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas), and floodplain and streambank stabilization and revegetation efforts where necessary. In general, natural recovery of disturbed systems is preferred, however it is acknowledged that the climate and geology of the Lower Clark Fork area may not readily allow for unassisted recovery in some areas where disturbance has occurred. Active vegetation planting along with bank sloping may increase costs, but still remains within a reasonable and relatively cost effective restoration approach. When stream channel restoration work is needed because of altered stream channels, costs increase and projects should be assessed on a case by case basis. Any BMPs implemented should aim to prevent availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport, through the most natural or natural-like means possible. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g. WRP).

Although roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams should be to divert water off of roads and ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. Sediment loads from culvert failure and culvert caused

scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in the Lower Clark Fork TPA. In particular, the Green Mountain Conservation District in Thompson Falls, and the Lower Clark Fork Watershed Group are two resources that are valuable aids for assisting with investigating, developing, and implementing measures to improve conditions in the Lower Clark Fork watershed.

7.4.2 Pollution Restoration Approach

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Lower Clark Fork TPA are described in **Section 6**. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Therefore, if restoration goals within the Lower Clark Fork TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered.

7.5 RESTORATION APPROACHES BY SOURCE

Generalized management recommendations are outlined below for the major sources of human caused pollutant loads in the Lower Clark Fork TPA: grazing, upland sources, riparian vegetation removal, irrigation, unpaved roads. Applying ongoing BMPs are the core of the sediment reduction strategy, but are only part of the restoration strategy. Restoration activities may also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key sediment sources. In these cases, BMPs are usually identified as a first effort and an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process. Monitoring recommendations are outlined in **Section 8.0**.

7.5.1 Upland Sediment (Agriculture)

The primary strategy of the recommended upland BMPs is to reduce sediment and nutrient 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 Lower Clark Fork watersheds are riparian buffers and vegetated filter strips (VFS), where appropriate. 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 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, stripcropping, and precision farming. 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2007).

Reducing sediment loading will decrease loading of sediment-bound nutrients, but nutrient management is also needed to reduce nutrient loading. Nutrient management is managing the amount,

source, placement, form, and timing of plant nutrients and soil amendments. Nutrient management components of the conservation plan should include the following information:

- Field maps and soil maps,
- Planned crop rotation or sequence,
- Results of soil, water, plant, and organic materials sample analysis,
- Realistic expected yields,
- Sources of all nutrients to be applied,
- Nutrient budget, including credits of nutrients available,
- Nutrient rates, form, timing, and application method to meet crop demands and soil quality concerns,
- Location of designated sensitive areas, and
- Guidelines for operation and maintenance.

More information about nutrient management techniques can be found at your local NRCS office or in the NRCS publication MT 590-1. Further discussion of management practices related to specific elements of agricultural production continue below.

7.5.1.1 Grazing

Although grazing and livestock production is not as prevalent in the Lower Clark Fork watershed as in other TMDL planning areas, development of riparian grazing management plans should be a goal for any landowner in the watershed who operates livestock and does not currently have such plans. Private land owners may be assisted by state, county federal, and local conservation groups to establish and implement appropriate grazing management plans (note that riparian grazing management does not necessarily eliminate all grazing in riparian corridors). 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 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 stream bank and channel. The primary recommended BMPs for the Lower Clark Fork watershed are providing off-site watering sources, limiting livestock access to streams and hardening the stream at access points, planting woody vegetation along stream banks, and establishing riparian buffers. Although bank revegetation is a preferred BMP, 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 pollution are listed below (**Table 7-1**). Further information on grazing BMPs can be obtained in **Appendix A** of Montana's NPS Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2007).

Table 7-1. General grazing/wildlife BMPs and management techniques.

BMP and Management Techniques	Pollutants Addressed
Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species. In this case, native riparian vegetation.	Sediment, temperature, nutrients
Encourage the growth of woody species (willow, alder, etc.) along the streambank, which will limit animal access to the stream and provide root support to the bank.	Sediment, nutrients, temperature

Table 7-1. General grazing/wildlife BMPs and management techniques.

BMP and Management Techniques	Pollutants Addressed
Establish riparian buffer strips of sufficient width and plant composition to filter and take up nutrients and sediment from concentrated animal feeding operations.	Sediment, nutrients,
Create riparian buffer area protection grazing exclosures through fencing.	Sediment, temperature, nutrients
Maintain adequate vegetative cover to prevent accelerated soil erosion, protect streambanks, and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants.	Sediment
Ensure adequate residual vegetative cover and regrowth and rest periods. Periodically rest or defer riparian pastures during the critical growth period of plant species.	Sediment, nutrients
Distribute livestock to promote dispersion and decomposition of manure and to prevent the delivery of manure to water sources.	Nutrients
Alternate a location's season of use from year to year. Early spring use can cause trampling and compaction damage when soils and streambanks are wet. If possible, develop riparian pastures to be managed as a separate unit through fencing.	Nutrients, sediment
Provide off-site, high quality water sources.	Nutrients, sediment
Periodically rotate feed and mineral sites and generally keep them in uplands.	Nutrients, sediment
Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing).	Sediment, nutrients, temperature
Monitor livestock forage use and adjust strategy accordingly.	Sediment, nutrients, temperature
Create hardened stream crossings.	Sediment

7.5.1.2 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality and public health due to the amount of animal manure and wastewater they generate. To minimize water quality and public health impacts from AFOs and land applications of animal waste, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (US Department of Agriculture, 2005). This strategy encourages owners of AFOs of any size or number of animals to voluntarily develop and implement site-specific Comprehensive Nutrient Management Plans (CNMPs) by 2009. 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 waste loads 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 (US Department of Agriculture, 2005). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water. Studies have shown benefits in red meat and milk production of 10 to

20 percent by livestock and dairy animals when good quality drinking water is substituted for contaminated surface water.

Opportunities for financial and technical assistance (including CNMP development) in achieving voluntary AFO and CAFO compliance 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 internal (Permitting Division), as well as external entities (DNRC, local watershed groups, conservation districts, MSU Extension, etc.).

7.5.2 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 attenuate pollutants, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow sediment to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced ((Andrews and Nankervis, 1995), (Schmidt and Potyondy, 2004)). Restoration targets and implementation strategies recognize the need for specific flow regimes, and may recommend flow-related recommendations and enhancements as a means to achieve full support of beneficial uses. However, local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

Irrigation management is a critical component of attaining both cold water fishery conservation and TMDL goals. Irrigation efficiency management practices in the lower Clark Fork should involve investigating how to reduce the amount of stream water diverted during July and August, while still growing crops on traditional cropland. It may be desirable to investigate irrigation practices earlier in the year that promote ground water return during July and August. Understanding irrigation water, ground water and surface water interactions is an important part of understanding how irrigation practices will affect stream flow during specific seasons.

7.5.2.1 Irrigation Flow Restoration Recommendations

Improving Irrigation Efficiency During Low Streamflow Timeframes

Many of the irrigation practices in western Montana are based in flood irrigation methods. In some cases, head gates and ditches leak, which can decrease the amount of water in-channel flows. The following recommended activities would result in notable water savings.

- Install upgraded head gates for more exact control of water diversions and to minimize leakage when not in operation.
- Develop more efficient means to supply water to livestock.
- Determine necessary amounts of water to divert that would reduce over watering and improve forage quality and production.
- Redesign irrigation systems.
- Upgrade ditches (including possible lining) to increase ditch conveyance efficiency.

Future studies could investigate irrigation water return flow timeframes from specific areas along the Lower Clark Fork River tributaries. A portion of spring and early summer flood irrigation water likely returns as cool ground water to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer ground water returns to the river should be identified as areas were year round irrigation efficiencies could be more beneficial to preserving flow in the stream during hot summer timeframes. Winter baseflow should also be considered during these investigations.

7.5.3 Upland Sediment (Forestry and Timber Harvest)

Currently, active timber harvest is not significantly affecting sediment production in the Lower Clark Fork TPA, but harvesting will likely continue in the future within the Kootenai National Forest, Lolo National Forest, and on private land. Future harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana SMZ Law (MCA 77-5-301 through 307). The Montana Forestry BMPs cover timber harvesting and site preparation, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e. within 50 feet of a waterbody), the riparian protection principles behind the law can be applied to numerous land management activities (i.e. timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. 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.

Timber harvest should not increase the peak water yield by more than 10 percent of historic conditions. If a natural disturbance, such as a forest fire, increases peak water yield, the increase should be accounted for as part of timber harvest management.

7.5.4 Riparian Corridors

Reduction of riparian vegetative cover by various land management activities and/or natural occurences, is a principal cause of water quality and habitat degradation in the Lower Clark Fork TPA. Although implementation of passive BMPs that allow riparian vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e. plantings) may be necessary in some instances. The primary advantage of riparian plantings is that installation can be accomplished with

minimum impact to the stream channel, existing vegetation, and private property. In addition to providing shade (and possible reduced water temperature) and cover for aquatic species, riparian plantings can develop root masses that penetrate deep into the soils, increasing bank resilience to erosion. All areas that are actively restored with vegetation must have a reasonable approach to protecting the invested effort from further degradation from livestock or hay production.

Factors influencing the appropriate riparian restoration would include severity of degradation, site-potential for various species, and availability of local sources for transplant materials. In general, riparian plantings would promote establishment of functioning stands of native species (grasses and willows). The following recommended restoration measures would allow for stabilization of the soil, decreasing sediment delivery to the stream, and increasing absorption of nutrients from overland runoff.

- Harvest and transplant locally available sod mats with an existing dense root mass which provide immediate promotion of bank stability and filtering nutrients and sediments.
- Transplanting mature shrubs, particularly willows (*Salix* sp.), provides rapid restoration of instream habitat and water quality through overhead cover and stream shading as well as uptake of nutrients.
- Seeding with native graminoids (grasses and sedges) and forbs is a low cost activity where lower bank shear stresses would be unlikely to cause erosion.
- Willow sprigging would expedite vegetative recovery, involving harvest of dormant willow stakes from local sources.

7.5.5 Unpaved Roads

The road sediment reductions in this document represent a gross estimation of the sediment load that would remain once road BMPs were applied, assuming no current BMPs are in place. In general, a road with associated BMPs assumes contributing road treads, cut slopes, and fill slopes were reduced to 100 feet (from each side of a crossing). This distance is selected as an example to illustrate the potential for sediment reduction through BMP application and is not a formal goal at every crossing. For example, many roads may easily have a smaller contributing length, while others may not be able to meet a 100ft milestone. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's NPS Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 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, grading materials to the center of the road and avoiding 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.

7.5.5.1 Culverts

Although culverts were not part of the source assessment, they can be large sources of sediment, and should be included in the restoration strategy. A field survey should be conducted and combined with local knowledge to prioritize culverts for restoration. 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. Culverts should be at grade with the streambed, and inlets and outlets should be vegetated and armored. 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.

Another consideration for culvert upgrades will be providing fish passage. During the assessment and prioritization of culverts, additional crossings should be assessed for streams where fish passage is a concern. 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, it should be involved in culvert design. If funding is available, culverts should be prioritized and replaced prior to failure.

A subset of culverts in the Lower Clark Fork were analyzed for fish passage using the criteria from A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska (U.S.Department of Agriculture, 2002). Using this methodology, 33 of 35 culverts were classified as partial or total fish barriers, and 2 of 35 were classified as needing additional evaluation. None of the field assessed culverts were classified as capable of passing fish at all flows and life stages. More information regarding the roads and culvert assessment can be found in **Attachment 1, Road Sediment Assessment and Modeling.**

7.5.6 Bank Hardening/Riprap/Revetment/Floodplain Development

The use of riprap or other “hard” approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although it is necessary in some instances, it generally redirects channel energy and exacerbates erosion in other places. Bank armoring should be limited to areas with a demonstrated 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. Limit infrastructure threats by reducing floodplain development through land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and habitat potential. The primary recommended structures are large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood dominated riparian community types. When used in together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fill slopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

7.7 RESTORATION ACTIVITIES IN THE LOWER CLARK FORK WATERSHED

For much of the last decade, various stakeholders and interested parties within the Lower Clark Fork Tributaries TPA have been actively pursuing and implementing projects to improve the overall health

and condition of the watershed. Many of these projects have been consistent with the goals of this TMDL, and the restoration principles described above. As work continues in the Lower Clark Fork, it will be important to maintain and improve upon the effectiveness and efficiency of these endeavors, and ensure that the achievement of Montana state water quality standards are ultimately met. **Table 7-2** presents a compilation of restoration project completed to date.

Table 7-2. Restoration Projects in the Lower Clark Fork Tributaries TPA

Stream	Year	Project Name	Project Type	Project Goal
Elk Creek	1997	Elk Creek (Heron)	Channel Restoration	Channel and Bank Stabilization
Clear Creek	1997	Clear Creek Restoration	Channel Restoration	Restoration/Reveg (failed)
Elk Creek	1998	Springer EWP	Emergency Watershed Protection	Bank Stabilization
East Fork Elk Creek	1999	Platt Riparian Fencing	Riparian Fencing	Bank Stabilization
Beaver Creek	Late 90s	Beaver 301 (ERFO)	Channel Restoration	Bank Stabilization
Elk Creek	Early 00s	John Hollinshed WRP	Bank Stabilization	Bank Stabilization
Thorne Creek	2000	Thorne Creek Culvert Removal	Culvert Replacement	Fish Passage
Whitepine Creek	2001	Whitepine Creek Restoration 2001	Channel Restoration	Bank Stabilization
Bull River	2001	McDowell Bank Stabilization	Bank Stabilization	Bank Stabilization
East Fork Bull River	2001	East Fork Bull River - Stein	Channel Restoration	Bank Stabilization
East Fork Bull River	2001	EFBR vegetation restoration	Riparian Revegetation	Bank Stabilization
Elk Creek	2001	Platt Restoration #1		Bank Stabilization
Prospect Creek	2001	Lower Prospect Creek Restoration - Phases I & II	Channel Restoration	Bank Stabilization
Trout Creek	2001	Trout Creek Restoration (Morkert)	Stream Restoration	Bank Stabilization
Whitepine Creek	2002	Whitepine Creek Restoration 2002	Channel Restoration	Bank Stabilization
East Fork Bull River	2002	EFBR Stein Revegetation	Riparian Revegetation	Riparian Revegetation
Bull River	2002	McDowell Revegetation	Riparian Revegetation	Bank Stabilization
Jungle Creek	2002	Jungle Cr. Culvert Replacement	Culvert Replacement	Fish Passage
Whitepine Creek	2003	Michaels Repair	Restoration Repair	Bank Stabilization
South Fork Bull River	2003	SFBR Slide Restoration	Channel Restoration	Channel Reconstruction
Pilgrim Creek	2003	King Channel Shaping	Channel Restoration	Bank Stabilization
Prospect Creek	2003	YPL Relocation/Removal Reclamation	Bank Stabilization	Remove YPL
Whitepine Creek	2004	Chambers Repair	Restoration Repair	Bank Stabilization
Whitepine Creek	2004	Chambers and Self Repair	Restoration Repair	Bank Stabilization
Whitepine Creek	2004	Michaels Repair	Restoration Repair	Bank Stabilization
Snake Creek	2004	SN-6 Snake Creek Restoration	Channel Restoration	Sediment Reduction
East Fork Bull River	2004	EF-9 Lost Girl Slide Stabilization	Riparian Revegetation	Bank Stabilization

Table 7-2. Restoration Projects in the Lower Clark Fork Tributaries TPA

Stream	Year	Project Name	Project Type	Project Goal
Whitepine Creek	2005	Cole Creek Road Decomissioon	Culvert Installation	Road decomission
Pilgrim Creek	2005	King Road Dip and Riparian Reveg	Riparian Revegetation	Bank Stabilization
Daisy Creek	2005	Daisy Creek Restoration	Channel Restoration	Bank Stabilization
Bull River	2006	Dabronski Bridge Removal	Abutment Removal	Bank Stabilization
Bull River	2006	Ross Revegetation (North)	Riparian Revegetation	Bank Stabilization
Bull River	2006	Ross Revegetation (South)	Riparian Revegetation	Bank Stabilization
South Fork Bull River	2006	SF-17 SFBR bridge replacement	Culvert and Bridge Replacement	Fish Passage
Elk Creek	2006	Platt Restoration #2	Channel Restoration	Bank Stabilization
Pilgrim Creek	2006	Pilgrim Creek Railroad Bridge	Channel Restoration	Bank Stabilization
Pilgrim Creek	2006	Reishus/McDowell Restoration	Channel Restoration	Bank Stabilization
Pilgrim Creek	2006	West Fork Pilgrim Creek Bridge	Bridge Replacement	Bridge Replacement
Thompson River (upper)	2006	Thompson River Riparian Restoration	Revegetation	Revegetation
Fishtrap Creek	2006	Fishtrap Creek LWD Pilot (Plum Creek)	LWD Addition	Habitat Improvement
Vermilion River	2006	Vermilion Bank Stabilization	Channel Restoration	Bank Stabilization
Whitepine Creek	2007	Whitepine Fish Habitat Improvement	Channel Restoration	Fish Habitat Improvement
Bull River	2007	McDowell Revegetation	Riparian Revegetation	Bank Stabilization
East Fork Bull River	2007	EFBR - Stein repair	Minor Restoration Repair	Bank Stabilization
East Fork Elk Creek	2007	Lans Restoration	Channel Restoration	Bank Stabilization
Graves Creek	2007	Graves Creek Trap Site Improvement	Other	Stabilize Trapping Site
Pilgrim Creek	2007	King Revegetation	Riparian Revegetation	Bank Stabilization
West Fork Pilgrim Creek	2007	WFk Pilgrim Creek restoration	Channel Restoration	Channel Stabilization
Pilgrim Creek	2007	Reishus/McDowell Repair	Restoration Repair	Channel Stabilization
Cooper Gulch	2007	Cooper Gulch Culvert Replacement	Culvert Removal	Fish Passage
Chipmunk Creek	2007	Chipmunk Creek Culvert Replacement	Culvert Removal	Fish passage
Crow Creek	2007	Crow Creek Restoration	Channel Restoration	Fish Habitat Improvement
Bull River	2008	Ross Revegetation (again)	Riparian Revegetation	Bank Stabilization
East Fork Bull River	2008	EFBR slide restoration	Channel Restoration	Sediment Reducation
Pilgrim Creek	2008	Reishus/McDowell Repair	Restoration Repair	Channel Stabilization
Prospect Creek	2008	Wilkes Creek Bridge Abutment Removal	Bridge Abutment Removal	Bank Stabilization
Swamp Creek	2008	Swamp Creek Ford	Replace Concrete Ford	Other
Graves Creek	2009	Graves Creek Restoration (Cox/Newby)	Channel Restoration	Improve Channel Function

Table 7-2. Restoration Projects in the Lower Clark Fork Tributaries TPA

Stream	Year	Project Name	Project Type	Project Goal
Marten Creek	2009	Marten Creek - Smith	Channel Restoration	Bank Stabilization
Cooper Gulch	2009	Cooper Gulch LWD	LWD Addition	Habitat Improvement
Prospect Creek	2009	YPL Riparian Revegetation	Revegetation	Revegetation
Prospect Creek	2009	Prospect Creek Riparian Re-Forestation	Revegetation	Riparian Revegetation
Fishtrap Creek	2009	Fishtrap Creek LWD (USFS)	LWD Addition	Habitat Improvement
Whitepine Creek	Pending	Whitepine Bank Stabilization	Channel Restoration	Bank Stabilization
East Fork Blue Creek	Pending	Blue Creek mine tailings	Clean Up Mine Tailings Pile	Remove Contaminants
Bull River	Pending	Bull River - Scalf	Road Decommission and Revegetation	Wetland & Riparian Restoration
Marten Creek	Pending	Marten Creek Revegetation	Revegetation	Revegetation

8.0 MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

8.1 INTRODUCTION

The monitoring strategies discussed in this section are an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. Montana state law contains provisions that address evaluation of TMDL effectiveness through long-term water quality monitoring. As defined in (MCA 75-5-703 (7) (9):

> *"(7) Once the control measures identified in subsection (6) have been implemented, the department shall…develop a monitoring program to assess the waters that are subject to the TMDL to determine whether compliance with water quality standards has been attained for a particular water body or whether the water body is no longer threatened. The monitoring program must be designed based on the specific impairments or pollution sources. The department's monitoring program must include long-term monitoring efforts for the analysis of the effectiveness of the control measures developed.*
>
> *(9) If the monitoring program … demonstrates that the TMDL is not achieving compliance with applicable water quality standards within 5 years after approval of a TMDL, the department shall conduct a formal evaluation of progress in restoring water quality and the status of reasonable land, soil, and water conservation practice implementation to determine if:*
> *(a) the implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practice is necessary;*
> *(b) water quality is improving but a specified time is needed for compliance with water quality standards; or revisions to the TMDL are necessary to achieve applicable water quality standards."*

Water quality targets and allocations presented in this document are based on available data at the time of analysis, however the scale of the watershed coupled with constraints on time and resources often result in compromises that must be made that include estimations, extrapolation, and a level of uncertainty. The margin of safety (MOS) is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

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

8.2 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach is recommended to control costs and meet the water quality standards to support all beneficial uses. This approach works in cooperation with the monitoring strategy, and as new information is collected, it allows for adjustments to restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary.

8.3 FUTURE MONITORING GUIDANCE

The objectives for future monitoring in the Lower Clark Fork watershed include: 1) strengthen the spatial understanding of sources for future restoration work, which will also strengthen source assessment analysis for future TMDL review, 2) gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development, 3) gather consistent information among agencies and watershed groups that is comparable to targets and allows for common threads in discussion and analysis, 4) expand the understanding of streams throughout the Lower Clark Fork beyond those where TMDL have been developed and address issues if necessary, and 5) track restoration projects as they are implemented and assess their effectiveness.

8.3.1 Strengthening Source Assessment

In the Lower Clark Fork TPA, the identification of sources was conducted largely through watershed field tours, aerial assessment, the incorporation of GIS information, available data and literature review, with limited field verification and on-the-ground analysis. In many cases, assumptions were made based on overall TPA conditions and extrapolated throughout the watershed. As a result, the level of detail often does not provide specific areas by which to focus restoration efforts, only broad source categories to reduce sediment loads from in each of the discussed subwatersheds. Strategies for strengthening source assessments for each of the pollutants may include:

Sediment
Field surveys of road and road crossing to identify specific contributing road crossings, their associated loads, and prioritize those road segments/crossings of most concern.

Review of land use practices specific to subwatersheds of concern to determine where the greatest potential for improvement and likelihood of sediment reduction can occur for the identified major land use categories.

More thorough examinations of bank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed scale BEHI assessments. Additionally, the development of bank erosion retreat rates specific to the Lower Clark Fork TPA would provide a more accurate quantification of sediment loading from bank erosion. Bank retreat rates can be determined by installing bank pins at different positions on the streambank at several transects across a range of landscapes and stability ratings. Bank erosion is documented after high flows and throughout the year for several years to capture retreat rates under a range of flow conditions.

8.3.2 Increase Available Data

While the Lower Clark Fork watershed has been the recipient of significant remediation and restoration activities, data is still often limited depending on the stream and pollutant of interest. Infrequent

sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition, however regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change.

Sediment
For sediment investigation in the Lower Clark Fork, each of the streams of interest were stratified into unique reaches based on physical characteristics and anthropogenic influence. A total of 25 sites were sampled throughout the watershed, however this equates to only a small percentage of the total number of stratified reaches, and even less on a stream by stream basis. Sampling additional monitoring locations to represent some of the various reach categories that occur would provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole, by which to assess reach by reach comparisons and the potential influencing factors and resultant outcomes that exist throughout the watershed.

In addition to the sediment and habitat parameters targeted during the 2008 DEQ field assessment, there are further parameters that would support the analysis of sediment impact on beneficial uses, such as McNeil core sampling of subsurface substrate composition, and suspended sediment concentrations within the water column. Aquatic biological community information would also aid in assessing the response to changes in sediment loads; fish assemblages, redd numbers, macroinvertebrate population diversity, and periphyton analyses are all factors that could be incorporated toward assessing achievement of beneficial uses.

8.3.3 Consistent Data Collection and Methodologies

Data has been collected throughout the Lower Clark Fork TPA for many years and by many different agencies and entities, however the type and quality of information is often variable. Where ever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

The Montana Department of Environmental Quality (DEQ) is the lead agency for developing and conducting impairment status monitoring. However, other agencies or entities may work closely with DEQ to provide compatible data if interest arises. Impairment determinations are conducted by the state but can use data collected from other sources. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking.

It is important to note that monitoring recommendations are based on TMDL related efforts to protect beneficial uses in a manner consistent with Montana's water quality standards. Other regulatory programs with water quality protection responsibilities may impose additional requirements to ensure full compliance with all appropriate local, State and Federal laws. For example, reclamation of a mining related source of metals under CERCLA and CECRA typically requires source-specific sampling requirements, which cannot be defined at this time, to determine the extent of and the risk posed by contamination, and to evaluate the success of specific remedial actions.

Sediment
Sediment and habitat assessment protocols consistent with DEQ field methodologies and that serve as the basis for sediment targets and assessment within this TMDL should be conducted whenever possible. Current protocols are identified within Field Methodology for the Assessment of TMDL

Sediment and Habitat Impairments (DEQ, 2010). It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to achieve those objectives. However, when possible, when collecting sediment and habitat data in the Lower Clark Fork it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle Cross Section; using Rosgen methodology
- Riffle Pebble Count; using Wolman Pebble Count methodology
- Pool Assessment; Count and Residual Pool Depth Measurements
- Greenline Assessment; NRCS methodology

As mentioned in **8.3.2**, additional information will undoubtedly be useful and assist DEQ with TMDL effectiveness monitoring in the future. Macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts are examples of additional useful information used in impairment status monitoring and TMDL effectiveness monitoring which were not developed as targets but reviewed where available during the development of this TMDL. Wherever possible, the methods used to collect and analyze these data should also strive to be consistent throughout the watershed.

8.3.4 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, watershed-scale monitoring may be valuable in determining if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in bank stability and riparian habitat, increases in instream flow, and changes in communities and distribution of fish and other bio-indicators. Specific monitoring methods, priorities, and locations will depend heavily on the type of restoration projects implemented, landscape or other natural setting, the land use influences specific to potential monitoring sites, and budget and time constraints.

As restoration activities begin throughout the watershed, pre and post monitoring so as to understand the change that follows will be necessary to track the effectiveness of specific given practices or implementation projects. The following recommendations are categorized by the type of restoration practice to which they apply.

8.3.4.1 Road BMPs

Monitoring road sediment delivery is necessary to determine if BMPs are effective, to determine which are most effective, and to determine which practices or sites require modification to achieve water quality goals. Effectiveness monitoring should be initiated before implementing BMPs at treatment sites.

Monitoring actual sediment routing is difficult or prohibitively expensive. It is likely that budget constraints will influence the number of monitored sites. Once specific restoration projects are identified, a detailed monitoring study design should be developed. To overcome environmental

variances, monitoring at specific locations should continue for a period of two to three years after BMPs are initiated.

Specific types of monitoring for separate issues and improvements are listed in **Table 8-1**.

Table 8-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 7.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Ditch Relief Combined with Stream Crossings	Re-engineer & rebuild roads to completely disconnect stream sloped ditches from stream crossings. Techniques may include: • Ditch relief culverts • Rolling dips • Water Bars • Outsloped roads • Catch basins • Raised road grade near stream crossing	• Place silt trap directly upslope of tributary crossing to determine mass of sediment routed to that point. • Rapid inventory to document improvements and condition.	• Sediment yield monitoring based on existing literature/USFS methods. • Revised Washington Forest Practices Board methodology.
Ditch Relief Culverts	• Consider eliminating stream sloped ditches and outsloping the road or provide rolling dips. • When maintaining/ cleaning ditch, do not disturb toe of cutslope. • Install culverts with proper slope and angle following Montana road BMPs. • Armor culvert outlets. • Construct stable catch basins. • Vegetate cutslopes above ditch. • Increase vegetation or install slash filters. • Provide infiltration galleries where culvert outlets are near a stream.	• Rapid inventory to document improvements and condition. • Silt traps below any ditch relief culvert outlets close to stream.	• Revised Washington Forest Practices Board methodology. • Sediment yield monitoring based on existing literature/USFS methods.
Stream Crossings	• Place culverts at streambed grade and at base of road fill. • Armor and/or vegetate inlets and outlets. • Use proper length and diameter of culvert to allow for flood flows and to extend beyond road fill.	• Repeat road crossing inventory after implementation. • Fish passage and culvert condition inventory.	• Revised Washington Forest Practices Board methodology. • Montana State (DNRC) culvert inventory methods.
Road Maintenance	• Avoid casting graded materials down the fill slope & grade soil to center of road, compact to re-crown. • Avoid removing toe of cut slope. • In some cases graded soil may have to be removed or road may have to be moved.	• Repeat road inventory after implementation. • Monitor streambed fine sediment (grid or McNeil core) and sediment routing to stream (silt traps) below specific problem areas.	• Revised Washington Forest Practices Board methodology. • Standard sediment monitoring methods in literature.

Table 8-1. Monitoring Recommendations for Road BMPs

Road Issue from Section 7.0 (Restoration)	Restoration Recommendation	Monitoring Recommendation	Recommended Methodology
Oversteepened Slopes/ General Water Management	• Where possible outslope road and eliminate inboard ditch. • Place rolling dips and other water diverting techniques to improve drainage following Montana road BMPs. • Avoid other disturbance to road, such as poor maintenance practices and grazing.	• Rapid inventory to document improvements and condition.	• Revised Washington Forest Practices Board methodology.

8.3.4.2 Agricultural BMPs

Grazing BMPs reduce grazing pressure along streambanks and riparian areas. Implementing BMPs may improve water quality, create narrower channels and cleaner substrates, and result in recovery of streambank and riparian vegetation. Effectiveness monitoring for grazing BMPs should be conducted over several years, making sure to start monitoring before BMPs are implemented. If possible, monitoring reaches should be established in pastures keeping the same management as well as in those that have changed. Where grazing management includes moving livestock according to riparian use level guidelines, it is important to monitor changes within the growing season as well as over several years. Monitoring recommendations to determine seasonal and long-term changes resulting from implementing grazing BMPs are outlined below in **Table 8-2**.

Table 8-2. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Seasonal impacts on riparian area and streambanks	• Seasonal monitoring during grazing season using riparian grazing use indicators. • Streambank alteration. • Riparian browse. • Riparian stubble height at bank and “key area.”	BDNF/BLM riparian standards (Bengeyfield and Svoboda, 1998)
Long-term riparian area recovery	• Photo points. • PFC/NRCS Riparian Assessment (every 5-10 yrs). • Vegetation Survey (transects perpendicular to stream and spanning immediate floodplain) every 5-10 years. • Strip transects- Daubenmire 20cm x 50cm grid or point line transects • Greenline.	(Harrelson et al., 1994); (Bauer and Burton, 1993); (US Department of Agriculture, 2001)
Streambank stability	• Greenline including bare ground, bank stability, woody species regeneration (every 3-5 years)	Modified from (Winward, 2000)
Channel stability	• Cross-sectional area, with % fines/ embeddedness. • Channel cross-section survey. • Wolman pebble count. • Grid or McNeil core sample. • Bank Erosion Hazard Index.	(Rosgen, 1996); (Harrelson et al., 1994)

Table 8-2. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Aquatic habitat condition	• Aquatic macroinvertebrate sampling. • Pool quality. • R1/R4 aquatic habitat survey. • Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.	(Montana Department of Environmental Quality, 2004); (Hankin and Reeves, 1988); (Overton et al., 1997) DEQ Longitudinal Assessment Protocols (DEQ, 2010)
General stream corridor condition	• EMAP/Riparian Assessment (every 5-10 yrs).	(US Department of Agriculture, 2001); (Peck et al., 2003).

8.3.5 Watershed Wide Analyses

Recommendations for monitoring in the Lower Clark Fork should not be confined to only those streams addressed within this document. The water quality targets presented herein are applicable to all streams in the watershed, and the absence of a stream from the State's 303(d) List does not necessarily imply a stream Fully Supporting all beneficial uses. Furthermore, as conditions change over time and land management evolves, the consistent application of data collection methods and information collected throughout the watershed will best allow resource professionals to identify problems as they occur, and to track improvements over time.

9.0 PUBLIC PARTICIPATION AND RESPONSE TO COMMENTS

Public and stakeholder involvement is a component of TMDL planning efforts. Stakeholders, including Green Mountain Conservation District, Lower Clark Fork Watershed Group (LCFWG) (which serves as an umbrella organization for watershed groups within the lower Clark Fork watershed including: Bull River Watershed Council, Elk Creek Watershed Council, Little Beaver Creek Watershed Council, Pilgrim Creek Watershed Council, Prospect Creek Watershed Council, Rock Creek Watershed Council, Trout Creek Watershed Council, and Whitepine Creek Watershed Council), Avista Corporation, Montana Department of Environmental Quality (DEQ), Montana Fish, Wildlife and Parks (MFWP), US Department of Agriculture - Natural Resources Conservation Service (DNRC), US Department of Agriculture - US Forest Service (Kootenai and Lolo National Forests), US Department of Interior – US Fish & Wildlife Service, as well as local land owners and watershed residents were kept abreast of the TMDL process through periodic meetings of the Lower Clark Fork Watershed Group and Green Mountain Conservation District. In addition, Technical Advisory Group meetings, and other outreach and education efforts conducted by the LCFWG provided opportunities to review and comment on technical documents. Stakeholder review drafts were provided throughout the process to several agency representatives, landowners, conservation district and government representatives, and representatives from conservation and watershed groups. Stakeholder comments, both verbal and written, were accepted and are addressed within the document.

An additional opportunity for public involvement is the public comment period. This public review period was initiated on September 23rd, 2010 and extended to October 8th, 2010. At a public meeting on October 4th in Noxon, MT, DEQ provided an overview of the Lower Clark Fork River Tributaries Total Maximum Daily Loads, 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 Technical Advisory Group, and advertised in the following newpapers: Sanders County Ledger, The Missoulian, and the Clark Fork Valley Press. This section includes DEQ's response to all official public comments received during the public comment period. This final document was updated, based on public input and comment.

9.1 RESPONSE TO PUBLIC COMMENTS

The formal public comment period for the Lower Clark Fork River Tributaries Sediment TMDLs and Framework for Water Quality Restoration (TMDL) extended from September 23rd to October 8th, 2010. One letter compiling formal comments was submitted to DEQ during the public comment period. Excerpts from the comment letter are provided below. Responses prepared by DEQ follow each of the individual comments and where applicable, the text of the Final document has been modified to address these comments. Original comment letters are held on file at the DEQ and may be viewed upon request.

Dave McCarthy, Copper Environmental Consulting, LLC, on behalf of Roy Thun, Atlantic Richfield Company

Comment #1
The basis of the original impairment determination is not presented. This information should be transparently presented, and linked to the narrative standards presented, and to the characterization of impairment presented in the 2008 impaired waters list. Impairment appears to be assumed, as is the linkage between excess sediment and impairment. Only generic text references are provided to

establish the relationship between sediments and impairment, but no specific ecological, biological, or water quality data or other information providing evidence of impairment in the tributaries in question are provided.

Response to #1
Impairment has not been assumed, rather it has been determined through an assessment process developed by the State and approved by the EPA. The process for how waterbodies are identified as impaired is summarized in **Section 3.0**, which also contains reference to Montana's Water Quality Integrated Report where a full description of the methodology for determining the impairment status of a waterbody is included in **Appendix A** of that document. The linkages between excess sediment and impairment are described in detail in **Sections 5.1**, **5.4.1, and 5.4.2**.

This document specifically addresses those impairment listings and develops TMDLs as a result of the state's impairment determinations. To further clarify this connection, summary information from the original assessment files has been added to **Section 5.4.3 –** Comparison of Listed Waters to Targets (by stream segment). The data used for target development and presented in **Section 5.4.3** is made available to further describe and characterize the impairment determinations. In some cases, this information may lead DEQ to revisit an impairment determination; however in the cases of the Lower Clark Fork tributaries, it served as further evidence of impairment. For a full review of all data that was originally reviewed as part of the assessment and impairment determination process, the assessment files for each of the waterbodies addressed in this document are available at the main DEQ office in Helena, and electronically via the internet at http://cwaic.mt.gov/.

The exception to the above paragraph is Swamp Creek, which did not have sufficient information to determine impairment at the time of original assessment. However, data collected and reviewed during the development of this TMDL document concluded that impact from sediment exists and warrants the TMDL. Although Swamp Creek has not yet gone through the full assessment and impairment determination protocol, the data and conclusions presented in this document were reviewed by DEQ's Monitoring and Assessment staff, and were found acceptable. It should be noted that a stream need not be listed for a pollutant for a TMDL to be developed.

Comment #2
Based on an assumption of impairment and an assumption of a linkage between impairment and excess sediment, target development is then pursued based on considering physical attributes of stream condition (which are assumed to be linked to excess sediment). The resulting targets (reflected as specific stream attribute goals which are then translated to sediment loading reductions) are assumed to achieve a reference condition which will achieve designated beneficial uses. There is no discussion provided, however, of the potential for the LCFR tributaries to achieve the same biological usage/productivity as the reference streams, and/or how this relates to the original basis for assuming that coldwater fisheries and/or aquatic life are impacted *vis-à-vis* the narrative criteria (i.e., by sediment loads above and beyond background conditions).

Response to #2
As described in the Response to #1, the impairment is not assumed. Data was reviewed and considered sufficient and credible to make the initial impairment determination, and further supported by the review of additional information contained within this document.

The linkage between sediment impairment and the physical attributes of stream condition is well documented and the target parameters chosen were specifically selected based on their ability to display effects from sedimentation, and the impacts these effects then have on aquatic life and cold water fish – in the case of the Lower Clark Fork tributaries, specifically bull trout and cutthroat trout. These linkages are discussed in **Section 5.4** and **Appendix D** and include references to scientific literature and academic research that support these linkages. These discussions within the text have been reviewed and, where deemed appropriate, additional text has been included to clarify these linkages.

The water quality targets provided in **Section 5.4** and **Appendix D** are developed to serve as a tool to indicate if impact to the beneficial uses persists, the degree of that impact, and which direction conditions in a particular stream are trending. It is the source assessment information, presented in **Section 5.5**, which serves as the basis for the analysis of sediment load, and the potential for sediment reductions that can be achieved. In determining those sediment load reductions, the existing conditions are considered along with the potential for recovery and sediment reduction in comparison to reference conditions. Reference conditions are reflective of desired conditions and reasonable expectations for sediment reduction within the basin as a result of watershed wide analyses specific to the Lower Clark Fork and based on known and accepted practices as they relate to the Lower Clark Fork tributary watersheds. It is therefore a reasonable expectation that as sediment loads are reduced from the various sources, and stream conditions comply with target values, that subsequently biological usage/productivity will improve, and stream conditions will reflect 'full support' of the previously impaired beneficial uses.

It is acknowledged that the targets and load reductions developed in this document are at a watershed scale and that in some cases, discrete locations may not be able to achieve all targets or source load reductions. In any case, the overall watershed improvement and resultant effects is discussed both explicitly and implicitly throughout **Section 5.0** and the appendices and attachments included in this document.

Comment #3
It is also stated in the draft TMDL that the proposed stream attribute targets cannot necessarily be looked at individually, or in any specific combination to define impairment. It then logically follows that they could not be looked at individually, or in any specific combination, to establish attainment of designated uses.

Response to #3
In its full context, the discussion on stream attribute targets describes the application of target values as a 'weight-of-evidence' approach, where not one specific target value holds prominence over others, but a combination of factors lead to a determination of impairment. Never the less, the discussion of the use of stream attribute targets as presented in the draft document has been reworded to provide better clarity about how these targets should be applied and what divergence from the targets indicates.

Comment #4
It is unclear how the adaptive implementation process will be applied given these uncertainties. A comprehensive monitoring program is indicated, yet there appear to be no specific success criteria. The net result is that the proposed TMDL provides little basis for determining if or when use attainment can, will be, or has been achieved.

Response to #4
Given Comment #3, it is understandable that there is confusion regarding the expected outcome as it relates to the water quality targets. That language has been edited to provide clarity as described in Response to #3. With that in mind, the goal of any TMDL document is to reduce pollutants to levels where beneficial uses are supported. The water quality targets are developed to indicate when and where use attainment has occurred, and the source assessment and allocations are developed to direct measures via pollutant reductions necessary to achieve use attainment. 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 ultimate responsibility for meeting a TMDL is with the residents and resource managers of that affected watershed. However, as the assessments and analysis of data is often at a broader, watershed scale, the adaptive management strategy is incorporated to acknowledge a level of uncertainty and allow for further refinement of targets, and evaluation of the potential for reduction within a watershed. The TMDL document provides information and suggestions for stakeholders to implement pollutant reductions and assess progress. This information is provided in **Section 5.7.3, Section 7.0**, and **Section 8.0**. **Section 8.0** has also been expanded to describe the relationship between Montana state law, monitoring needs, and TMDLs.

Comment #5
Table 3-3 summarizes applicable narrative standards [e.g., no increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife], where naturally occurring is defined as "conditions or materials 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." **Section 3.3.2** of the TMDL document states that "reasonable land, soil, and water conservation practices" are defined as "methods, measures, or practices that protect present and reasonably anticipated beneficial uses." Hence, the narrative standards described circular logic where uses are deemed protected if reasonable practices are installed, and reasonable practices are defined as those that protect uses.

Response to #5
Montana's narrative sediment standard was built to protect the Montana's aquatic resources. The narrative standard is expressed in its' current form of "no person may violate the following specific water quality standards…" (17.30.623(a)) and is followed by "No increases are allowed above naturally occurring concentrations of sediment… that are likely to render the waters harmful…" (17.30.623(a)(f)) in order to protect Montana's diverse landscape. The narrative expression is designed to allow for anthropogenic activity while maintaining the varying conditions promulgated by the diverse landscape settings; differing geologies, climate, soils, hydrology and other natural physiochemical differences. In other words, the intent is to capture a unique waterbody's potential and to protect conditions that do not limit this potential.

The naturally occurring definition is designed for management of anthropogenic activity that will not lead to impairment of beneficial uses. The intent is not to preclude all human activity. Due to the

inherent natural variability in Montana's waterways, reasonable land, soil, and water conservation practices that protect the beneficial use in a resilient landscape may not be protective of a more sensitive landscape. Therefore, describing what is reasonable in standards language would lead to regulations that may protect some waterbodies while impairing others. Determining the sufficiently protective practices for specific waterbodies can be difficult. Due to these complexities, defining these "reasonable" conditions is done on a case-by-case basis with the end goal being the support of the beneficial use.

Taken at face value, the logic appears to be circular. When considering the intent of the logic, and implementation, the expression of the standards allows for varying levels of anthropogenic activity while protecting beneficial uses.

Comment #6

The interpretation of the narrative standards does not address the following critical questions:

1. What is the nature and scale of the stated impairment?
2. Are excess sediments the only, or the most significant, stressor impacting uses?
3. What reductions in pollution loading are needed to result in attainment of designated uses?

The TMDL should specifically address these critical questions, and relate the answers specifically to the definition of the problem (the description of impairment), and the solution (the proposed TMDLs for sediments).

Response to #6

1. The nature and scale of the stated impairment is described within the waterbody assessment files that were used to list the streams on the 303(d) List. Information presented in **Section 5.4.3** further describes the condition of the streams and their relative impairment. Summaries from the assessment files have been included to each of the applicable streams within this document.
2. Given the data available to DEQ at the time of assessment, it was found that sediment is a significant stressor impacting uses. This document addresses only sediment as a pollutant, and pollution in the form of habitat alterations, etc that have common linkages to sediment. However, White Pine Creek is also listed for impairment from temperature. That pollutant will be addressed in a future document.
3. Necessary reductions in pollutant loading to attain the TMDL, and thereby the attainment of designated uses (affected by sediment), are clearly described in **Section 5.6**.

Comment #7

It does not appear that any attempt has been made to document where impairment may exist (from a biological use perspective) and to relate this to actual measures of sediment loading (e.g. total settleable solids or particulate loads during storm flow and/or baseflow). Another approach for connecting total allowable load to achievement of goals would be to more specifically identify load reduction potential based on "reasonable land, soil, and water conservation practice" and evaluate the potential for use attainment given the predicted loading reductions.

Response to Comment #7

Information within the assessment files used in the 303(d) listing process may contain some site specific information, or reach bracketed information, including biological data, as part of the data used to make the impairment determination. Once that determination has been made however, it is the ultimate goal of the TMDL document to reduce those pollutants that cause the impairment. The approach taken by DEQ, and accepted by EPA, is to address sediment impairment at the watershed scale. In so doing,

numerous sites throughout a watershed under a variety of conditions, and from a variety of sources were investigated on the ground to determine their loading characteristics and potential for improvement. This real data serves as the basis for the extrapolation of loads and improvement measures across the watershed, which provides a reasonable approximation and characterization of what is occurring in the streams of interest. The targets developed to measure the level of impact are directly related to the success of coldwater fish and aquatic life, and the reductions in sediment are determined based on the potential for improvement as identified in the field assessments, discussions with stakeholders and local resource managers, and documented literature. The total allowable load takes into account "reasonable land, soil, and water conservation practices."

Comment #8
The use of stream attribute targets to estimate allowable load is unsupported. For example, the median percent eroding banks (i.e., 9%) of the total sample population was used as a basis for determining stream specific allowable loads. For each stream, the existing load (expressed as average percent eroding banks) was reduced by the percent reduction necessary for that stream to achieve an equivalent of 9% eroding banks. The difference is proposed to represent the desired sediment load reduction from eroding banks, and translated directly to the allowable load. There are a number of problems with this approach. The use of the median percent from the sample population is not substantiated, as half of the sample population would then be identified as requiring a load reduction to attain designated uses. Also, no direct connection has been established between this metric and impairment and/or use attainment. If the 9% goal cannot be achieved in all stream segments or on average by applying reasonable land, soil, and water conservation practices, then this metric should be removed as a basis for identifying allowable loads.

Response to Comment #8
Due to the scale of the watersheds concerned, and the resources available in developing a TMDL, it is necessary to combine real field data, conclusions from scientific literature, and land use/water quality models in order to determine existing and total allowable loads for sediment from the various sources that occur in the watershed. This approach, and a variety of other approaches, is supported within the EPA document *Protocols for Developing Sediment TMDLs*.

The median is used precisely because the sample population contains a combination of sites displaying a variety of stream conditions and levels of impact. It stands to reason then that not all of a sample population will display "desired conditions." **Appendix D** provides further discussion on the use of statistics in developing targets and analyzing data, and has been further expanded for the final document. Part of this discussion is included below:

"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 (EPA 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 (DEQ 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."

The 9% eroding banks is applied at the watershed scale within each stream of concern and represents a reasonable expectation of a desired condition based on the data and statistical analysis. Adaptive management however allows for additional data and assessment to be used to adjust a target value or allocation if it can be shown that this metric is unachievable or inappropriate for a specific waterbody.

Comment #9
Despite the emphasis on the derivation of "target values", it appears that these values are not directly linked to TMDL allocations. TMDL allocations for sediment were apparently based on the widespread application of BMPs. Consequently, the TMDL is not water quality-based, but technology (i.e., BMP)-based, which is appropriate when nonpoint sources are the primary source of impairment. Given that this TMDL appears to address nonpoint sources, and the numeric targets and proposed quantitative and proposed quantitative load reductions are not directly tied to use attainment, the purpose and implications of providing specific numeric instream targets or goals is unclear. A better approach might be to specifically define "reasonable land, soil, and water conservation practices", estimate potential loading reductions associated with implementation of these actions, and conduct a more specific assessment of biological or ecological indicators to monitor progress toward use attainment.

Response to Comment #9
The development of a TMDL combines the use of various metrics to determine impact from a particular pollutant of concern. These metrics may include water quality values, habitat and morphology characteristics, or biological and ecological community indices. These targets reflect a condition that is supportive of the beneficial uses and are developed to determine the degree of impairment in a given watershed. Once impairment is determined, a review and assessment of the various sources is completed, which incorporates an estimate of potential loading reduction associated with the application of reasonable land, soil, and water conservation practices. These practices are described within **Section 5.5** and **Section 7.0**. Therefore it is a combination of both water quality based measures and technology based measures by which a TMDL is assessed and achieved. If over time, additional data collection and analysis finds that either the targets are unachievable or the allocations of load reductions are unachievable, despite all best efforts, the TMDL process allows for adaptive management to address these issues, just as you have suggested.

Comment #10
The draft TMDL describes the MOS as accounting for "the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses", and states that it can be applied implicitly by using conservative assumptions, or by setting aside a specific portion of the allowable load" (p32). It is difficult, however, to understand if the MOS inherent in this TMDL results in an overly conservative characterization of actions needed to achieve use attainment, as the linkages between current sediment loads and impairment, and sediment loading reductions and attainment, have not been defined.

Response to Comment #10
The MOS in this document is incorporated implicitly as a result of the conservative characterization of sediment loads developed from the methods employed in this study, and is described in **Section 5.7.2**. The specific assumptions and considerations within each method are described in their respective

sections within the document. Linkages between sediment loads, impairment, and reductions and attainment have been defined within the document but as before, strengthened and clarified where ever possible.

Comment #11
A site-specific evaluation of mechanisms of effect is needed. The draft TMDL provides only a generic discussion of potential effects associated with increased sediment, and provides no discussion of magnitudes of "sediment increases" and association with types or magnitudes of impacts. A general statement is provided indicating that "an accumulation of benthic fine sediment reduces the flow of water through gravels harboring salmonid eggs, hindering emergence of newly hatched fish, depleting oxygen supply to embryos, and causing metabolic wastes to accumulate around embryos, resulting in higher mortality rates (Armour et. Al, 1991)", yet no attempt is made to relate these potential impacts to the tributaries addressed by the TMDL.

Response to Comment #11
Full assessment of biological communities and site-specific evaluation of mechanisms of effect would certainly further clarify the linkages between sediment impact and the beneficial uses for the streams of interest. This further evaluation however increases the time and cost of the assessment and development of the TMDL, the resources to which, are not unlimited. The data collected throughout the course of the analysis of this watershed, both site specific and modeled, is sufficient for addressing the sediment impairment determination and understanding of the impacts to the beneficial uses, as well as the development of allocations to eventually attain full support. This is sufficient largely because a considerable wealth of information is known regarding the impacts of sediment to fish and aquatic life, and the morphological characteristics we can view that display the effects of sediment and infer health of the aquatic biologic community. Examples of this information are cited throughout the document.

Comment #12
For a parameter such as sediment, attainment of aquatic life uses should be at least partially based on biological monitoring. It is acknowledged that sediment is a difficult parameter to link directly to use attainment. Even if target values were directly based on designated use attainment, as recommended above, there is expected to be a certain amount of uncertainty in the "correct" target values. For this reason, the adaptive management approach should include mechanisms for directly evaluating the biological health of stream segments, and assessing attainment of aquatic life uses accordingly. For example, if in-stream aquatic life is healthy and has adjusted to modified stream morphology, the aquatic life use should be considered attained even if certain stream metrics do not conform to target values.

Response to Comment #12
It is agreed that the inclusion of biological data as a metric by which to determine impairment and eventual use attainment should be included within the adaptive management strategy. Language in **Section 8.0** has been strengthened to address this point.

However, the classification of in-stream aquatic life as healthy should also include those features and functions that support the in-stream aquatic life. The presence of a particular species within a modified environment does not necessarily equate to healthy aquatic life. The potential to support and propagate that species within that environment (e.g. a modified stream morphology), provided all reasonable land, soil, and water conservation practices, is equally important to sustaining and protecting that species, and thereby attaining that beneficial use. To provide another example, a bull trout may reside in an

environment with limited resources, yet enough resources to keep that individual trout healthy. But if pollutant reductions and land and water quality management changes provided conditions that would allow greater population abundance and/or diversity in that environment more akin to what would be expected for that stream, then that would be the measure of attaining a healthy system to support that beneficial use.

Comment #13
One of the water quality targets for sediments is stream morphology (i.e., width/depth ratio, entrenchment ratio, residual pool depth, substrate composition). Again, no data is presented illustrating how departing from these targets actually results in impacts to the aquatic life and other beneficial uses.

Response to Comment #13
A significant amount of scientific research has been done that correlates the target parameters chosen for the Lower Clark Fork tributaries to aquatic life and cold water fisheries. The development of these types of targets is also consistent with EPA sediment TMDL guidance. These relationships are well described and literature is cited throughout the discussion in **Section 5.4** and **Appendix D**.

Comment #14
There is some difference between the target values and those values measured at the reference locations. For example, the target entrenchment ratio for high gradient streams, as presented in Appendix D, is between 1.4 and 2.2; however, the median of the field measured values was 3.0.

Response to Comment #14
The data used by which to develop many of the targets were taken from sites throughout the watershed, and under a variety of stream conditions and therefore reflect that variability. The target values chosen to represent the expected and acceptable conditions were based on the median value of this mixed (desired and impaired conditions) data set. In the case of the targets for entrenchment ratio and width/depth ratio, these values were taken directly from the criteria presented in David Rosgen's Classification of Natural Rivers. The data set used to develop Rosgen's critera is much more extensive and has undergone rigorous scientific evaluation and confirmation. Because of this, the Rosgen values for those parameters were deemed to be appropriate, despite the slight variance between the median value for the LCF sites and the Rosgen criteria value.

Comment #15
The sediments found within a stream are highly variable over time: that is, if measurements are taken following a flood or a long drought, very different substrate compositions may result. This variability is important, and should be explicitly addressed from an uncertainty perspective in the TMDL.

Response to Comment #15
This variability and the application of the TMDL targets as a result of seasonal and annual variability are explicitly addressed in **Section 5.7.3 – Uncertainty and Adaptive Management**.

Comment #16
The draft TMDL states that "…adaptive management 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" (p.72). While we applaud the use of an adaptive management strategy, given the uncertainties associated with actual loading reductions needed to

attain designated uses, the approach for adaptive implementation needs to be more focused. The monitoring approach described would be difficult to design and costly to implement, and there are no specific defined criteria for any of the proposed endpoints on which to judge success. As previously stated, the proposed stream attribute targets cannot necessarily be looked at individually, or in any specific combination to define impairment or attainment.

Response to Comment #16
The initial comment regarding the application of stream attribute targets (Comment #3) was taken out of context, however to stem any future misconceptions, the description of the application and interpretation of targets has been edited and clarified within the document. These targets, and the allocations of sediment reduction, are the endpoints on which to judge success. However, adaptive management allows for refinement of these targets and endpoints as more information becomes available. As the above comments have pointed out, additional information can be collected and analyzed to provide more specific answers to what is being impacted, how it is being impacted, where these impacts are greatest, etc. The monitoring methods described are not a prescription per say, but examples of the options available to local land managers and stakeholders by which to evaluate the achievement of the TMDL, and gather further knowledge about the mechanisms effecting impairment throughout the watershed. It is ultimately up to the people who live and work in the watershed to implement and achieve the TMDL, therefore the monitoring strategies that are employed should follow criteria by which to measure success of the projects they undertake, and the TMDLs as a whole. Generally, the reproduction of methods and assessment as had been done for the development of this TMDL would be the first step in analysis of comparing data to monitor change over time, and this point is explicitly stated in **Section 8.0**.

Comment #17
The TMDL has not defined the current baseline for aquatic or coldwater fish use, or the metrics to determine impairment or attainment of these designated uses. Prior to implementation of an extensive monitoring program to support adaptive implementation, specific goals and associated metrics for biological and ecological condition, and the associated natural range or variability should be defined.

Response to Comment #17
As previously stated in the Response to Comment #1, further information to describe the process for determining impairment and listing a waterbody to the State's Impaired Waters list can be found in Montana's Water Quality Integrated Report. A summary of this process is included in **Section 3.0**.

The information provided within this document offers a solid foundation by which to assess and implement change in the Lower Clark Fork tributaries. The targets developed herein serve to measure the impact from sediment, and directly relate to healthy environments that support coldwater fish and aquatic life.

Watershed scale recovery from pollutant impacts is a time consuming and sometimes expensive endeavor to undertake, yet a necessary one for the well being of the health of these ecosystems, and the people who live, work, and play there. The desire to have a more thorough picture of the complex mechanisms of sediment input, and the interactions between sediment loads, land management, and stream ecology is shared by the DEQ, but does not preclude actions from being taken now to ultimately achieve full support of the beneficial uses in the Lower Clark Fork tributaries. The Lower Clark Fork Watershed Group has worked collaboratively for well over the past decade with land owners, businesses, and local, state, and federal agencies to form partnerships by which to investigate these

issues. The strategies they, among others, have implemented, and the projects they have put on the ground have made a difference and are bringing the Lower Clark Fork tributaries closer to meeting the goals set forth in this document. This document is yet another tool in the toolbox for these individuals to use and more efficiently and effectively refine and focus their efforts for the continued reduction of pollutants and protection and improvement of these important watersheds.

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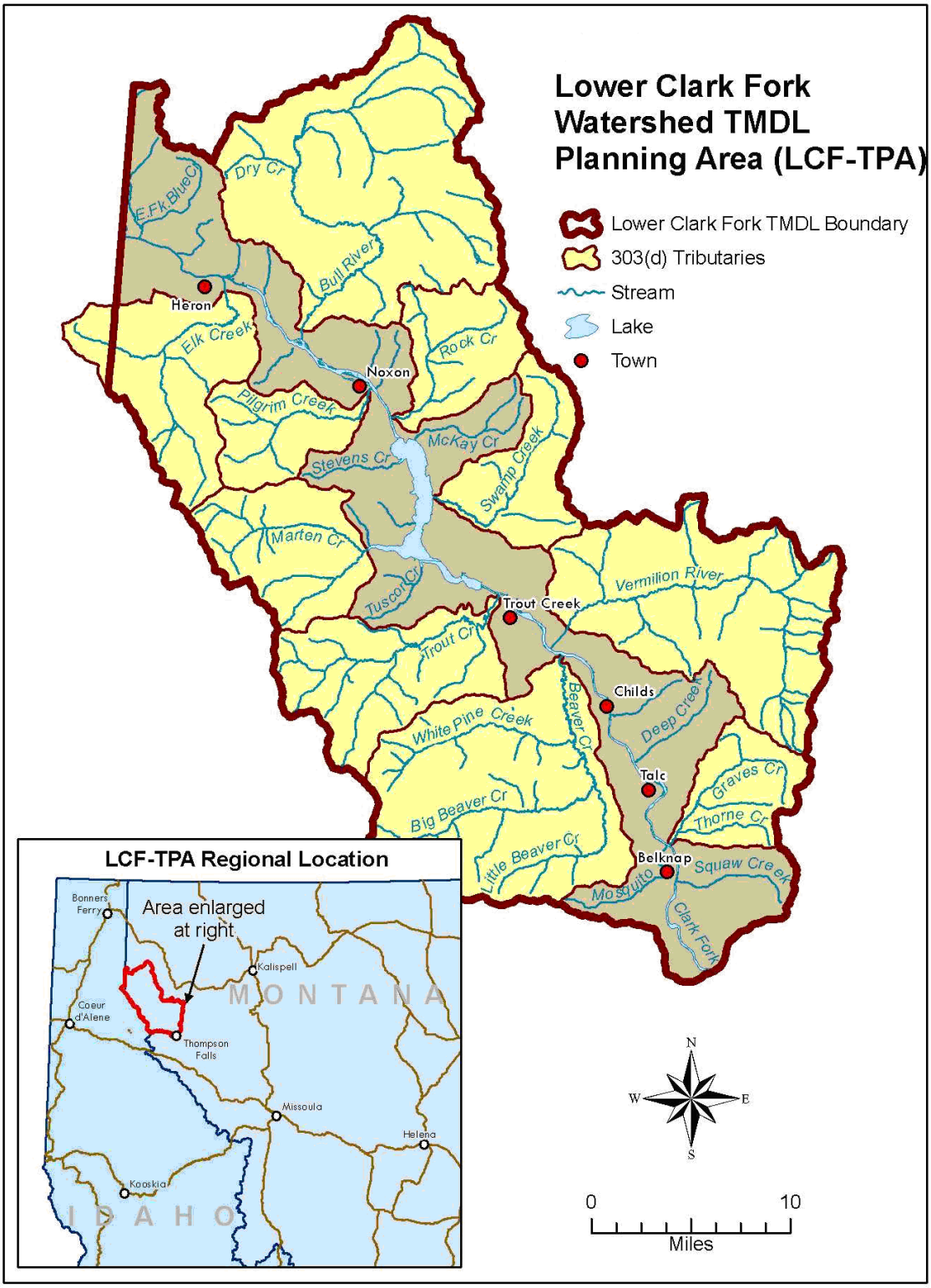


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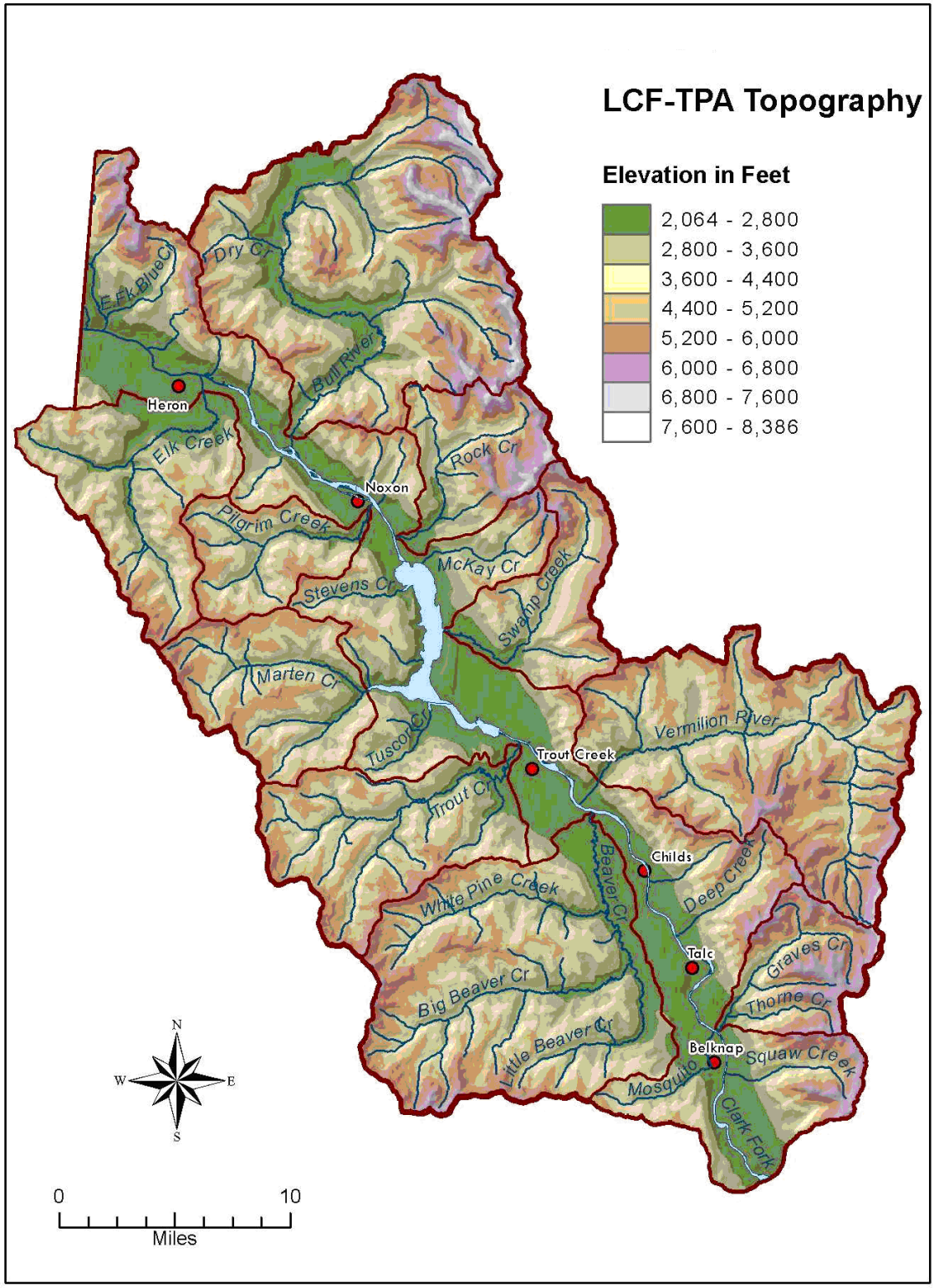


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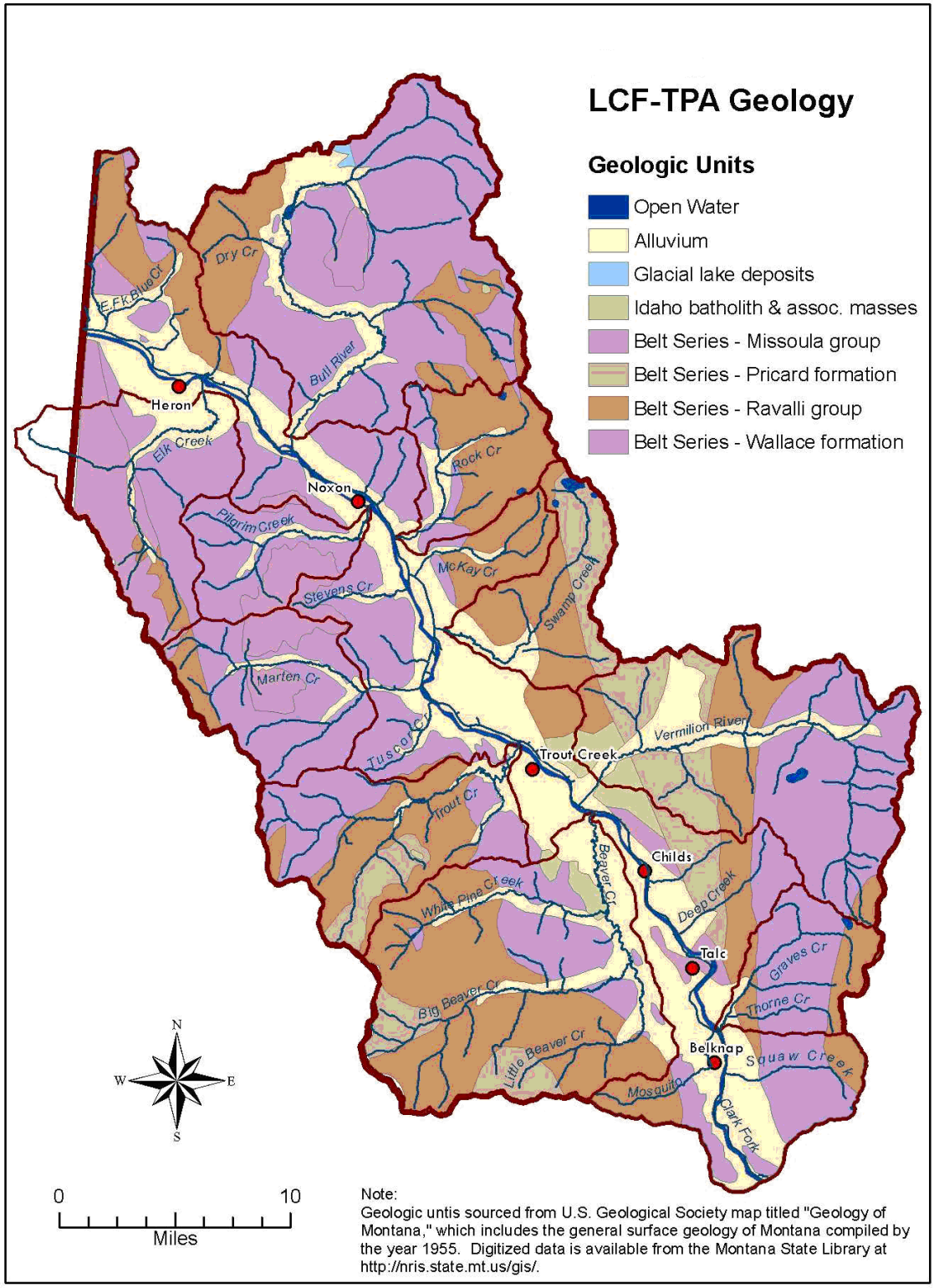


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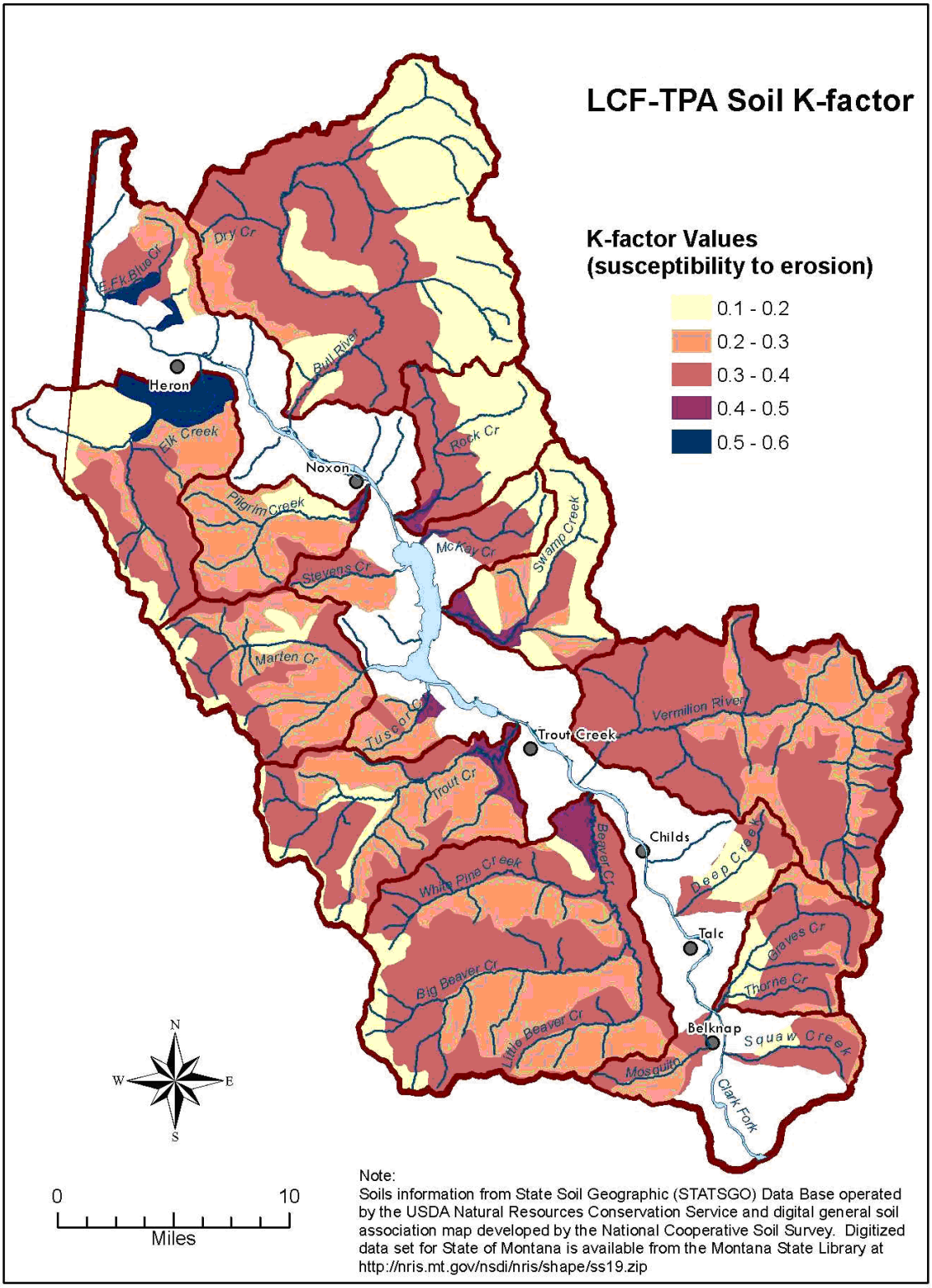


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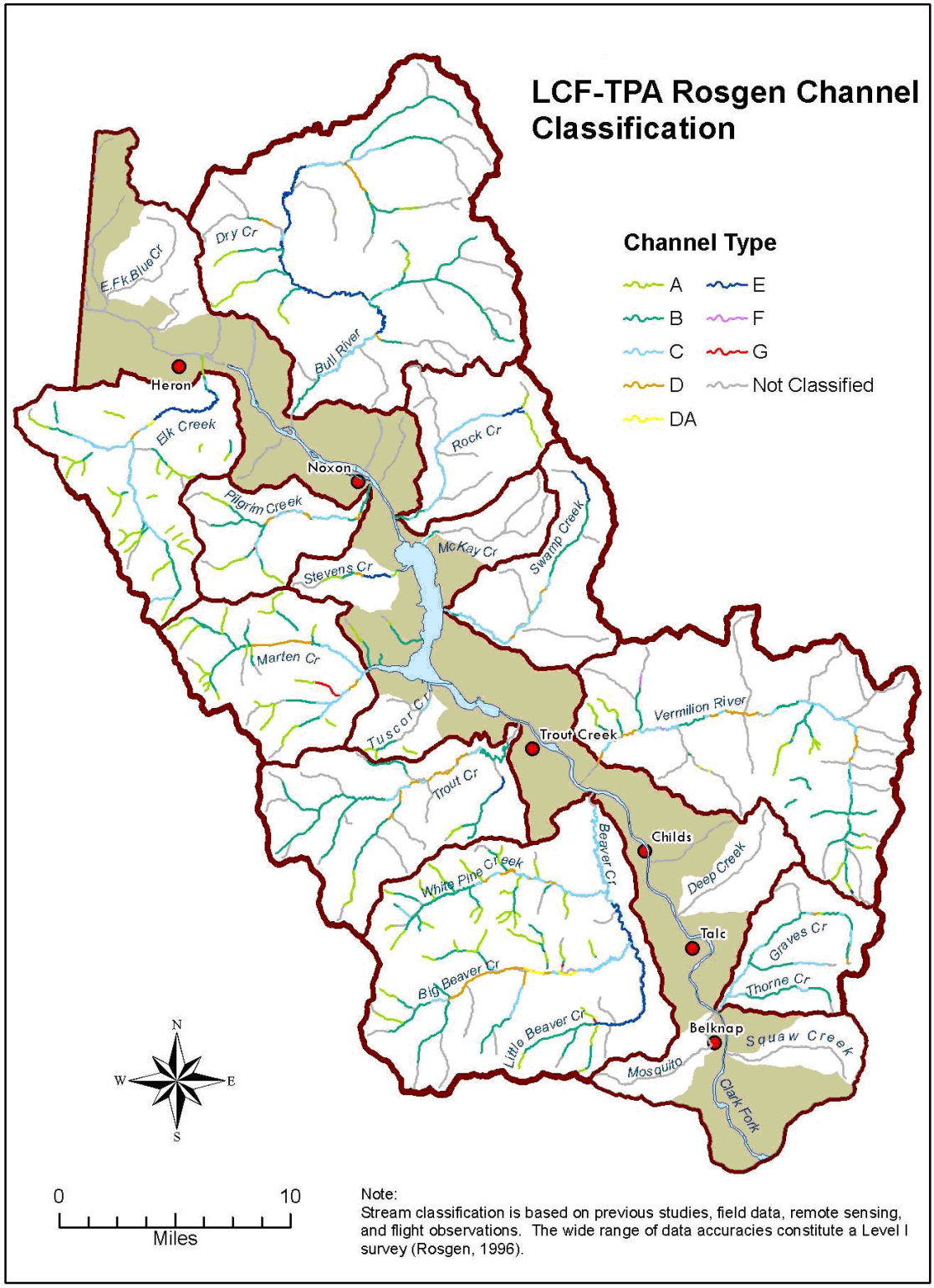


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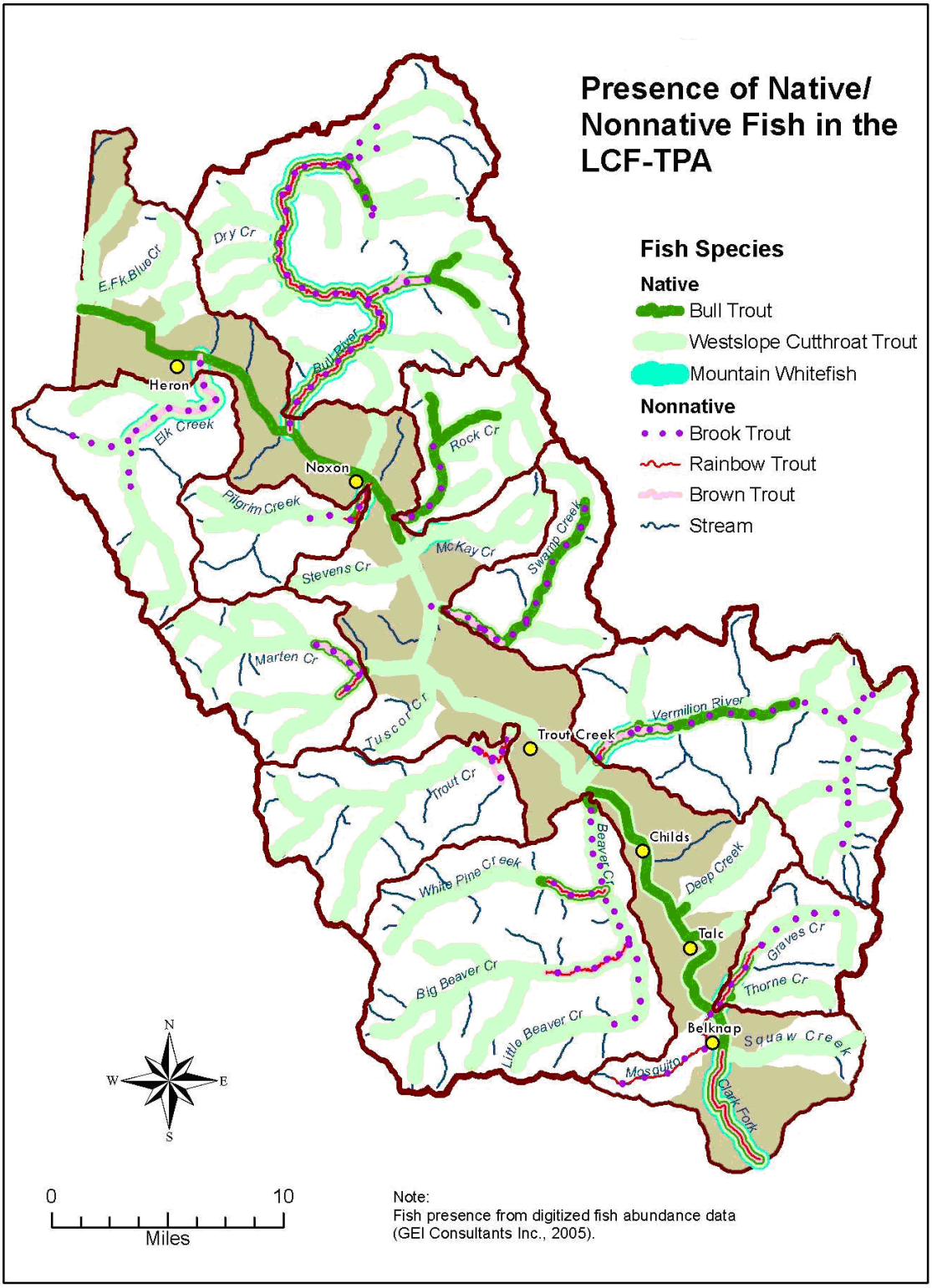


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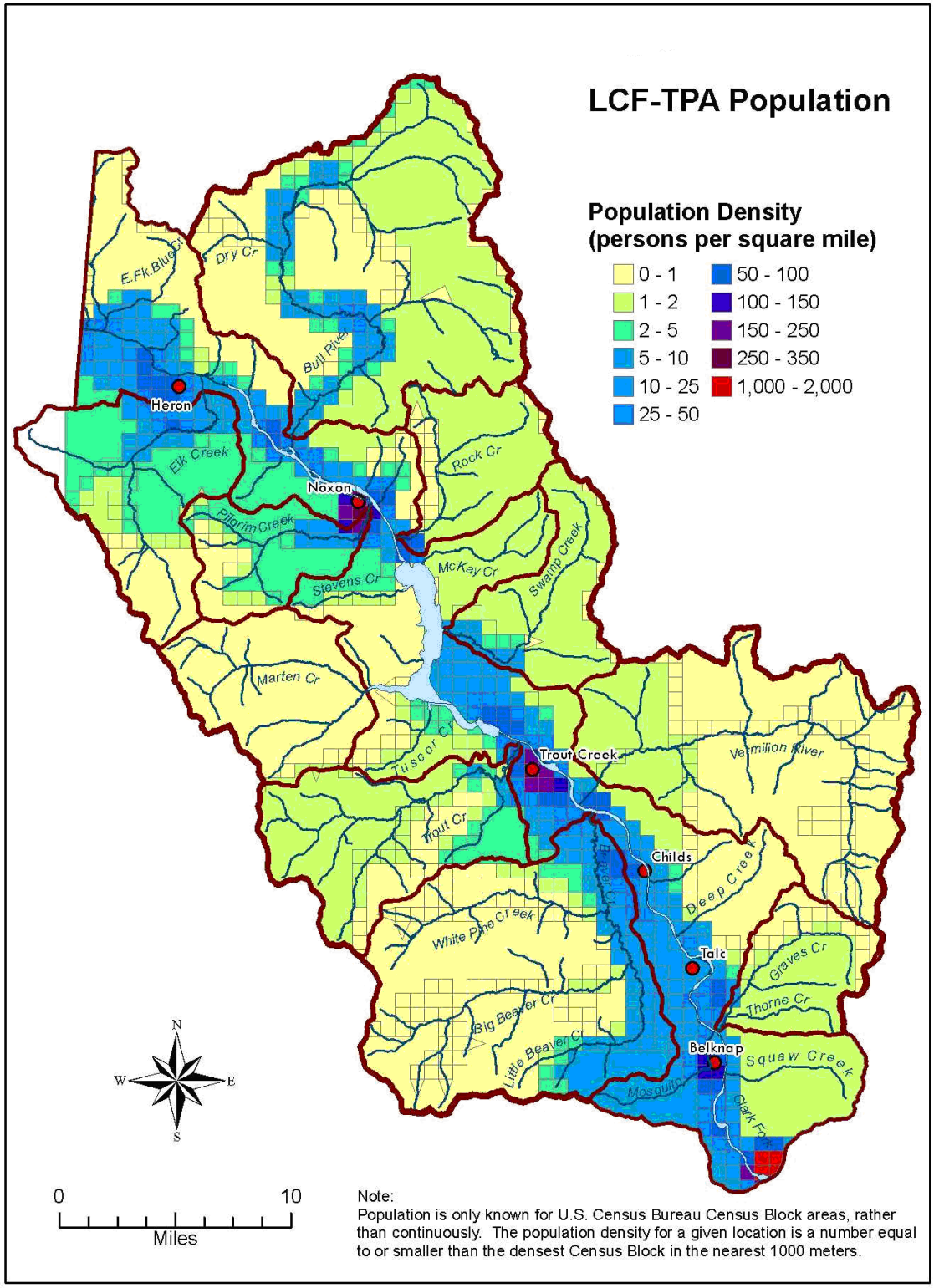


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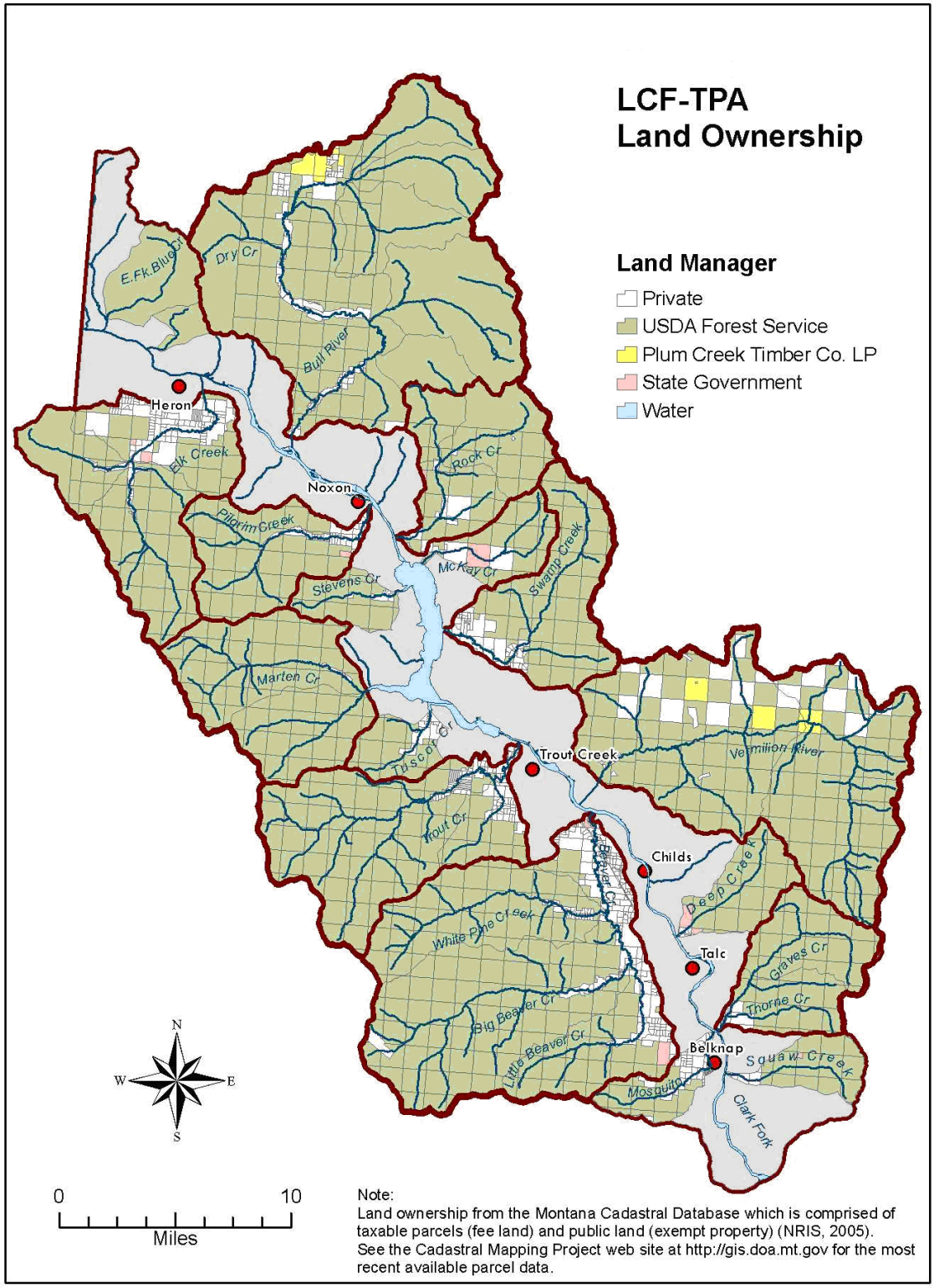


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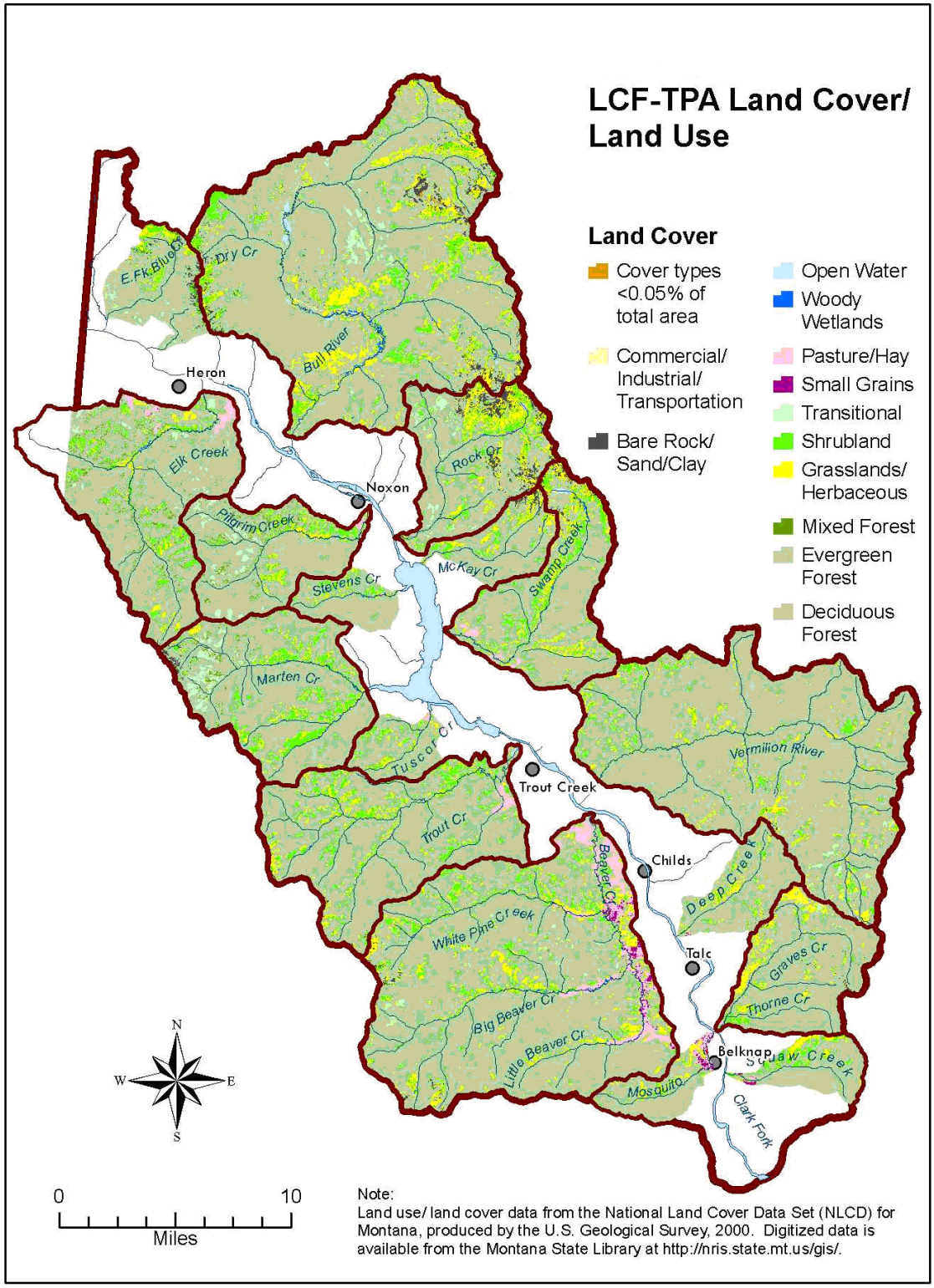


Figure A-9. NLCD Land Cover/Land Use

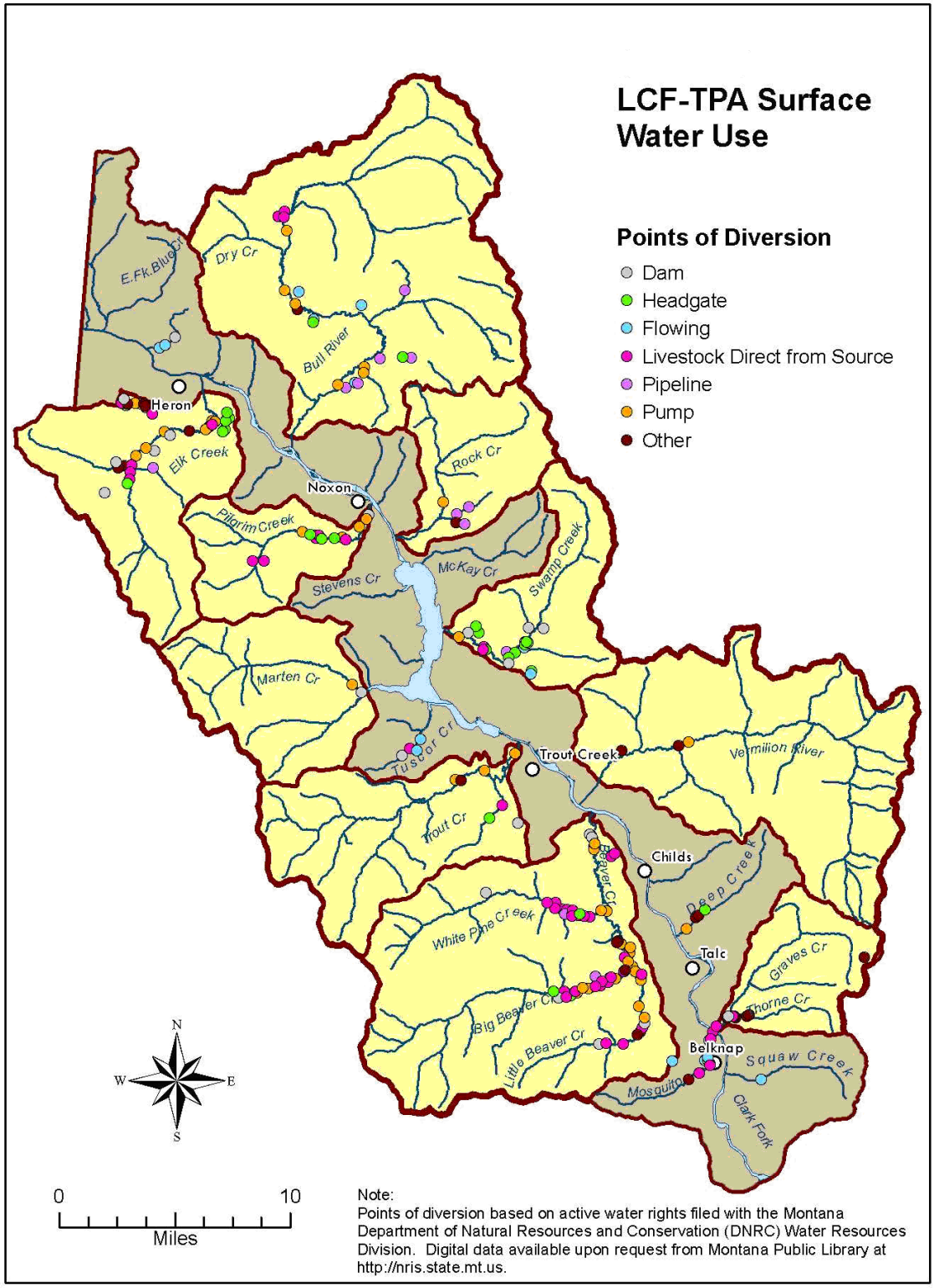


Figure A-10. Water Use in the Lower Clark Fork

APPENDIX B - LOWER CLARK FORK TRIBUTARIES TMDL PLANNING AREA SEDIMENT MONITORING REPORT

Prepared by:

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B1.0 INTRODUCTION

The Lower Clark Fork Tributaries Total Maximum Daily Load Planning Area ([TMDL] LCFT-TPA) is located entirely in Sanders County in northwestern Montana and includes the entire Lower Clark Fork River fourth level HUC watershed (**Figure B1-1**). The TPA addresses six tributary watersheds to the Lower Clark Fork River. Four tributaries are included on the 2006 State of Montana's 303(d) List for sediment impacts and habitat limitations (**Table B1-1**). Elk Creek TMDLs were completed in 1998 but is included in this investigation for monitoring and review. Swamp Creek was included to gather data for assessment purposes and potential TMDL development.

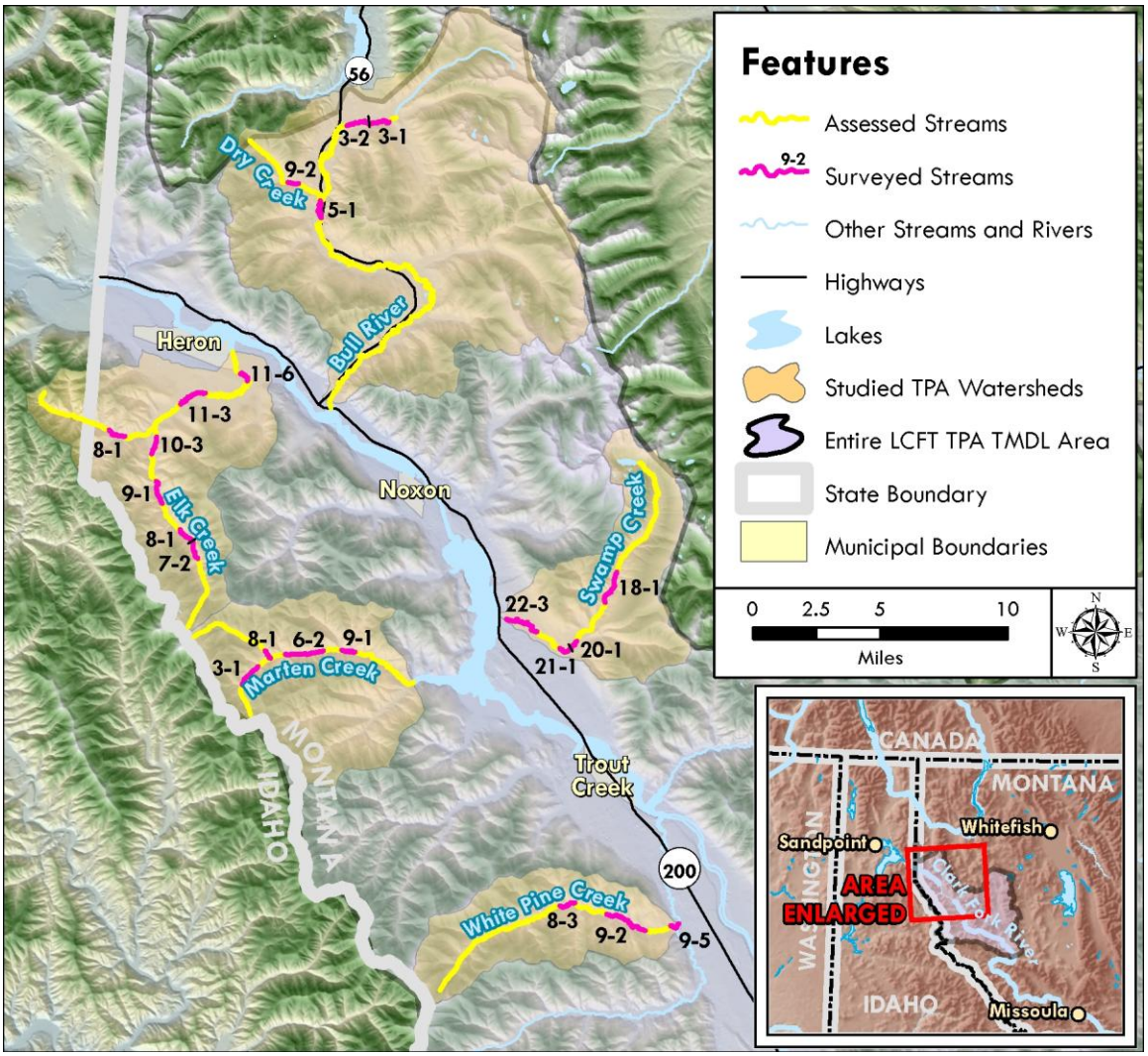


Figure B1-1. The project area vicinity map for the LCFT-TPA.

Table B1-1. Tributaries in the LCFT-TPA, stream class, impairment source description, and impairment cause.

Stream Name	Class	Source Description	Cause
BULL RIVER from the North Fork to the mouth (Cabinet Gorge Reservoir)	B-1	Silviculture Activities, Streambank Mod/destabilization	Sedimentation/Siltation, Physical substrate habitat alterations
DRY CREEK	B-1	Forest Roads (Road Construction and Use)	Sedimentation/Siltation
ELK CREEK from headwaters to mouth (Cabinet Gorge Res.)	B-1	Top of Form Grazing in Riparian or Shoreline Zones, Habitat Modification - other than Hydromodification Bottom of Form	Sedimentation/Siltation
MARTIN CREEK from headwaters to the mouth (Noxon Reservoir)	B-1	Forest Roads (Road Construction and Use, Silviculture Activities, Streambank Mod/Destabilization	Other habitat alterations, Siltation
SWAMP CREEK	A-1	N/A	N/A
Top of Form WHITE PINE CREEK, headwaters to the mouth (Beaver Creek) Bottom of Form	B-1	Forest Roads (Road Construction and Use), Grazing in Riparian or Shoreline Zones, Natural Sources, Silviculture Harvesting, Streambank Mod/Destabilization, Watershed Runoff Following Forest Fire	Top of Form Alteration in stream-side or littoral vegetative covers, Sedimentation/Siltation, Temperature/Water

Under Montana law, an impaired water body is defined as a water body for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired water bodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years. This list is referred to as the "303(d) List", and is included within Montana's biennial 305(b) "Integrated Report". The Montana Water Quality Act further directs states to develop TMDLs for all water bodies appearing on the 303(d) List as impaired or threatened by "pollutants" (MCA 75-5-703).

In 2008, Montana Department of Environmental Quality (MT MDEQ) initiated an effort to collect data to support the development of TMDLs and TMDL related investigation for the six tributaries in the LCFT-TPA listed above. The data collection effort involved assessing sediment and habitat conditions as these conditions influence aquatic life beneficial uses. River Design Group, Inc. (RDG), was contracted by MT MDEQ to assist in the implementation of stream stratification, sampling design, ground surveys, and sediment and habitat analyses.

The stream stratification method is intended to develop water body characterizations that can be applied across watersheds, accounting for localized ecological variations. The stratification enables comparison between observed and expected values for sediment and habitat parameters, quantifying the effects of anthropogenic influences. Stratification for the LCFT-TPA streams began by dividing the water bodies into reaches and sub-reaches. These divisions were based on aerial photo interpretation, landscape conditions, and land-use factors. This preliminary work was completed in summer 2008.

Following the initial stratification, representative sub-reaches were chosen by MT MDEQ for data collection. Following a two day sampling reach verification reconnaissance July 22-23, 2008, RDG and

MT MDEQ personnel completed site surveys from September 22 to October 2, 2008. RDG and MT MDEQ personnel visited the selected sub-reaches and recorded bank erosion sites, vegetation, and channel characteristics data. These data were analyzed in November and December 2008, resulting in full descriptions of sediment and habitat conditions for all of the surveyed reaches.

B2.0 AERIAL ASSESSMENT REACH STRATIFICATION

B2.1 METHODS

An aerial assessment of streams in the LCFT-TPA was conducted using ArcGIS (ESRI 2008) and 2005 color aerial imagery. Other relevant geographic data layers were acquired from the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA) and the Montana State National Resource Information System (MT NRIS) database. Additional layers include the following data sets.

- Ecoregion (USEPA)
- Scanned and Rectified Topographic Maps, 1:24,000 (USGS)
- National Hydrography Dataset Lakes and Streams (USGS)
- 2005 National Aerial Image Program (NAIP – NRIS)

GIS data layers were used to stratify streams into reaches based on landscape and land-use factors. The stream reach stratification methodology applied in this study is described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (MDEQ 2008a), with additional background information provided in *White Paper: A Watershed Stratification Approach for TMDL Sediment and Habitat Impairment Verification* (MDEQ 2008b).

The reach stratification methodology involves delineating a water body stream segment into stream reaches and sub-reaches. This process was completed for the following sediment-listed stream segments in the LCFT-TPA:

- Elk Creek
- Bull River
- Dry Creek
- White Pine Creek
- Martin Creek
- Swamp Creek

B2.2 STREAM REACHES

Water body segments are generally delineated by a water use class designated by the State of Montana, e.g. A-1, B-3, C-3 (Administrative Rules of Montana Title 17 Chapter 30, Sub-Chapter 6). Although a water body segment is the smallest unit for which an impairment determination is made, the stratification approach described in this document initially stratifies individual water body segments into discrete assessment reaches that are delineated by distinct variability in landscape controls such as Strahler stream order, valley slope, and valley confinement. The reason for this is that the inherent differences in landscape controls between stream reaches often prevents a direct comparison from being made between the geomorphic attributes of one stream reach to another.

By initially stratifying water body segments into stream reaches having similar geomorphic landscape controls, it is feasible to make comparisons between similar reaches in regards to observed versus expected channel morphology. Likewise, when land use is used as an additional stratification (e.g. grazed vs. non-grazed sub-reaches), sediment and habitat parameters for impaired stream reaches can be more readily compared to reference reaches that meet the same geomorphic stratification criteria.

The aerial photograph reach stratification methodology involves dividing a stream segment into distinct reaches based on four landscape factors:

- Level IV ecoregion
- Valley gradient
- Strahler stream order
- Valley confinement

B2.2.1 Sub-reaches

Once stream reaches have been classified by the four criteria identified in **Section B2.1**, reaches are further divided based on the surrounding vegetation and land-use characteristics as observed in the 2005 color aerial imagery using ArcGIS. The result is a series of stream reaches and sub-reaches delineated by landscape and land-use factors. Stream reaches with similar landscape factors can then be compared based on the character of surrounding land-use practices.

B2.3 REACH TYPES

Each individual combination of the four stream reach factors will be referred to as a "reach type" in this report.

Reach Type - Unique combination of Ecoregion, gradient, Strahler stream order, and confinement

Note that the Northern Rockies Level III Ecoregion contains six Level IV Ecoregions in the LCFT-TPA:

- Purcell-Cabinet-North Bitterroot Mountains (15q)
- Clark Fork Valley and Mountains (15k)
- Coeur D'Alene Metasedimentary Zone (15o)
- Grave Creek Range – Nine Mile Divide (15a)
- High Northern Rockies (15h)
- Salish Mountains (15l)

For the reach type analysis, the Northern Rockies Level III Ecoregion was assigned to all reaches. Possible reach type combinations based on the Level III Ecoregion identified in the LCFT-TPA are presented in **Table B2-1**.

Table B2-1. Possible Level III Ecoregion, Valley Gradient, Strahler Stream Order, and Confinement Combinations.

Ecoregion III	Valley Gradient	Strahler Stream Order	Confinement
Northern Rockies	> 10 %	1	Unconfined
	4 - 10 %	2	Confined
	2 - < 4 %	3	
	< 2 %	4	

Reach types were described using the following naming convention:

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

The following identifiers were applied for each of the four factors:

Level III Ecoregion:
- NR = Northern Rockies

Valley Gradient:
- 0 = 0-<2%
- 2 = 2-<4%
- 4 = 4-10%
- 10 = >10%

Strahler Stream Order:
- 1 = first order
- 2 = second order
- 3 = third order
- 4 = fourth order

Confinement:
- U = unconfined
- C = confined

Thus, a stream reach identified as NR-0-3-U is a low gradient (0-<2%), 3rd order, unconfined stream in the Northern Rockies Level III Ecoregion. Reach type combinations are presented in **Table B2-2** and the sampled reaches in the project area are presented in **Table B2-3**. A map of the classified stream reaches is included in **Figure B2-1**.

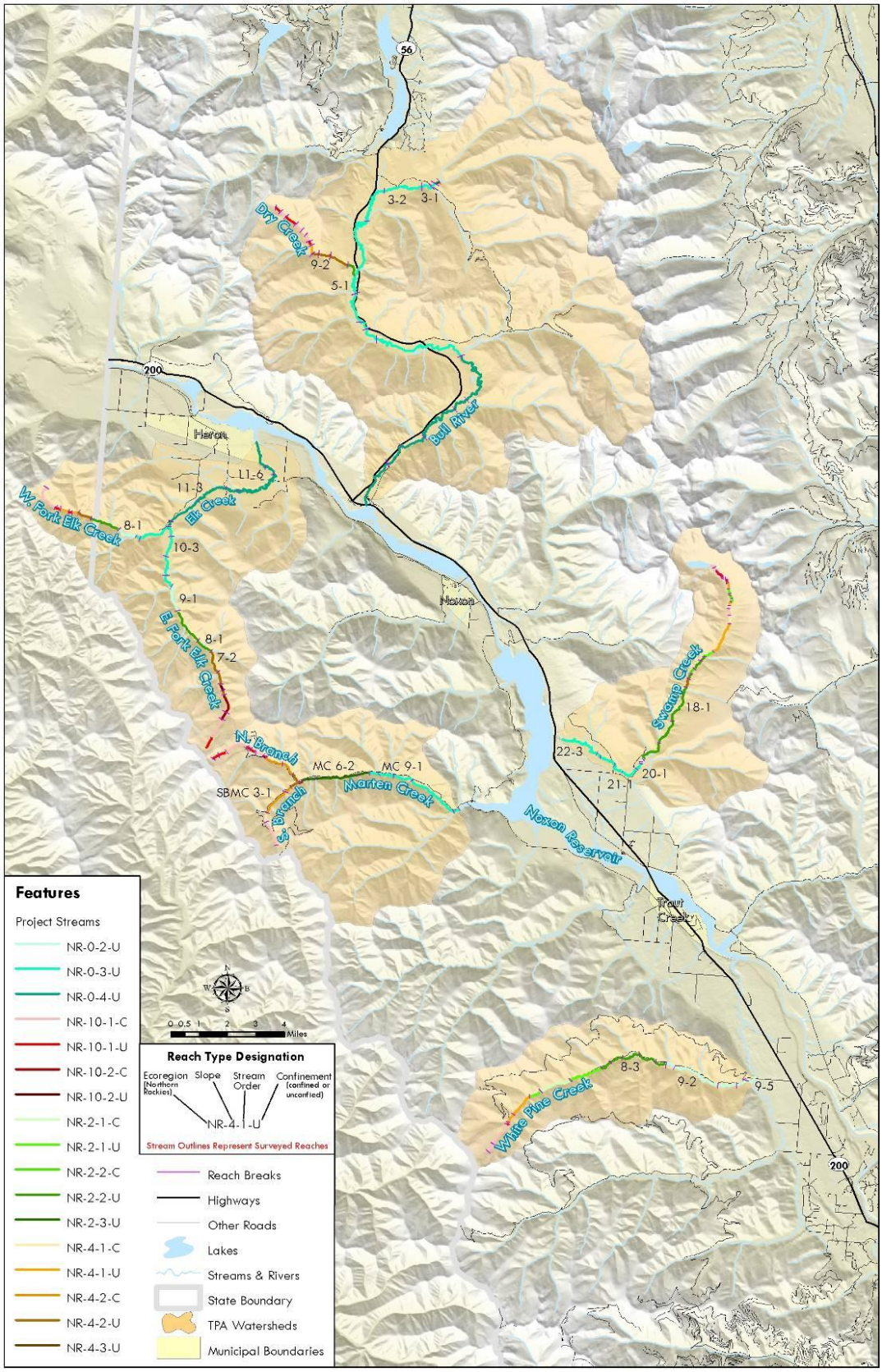


Figure B2-1. The reach type designation map for the LCFT-TPA.

Table B2-2. Identified Level III Ecoregion, Valley Gradient, Strahler Stream Order and Confinement Combinations.

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confine-ment	Reach Type	Level IV Ecosystem	Number of Reaches	Number of Monitoring Sites
Northern Rockies	0 - <2%	2	U	NR-0-2-U	15k,o,q	9	4
		3	U	NR-0-3-U	15k,o,q	28	8
		4	U	NR-0-4-U	15o,h	13	2
	2% - 4%	1	U	NR-2-1-U	15k,q	8	0
		1	C	NR-2-1-C	15k	1	0
		2	U	NR-2-2-U	15k,o,q	16	3
		2	C	NR-2-2-C	15q	1	0
		3	U	NR-2-3-U	15k,o,q	4	1
	4% - 10%	1	U	NR-4-1-U	15k,o,q	12	0
		1	C	NR-4-1-C	15o,q	4	0
		2	U	NR-4-2-U	15k,o,q	14	3
		2	C	NR-4-2-C	15o	4	1
		3	U	NR-4-3-U	15h	1	0
	>10%	1	U	NR-10-1-U	15k,o,q,h	30	0
		1	C	NR-10-1-C	k,o,q,h	15	0
		2	U	NR-10-2-U	15k,o	4	0
		2	C	NR-10-2-C	15k,o	3	0

Table B2-3. Sampled reaches in project area sorted by reach type			
Level III Ecoregion	**Reach Type**	**Reach ID**	**Number Sampled**
Northern Rockies	NR-0-2-U	WFELK 8-1,EFELK 9-1,WHP 9-2,WHP 9-5	4
	NR-0-3-U	BULL 3-2, BULL 3-3, BULL 5-1, EFELK 10-3, MC 9-1, SWP 20-1, SWP 21-1, SWP 22-3	8
	NR-0-4-U	ELK 11-3, ELK 11-6	2
	NR-2-2-U	EFELK 8-1, SWP 18-1, WHP 8-3	3
	NR-2-3-U	MC 6-2	1
	NR-4-2-U	DRY 9-2, EFELK 7-2,NBMC 8-1	3
	NR-4-2-C	SBMC 3-1	1

B3.0 SEDIMENT AND HABITAT DATASET REVIEW

B3.1 FIELD METHODOLOGY

The following sections include descriptions for the various field methodologies that were employed for the stream assessments. The methods follow standard MDEQ protocols for sediment and habitat assessment, as presented in the document, *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (MDEQ 2008a). All field forms used in the study are standard forms used by MDEQ for sediment and habitat assessments. On-site training in field methodologies and field forms was conducted by MDEQ for the entire assessment team during the first two days of the assessment period. For most survey sites, a minimum of 5 team members were present, which were always divided into 3 teams, referred to as the "Greenline," "Substrate," and "Cross-Section" teams in this section. The teams worked independently moving upstream through the survey site and in a pre-established order so as to create the least possible in-stream disturbance.

B3.1.1 Survey Site Delineation

Stream survey sites were delineated beginning at riffle crests at the downstream ends of reaches. Survey sites were measured upstream at pre-determined lengths based on the bankfull width at the selected downstream riffle. Survey lengths of 500 ft were used for bankfull widths less than 10 ft; survey lengths of 1,000 ft were used for bankfull widths between 10 ft and 50 ft; survey lengths of 1,500 ft were used for bankfull widths between 50 ft and 60 ft; and survey lengths of 2,000 ft were used for bankfull widths greater than 60 ft. Each survey site was divided into 5 equally sized study cells. For each site, the field team leader identified the appropriate downstream riffle crest to begin a reach. Where no riffles were present or the stream was dry, the field team leader identified the appropriate starting point.

The GPS location of the downstream end of the survey site was recorded on the **Sediment and Habitat Assessment Site Information Form**.

Digital photographs were taken at both upstream and downstream ends of the survey site, looking both upstream and downstream. Photo numbers and a brief description were recorded in the **Photo Log**.

B3.1.2 Field Determination of Bankfull

All members of the field crew (except for the "Greenline" team member) participated in determining the bankfull elevation prior to breaking into their respective teams. Indicators that were used to estimate the bankfull channel elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, stained rocks and inundation features. Multiple locations and indicators were examined, and bankfull elevation estimates and their corresponding indicators were recorded in the **Bankfull Elevation and Slope Assessment Field Form** by the field team leader. Final determination of the appropriate bankfull elevation was determined by the team leader, and informed by the team experience and notes from the field form.

B3.1.3 Channel Cross-sections

The "Cross-Section team" was composed of two members of the assessment crew, who also performed riffle grid tosses (**Section B3.1.4.4**), pebble counts (**Section B3.1.4.6**), and riffle stability index (**Section**

B3.1.4.7). Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod and recorded in the **Channel Cross-section Field Form**.

Cross-sections were conducted in each cell containing a riffle feature. In the case that riffles were present in only 1 or 2 cells, but those cells contained multiple riffles, additional cross-sections were performed at the most downstream unmeasured riffle, such that a minimum of three cross-sections were conducted. If only 1 or 2 riffles were present in the entire reach, they were measured. In no cases of this assessment was the stream devoid of riffles.

To begin, the Cross-Section team placed a bank pin at the pre-determined bankfull elevation (using bankfull indicators as guides) on the right and left banks. A measuring tape was strung perpendicular to the stream channel at the most "well-defined" portion of the riffle and tied to the bank pins.

Where mid-channel bars or other features or crossings were present in the channel which prevented a "clean" line across the channel, protocol provided in Section 2.3 of the *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* document were followed (MDEQ 2008a).

Depth measurements at bankfull were collected to a tenth of a foot across the channel at regular intervals. These intervals varied depending on channel width, following protocol in item 15, Section 2.3 of the *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (MDEQ 2008a). The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

From the recorded data, the following were calculated for each cross-section:

Mean depth = sum of depth measurements / number of depth measurements (excluding the RBF and LBF measurements, unless they were greater than zero, such as when there is a vertical bank)

Cross-sectional area = bankfull width x mean bankfull depth
Width/depth ratio = bankfull width / mean bankfull depth

Entrenchment ratio = floodprone width / bankfull width.

In the case that cross-sectional areas determined from different cross-sections varied greatly, a cross-section was re-strung and measured again. In some cases, major alterations in stream features caused these discrepancies, which were noted in the field form.

The floodprone elevation was determined by multiplying the maximum depth value by 2. The floodprone width was then determined by stringing a tape from the bankfull channel margin on both right and left banks until the tape (pulled tight and "flat") touched ground at the floodprone elevation. The total floodprone width was calculated by adding the bankfull channel width to the distances on either end of the channel to the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, best professional judgment was used to determine the floodprone width.

GPS coordinates for each cross-section were recorded. Photos were taken upstream and downstream of the cross section from the middle of the channel. A photo was also taken across the channel, showing the tape across the stream.

B3.1.4 Channel Bed Morphology

A variety of channel bed morphology features was measured and recorded by the "Substrate" team, which usually consisted of two team members, and included the field team leader. The length of the survey site occupied by pools and riffles was identified and recorded in the **Pools, Riffles and Large Woody Debris Field Form.** Beginning from the downstream end of the survey site, the upstream and downstream stations of "dominant" riffle and pool stream features were recorded. Features were considered "dominant" when occupying over 50% of the stream width. Pools and riffles were measured from head crest or riffle crest, respectively, until the end of that feature (defined as the tail crest for pools).

Runs and glides were not recorded in the field form. Stream features were identified per standard field method criteria (MDEQ 2008a).

B3.1.4.1 Residual Pool Depth

At all pools encountered, a residual pool depth measurement was taken. Backwater pools were not measured. Measured pools were recorded at each station (distance in feet) of occurrence, beginning at the downstream end (station 0) of the survey site. The depth of the pool tail crest (MDEQ 2008a) at its deepest point was measured. No pool tail crest depth was recorded for dammed pools (see **B3.1.4.2**).

The maximum depth of each pool was also recorded. In the case of dry channels, readings were taken from channel bed surface to bankfull height.

B3.1.4.2 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken and recorded in the **Pools, Riffles and Large Woody Debris Field Form** as follows:

1. Pool types were determined to be either Scour **(S)** or Dammed **(D)**.

2. Pool size was relative to bankfull channel width was recorded as Small **(S)**, Medium **(M)**, or Large **(L)**. Small pools were defined as those <1/3 of the bankfull channel; medium pools were >1/3 and <2/3 of the bankfull channel; and large pools were determined to be those >2/3 of the bankfull channel or >20 feet wide.

3. Pool formative features were recorded as either Lateral Scours **(LS)**, Plunge **(P)**, Boulder **(B)**, or Woody Debris **(W)**.

4. The primary pool cover type was recorded using the following codes:
   V = Overhanging Vegetation
   D = Depth
   U = Undercut
   B = Boulder
   W = Woody Debris
   N = No apparent cover

5. When undercut banks were present, their depths were measured to a tenth of a foot by inserting a measuring rod horizontally into the undercut bank.

B3.1.4.3 Fine Sediment in Pool Tail-outs

A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at the first and second scour pool of each cell. Grid toss readings were focused in those pool tail-out gravels that appeared to be suitable or potentially suitable for trout spawning.

Measurements were taken within the "arc" just upstream of the pool tail crest, following the methodology in Section 2.8 of *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (MDEQ 2008a). Three measurements were taken across the channel with specific attention given to measurements in gravels determined to be of appropriate size for salmonid spawning. The potential for spawning was recorded as Yes **(Y)**, No **(N)**, or Unclear **(?)** at each measurement site.

B3.1.4.4 Grid Toss - Fine Sediment in Riffles

Using the same grid toss method as used in pools by the Substrate team (**Section B3.1.4.3**), measurements of fine sediment in riffles were recorded by the Cross-Section team. Grid tosses were performed in the same general location but before the pebble counts (**Section B3.1.4.6**) and to avoid disturbances to fine sediments. These measurements were recorded in the **Riffle Pebble Count Field Form.**

B3.1.4.5 Woody Debris Quantification

The amount of large woody debris (LWD) was recorded by the Substrate team along the entire assessment reach in the **Pools, Riffles and Large Woody Debris Field Form**. Large pieces of woody debris located within the bankfull channel and which were relatively stable as to influence the channel form were counted as either single, aggregate or willow bunch. Further description of these categories is provided in Section 2.10 of *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (MDEQ 2008a).

B3.1.4.6 Riffle Pebble Count

One Wolman pebble count (Wolman 1954) was performed by the Cross-Section team at the first riffle encountered in cells 1, 3 and 5 as the team progressed upstream, providing a minimum of 300 particle sizes measured within each assessment reach. These data was recorded in the **Riffle Pebble Count Field Form**. Particle sizes were measured along their intermediate length axis (*b-axis*) and results were grouped into size categories. The team progressed from bankfull to bankfull using the "heel to toe" method, measuring particle size at the tip of the boot at each step. More specific details of the pebble count methodology and protocol followed in cases where riffles were not encountered in the designated cells can be found in Section 2.11 of *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (MDEQ 2008a).

B3.1.4.7 Riffle Stability Index

In streams that had developed point bars, a riffle stability index was performed to determine the average size of the largest recently deposited particle. This information was recorded in the **Riffle Pebble Count Field Form**.

For streams in which gravel bars were present, a total of 3 stability index measurements were conducted, which consisted of intermediate axis (*b-axis*) measurements of 15 particles determined to be among the largest size group to be recently deposited and which occur on over 10% of the point bar. During post-field data processing, the riffle stability index was calculated as the geometric mean of the survey site dataset.

B3.1.5 Riparian Greenline Assessment

After the entire survey length was strung by the Greenline team member, an assessment of riparian vegetation cover was performed. The greenline, which is located at approximately the bankfull channel margin, was walked by the Greenline team member, who noted the general vegetation community type of the groundcover, understory and overstory on both banks. Vegetation types were recorded at 10-foot intervals and were entered in the **Riparian Greenline Field Form**.

The ground cover vegetation (<1.5 feet tall) was described using the following categories:

W = Wetland vegetation, such as sedges and rushes
G = Grasses or forbs, rose, snowberry (vegetation lacking binding root structure)
B = Bare/disturbed ground
R = Rock, when a large cobble or bolder is encountered
RR = Riprap

The understory (1.5 to 15 feet tall) and overstory (>15 feet tall) vegetation were described using the following categories:

C = Coniferous
D = Deciduous, riparian shrubs and trees with sufficient rooting mass and depth to provide protection to the streambanks
M = mixed coniferous and deciduous

At 50-foot intervals, a riparian buffer width was estimated on either side of the bank. This width corresponded to the belt of vegetation buffering the stream from adjacent land uses. Upon conclusion of the greenline measurements, the total numbers of each type of vegetation were tallied.

B3.1.6 Streambank Erosion Assessment

An assessment of all actively/visually eroding and slowly eroding/undercut/vegetated streambanks was conducted along each survey site. This assessment consisted of the Bank Erosion Hazard Index (BEHI; see **Section B4.0**) and Near Bank Stress estimation which are used to quantify sediment loads from bank erosion. All streambank measurements were recorded in the **Streambank Erosion Field Form** and **Additional Streambank Erosion Measurements Form.** Further information related to the streambank erosion assessment methodology and results is included in **Section B4.0**.

B3.1.7 Water Surface Slope

Three water surface slope measurements were estimated using a clinometer and recorded in the **Elevation & Water Surface Slope Field Form** at each survey site. Two crew members, usually part of the Cross-Section team stood at the water's surface in a riffle or similar stream feature and at a distance from each other with a direct line-of-site.

B3.1.8 Field Notes

At the completion of data collection at each survey site, field notes were collected by the field leader with inputs from the entire field team. The following four categories contributed to field notes, which served to provide an overall context for the condition of the stream channel relative to surrounding and historical uses:

- Description of human impacts and their severity
- Description of stream channel conditions
- Description of streambank erosion conditions
- Description of riparian vegetation conditions

B3.1.9 Quality Assurance/Control

Two days of on-site training were held to familiarize the entire crew with all the field forms and procedures. The field team leader and most experienced crew members led the separate teams during these first two days. At the conclusion of the first day's training, all field forms were reviewed for completeness and accuracy.

To ensure the highest quality data collection, several protocols were followed at every site visit. Equipment checks were done every morning and field maps were reviewed with drivers before approaching the site. Field forms were distributed and double-checked before teams left the vehicles to the survey sites. Any questions that arose from field teams were brought to the attention of the field team leader until doubts and questions were resolved to the leader's satisfaction.

Summaries of data for selected parameters follows in **Section B3.2** and **Section B4**. Full field data results are included in **Tables B5-1** through **B5-7** in **Section B5**.

B3.2 Sampling Parameter Descriptions and Summaries by Reach Type

The following sections present a definition of the sampling parameters that were used to evaluate stream conditions for each surveyed reach. Graphs and data tables follow the sampling parameter descriptions. The box plots represent the 25th, 50th (median), and 75th percentile values. The whiskers include the maximum value and minimum values measured.

B3.2.1 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). 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."***

The channel width/depth ratio is one of several standard measurements used to classify stream channels (Rosgen 1996), making it a useful variable for comparing conditions on reaches within the same stream type. A comparison of observed and expected width/depth ratio is a useful indicator of channel over-widening and aggradation, which are often linked to excess streambank erosion or acute

or chronic erosion from sources upstream of the study reach. Channels that are over-widened often are associated with excess sediment deposition and streambank erosion, contain shallower, warmer water, and provide fewer deepwater habitat refugia for fish.

Width/depth data can be compared to guideline threshold values from previous studies to indicate if width/depth ratios observed on reaches in the LCFT-TPA are greater than those expected for minimally impacted channels. Results exceeding the guideline values may indicate over-widening. A general threshold value for width/depth ratio is 23 for Rosgen B type channels and 30 for C channels. These values represent an average of target values used in previous TMDL assessments in northwest Montana.

The width/depth ratios by reach type are presented in **Figure B3-1**. The summary data are also presented in **Table B3-1**.

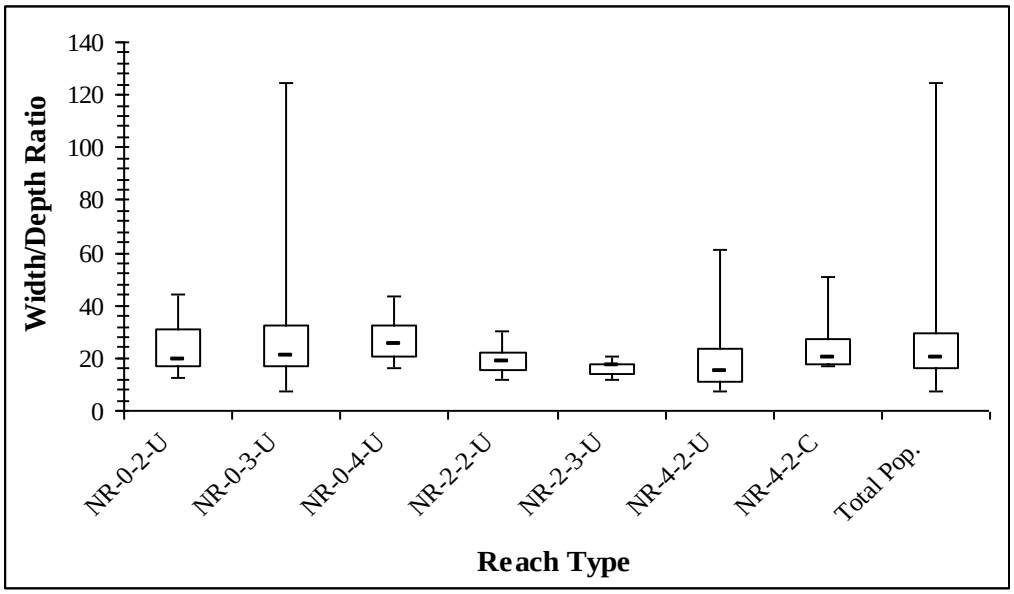


Figure B3-1. Width/Depth Ratio segregated by reach type.

Table B3-1. Summary of Width/Depth ratio statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	20	40	10	19	5	15	5	114
Minimum	12.3	7.4	15.9	11.5	11.5	7.3	17.3	7.3
25th percentile	16.6	17.0	20.7	15.1	13.9	10.8	17.6	16.0
Median	19.2	20.6	24.7	18.5	17.1	14.9	20.2	20.1
75th percentile	30.8	32.8	32.4	21.9	17.7	23.8	27.6	29.3
Maximum	44.0	124.8	43.3	30.3	20.9	61.1	50.5	124.8

B3.2.2 Entrenchment Ratio

Stream entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen 1996). Entrenchment ratio is used to help determine if a stream shows departure from its natural stream type. It is an indicator of stream incision, and therefore indicates how easily a stream can access its floodplain. Streams are often incised due to detrimental land management 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 in incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (down-cutting), the sources of human caused incision may be historical in nature and may not currently be present, although sediment loading may continue to occur. The entrenchment ratio is an important measure of channel condition as it relates to sediment loading and habitat condition, due to the long-lasting impacts of incision and the large potential for sediment loading in incised channels.

An expected entrenchment ratio for reaches classified as B channels falls within the range of 1.4-2.2, although an entrenchment ratio as low as 1.2 and as high as 2.4 is not outside the realm of expected channel dimensions. C channels, including Cb channels, generally have entrenchment ratios of greater than 2.2 (Rosgen 1996).

The entrenchment ratios by reach type are presented in **Figure B3-2**. The summary data are also presented in **Table B3-2**.

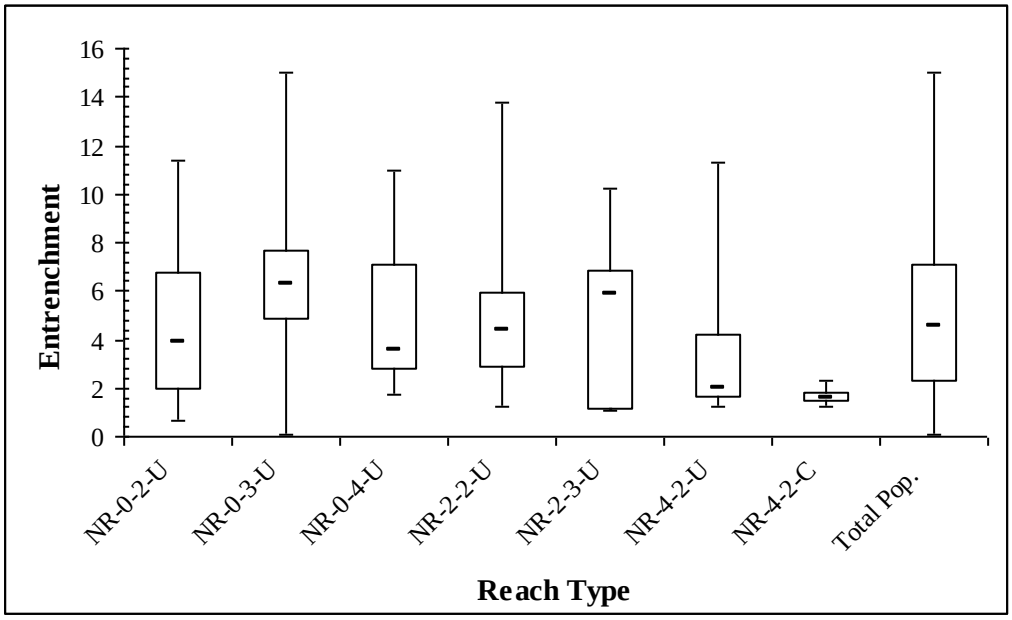


Figure B3-2. Entrenchment Ratio segregated by reach type.

Table B3-2. Summary of Entrenchment ratio statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	20	40	10	19	5	15	5	114
Minimum	0.7	0.1	1.8	1.2	1.1	1.3	1.2	0.1
25th percentile	2.0	4.9	2.8	2.9	1.2	1.6	1.5	2.3
Median	3.9	6.2	3.6	4.4	5.9	2.0	1.6	4.5
75th percentile	6.7	7.6	7.1	6.0	6.8	4.2	1.8	7.1
Maximum	11.4	15.0	11.0	13.8	10.2	11.3	2.3	15.0

B3.2.3 Greenline Inventory: Percent 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 increase 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 main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are an important food source for fish.

Targets for streambank shrub cover and resulting streambank stability generally fall within the range of 75% to 85%, based on previous studies in Montana and Canada. Study reaches with lower than 75% shrub cover may be prone to excessive streambank erosion or have excessive streambank instability. It is important to keep in mind that understory shrub cover from study reaches may be low due to dense overstory canopy cover and competition from overstory canopy species, as in spruce-dominated reaches on smaller streams.

The greenline understory shrub cover percentages by reach type are presented in **Figure B3-3**. The summary data are also presented in **Table B3-3**.

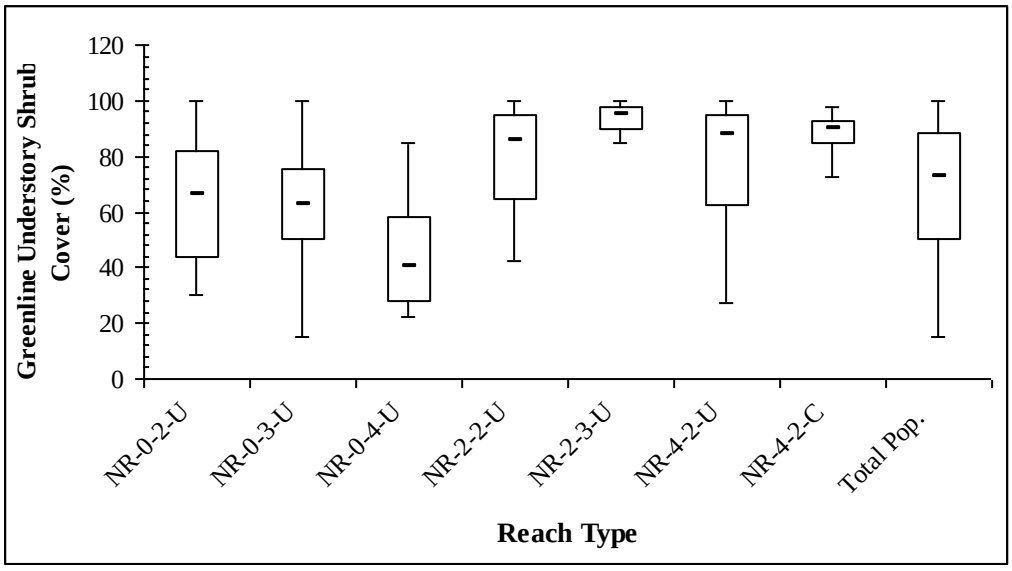


Figure B3-3. Greenline Understory Shrub Cover (%) segregated by reach type.

Table B3-3. Summary of Greenline Understory Shrub Cover statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	20	40	10	15	5	15	5	110
Minimum	30.0	15.0	22.5	42.5	85.0	27.5	72.5	15.0
25th percentile	43.8	50.0	28.1	64.5	90.0	62.5	85.0	50.6
Median	66.3	62.5	40.0	85.7	95.0	87.5	90.0	72.5
75th percentile	81.9	75.6	58.1	95.0	97.5	95.0	92.5	88.3
Maximum	100.0	100.0	85.0	100.0	100.0	100.0	97.5	100.0

B3.2.4 Greenline Inventory: Percent 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 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.

Natural levels of bare ground can vary according to the riparian site type or habitat type, and by the landscape setting of the stream reach. For the purposes of this assessment, a general guideline value of

greater than or equal to 10% bare ground is assigned to indicate a potential reduced riparian habitat quality or lowered filtering capacity.

Due to the large number of zero values, a box plot was not completed for the greenline bare ground percentage variable. The tabular data are presented in **Table B3-4**.

Table B3-4. Summary of Greenline Bare Ground statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	20	40	10	15	5	15	5	110
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25th percentile	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Median	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75th percentile	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0
Maximum	10.0	22.5	20.0	0.0	0.0	0.0	0.0	22.5

B3.2.5 Riffle Pebble Count: Substrate Fines (<2 mm)

Percent surface fine sediment provides a good measure of the siltation occurring in a river system and serves as an indicator of stream bottom aquatic habitat. Although it is difficult to correlate percent surface fines with loading in mass per time directly, the Clean Water Act allows “other applicable measures” for the development of TMDL water quality restoration plans. Percent surface fines have been used successfully in other TMDLs in western Montana addressing sediment related to stream bottom deposits, siltation, and aquatic life uses. Surface fine sediment measured in the Wolman (1954) pebble count is one indicator of aquatic habitat condition and can indicate excessive sediment loading. The Wolman pebble count method 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.

Studies have shown that increased substrate fine materials less than 2 mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan 1991). As well, the TMDL for the Flathead Headwaters cites recent work completed in the Boise National Forest in Idaho, which showed a strong correlation between the health of macroinvertebrate communities and percent surface fines defined as all particles less than two millimeters.

Other studies in western Montana have set a threshold value for percent fine substrate (<2 mm) at 15% to 20%. The guideline values used in these studies were based on best available conditions and empirical equations developed by Weaver and Fraley (1991). Surface fine sediment is difficult to measure with a great degree of precision using the Wolman pebble count method. To be conservative, any of the study reaches displaying greater than 15% fine sediment <2 mm diameter in riffles may indicate an impact to fisheries or aquatic life.

The pebble count measurements for particles <2 mm by reach type are presented in **Figure B3-4**. The summary data are also presented in **Table B3-5**.

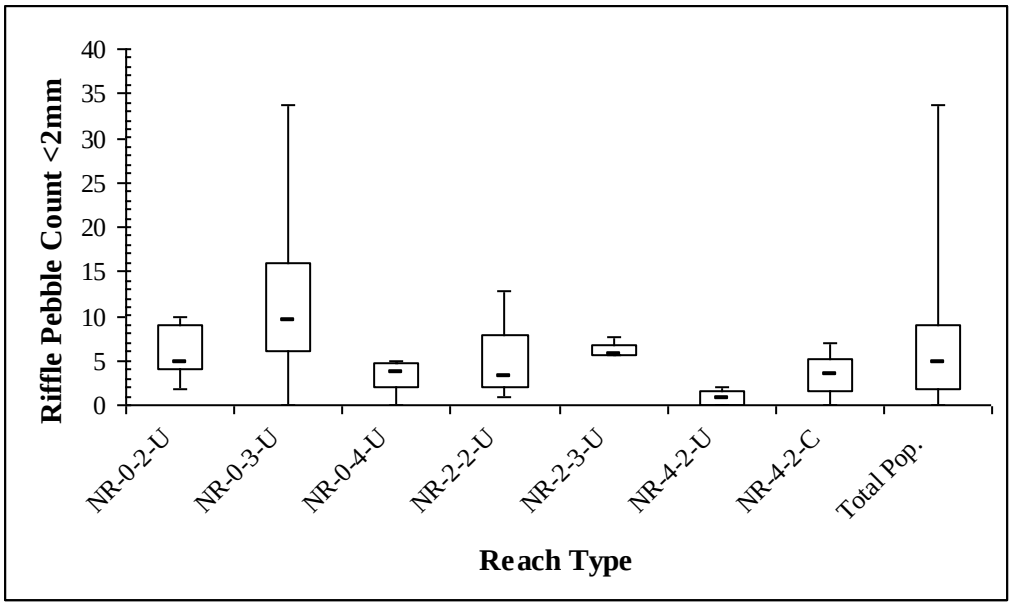


Figure B3-4. Riffle Pebble Count <2 mm by reach type.

Table B3-5. Summary of Riffle Pebble Count (<2 mm) statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	12	24	6	9	3	9	3	66
Minimum	1.8	0.0	0.0	0.9	5.6	0.0	0.0	0.0
25th percentile	4.1	6.1	2.0	1.9	5.6	0.0	1.7	1.8
Median	4.8	9.4	3.6	3.1	5.6	0.8	3.3	4.8
75th percentile	9.0	15.9	4.7	7.8	6.6	1.5	5.1	9.0
Maximum	10.0	33.6	5.0	12.7	7.6	1.9	7.0	33.6

B3.2.6 Riffle Pebble Count: Substrate Fines (<6 mm)

As with surface fine sediment smaller than 2 mm diameter, an accumulation of surface fine sediment less than 6 mm diameter may indicate excess sedimentation. The size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and incubation. Excess surface fine substrate may have detrimental impacts on aquatic habitat by cementing spawning gravels, thus reducing their accessibility, 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 6.35 mm and the emergence success of westslope cutthroat trout and bull trout.

Previous assessments in western Montana specify a wide range of target values for fine sediment less than 6 mm in diameter. Values vary by stream type and specific sampling method. For this assessment a guideline threshold value for fine sediment <6 mm in riffles is 20%, which represents an average value of the guideline values used in previous studies.

The pebble count measurements for particles <6 mm by reach type are presented in **Figure B3-5**. The summary data are also presented in **Table B3-6**.

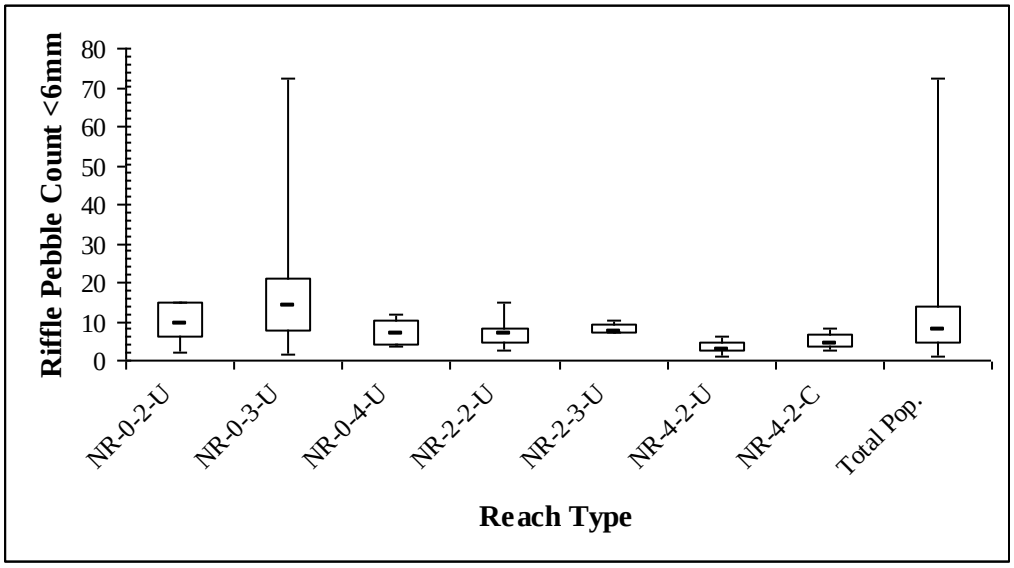


Figure B3-5. Riffle Pebble count <6 mm by reach type.

Table B3-6. Summary of Riffle Pebble Count <6 mm statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	12	24	6	9	3	9	3	66
Minimum	1.8	1.7	3.6	2.7	7.1	0.9	2.8	0.9
25th percentile	6.4	7.9	4.1	4.8	7.4	2.3	3.5	4.6
Median	9.0	13.8	6.5	6.7	7.1	2.7	4.2	7.7
75th percentile	14.6	21.0	10.4	8.3	9.0	4.8	6.7	13.9
Maximum	15.1	72.4	12.0	14.7	10.4	6.3	8.0	72.4

B3.2.7 Riffle Grid Toss: Substrate Fines (<6 mm)

The wire grid toss is a standard procedure frequently used in aquatic habitat assessment. This method provides a more precise (repeatable) measurement of surface fine sediment than the broader survey approach of the Wolman pebble count. This measurement does not cover the entire channel width, as in the Wolman pebble count, but rather provides a more thorough measurement of surface fines in a subsample of the cross-section.

Previous assessments in western Montana specify a wide range of target values for fine sediment less than 6 mm in diameter. Values vary by stream type and specific sampling method. For this assessment a guideline threshold value for fine sediment <6 mm in riffles is 20%, which represents an average value of the guideline values used in previous studies.

The pool tailout grid toss results for particles <6 mm are presented in **Figure B3-6** and **Table B3-7**.

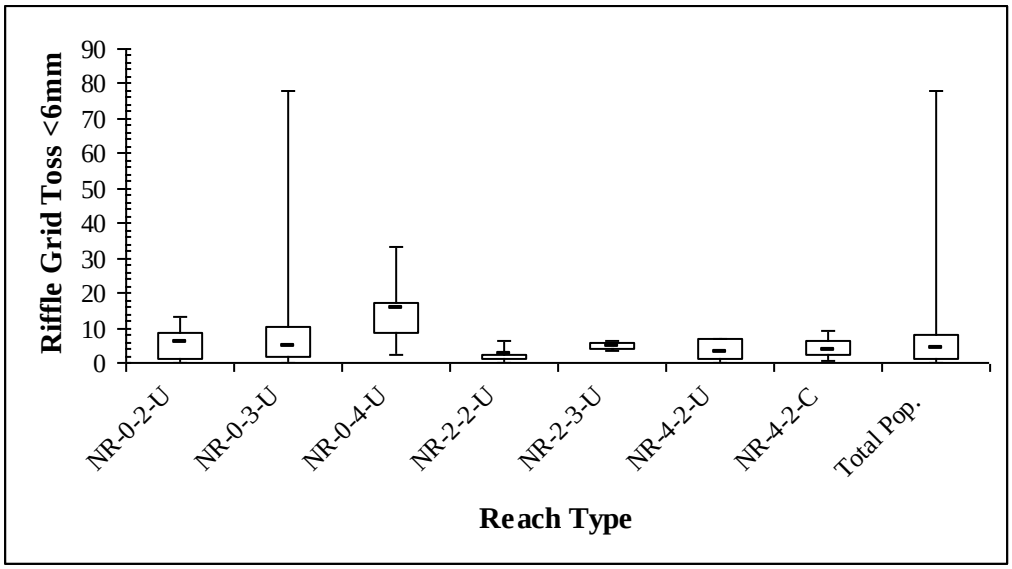


Figure B3-6. Riffle Grid Toss <6 mm by reach type.

Table B3-7. Summary of Riffle Grid Toss <6 mm statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	12	24	6	9	3	9	3	66
Minimum	0.0	0.0	2.0	0.0	3.4	0.0	0.7	0.0
25th percentile	1.0	1.6	8.8	1.0	4.1	1.4	2.0	1.4
Median	5.6	4.8	15.3	2.0	4.8	2.7	3.4	4.1
75th percentile	8.8	10.2	17.2	2.0	5.6	6.8	6.5	8.2
Maximum	12.9	78.2	33.3	6.1	6.4	6.8	9.0	78.2

B3.2.8 Pool Residual Depth (Reach mean value)

Residual pool depth, defined as the difference between pool maximum depth and 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. Pool residual depth is also an indirect measurement of sediment inputs to listed streams. An increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Previous assessments in western Montana specify target values for pool residual depth ranging from 1.5 ft to an average of 3 ft. Few individual pool depths exceeded 3 feet in the assessment reaches in this study, even in minimally impacted reaches, and most reaches had an average residual pool depth of less than 1.5 ft. Due to the stream sizes for most of the streams in the LCFT-TPA, a guideline value of 1.5 ft for mean residual pool depth appears to be the more suitable metric when examining these results.

The mean residual pool depths for the reach types are presented in **Figure B3-7** and **Table B3-8**.

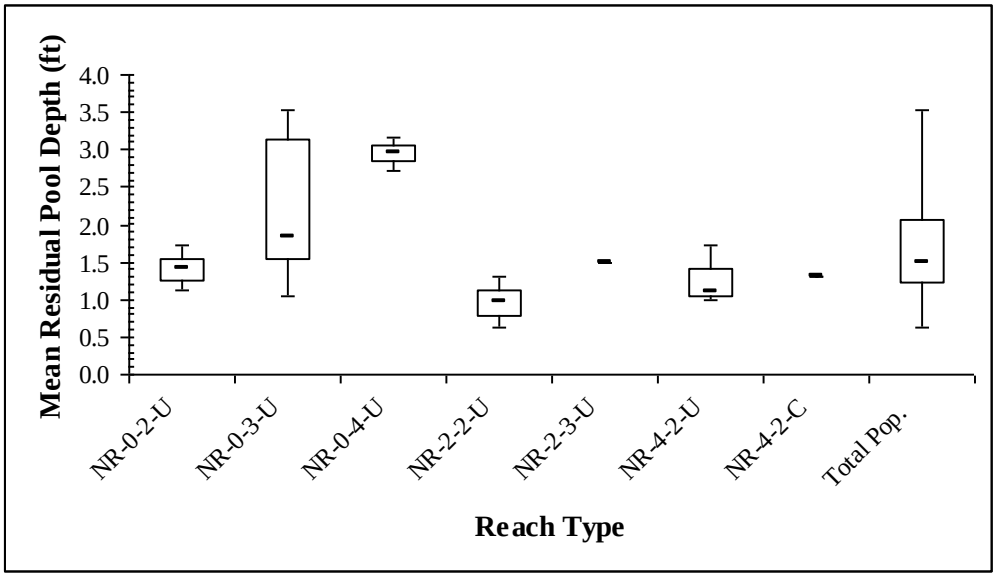


Figure B3-7. Mean Residual Pool Depth by reach type.

Table B3-8. Summary of Mean Residual Pool Depth statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	4	8	2	3	1	3	1	22
Minimum	1.1	1.0	2.7	0.6	1.5	1.0	1.3	0.6
25th percentile	1.3	1.6	2.8	0.8	1.5	1.1	1.3	1.2
Median	1.4	1.8	2.9	1.0	1.5	1.1	1.3	1.5
75th percentile	1.6	3.1	3.1	1.1	1.5	1.4	1.3	2.1
Maximum	1.7	3.5	3.2	1.3	1.5	1.7	1.3	3.5

3.2.9 Pool Frequency

Pool frequency is a measure of the availability of pool habitat 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 affected adversely by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

Previous assessments from western Montana have specified pool frequency target values that vary according to channel wetted width, and in some cases by stream order and Rosgen type. The average wetted width on assessed stream reaches in the LCFT-TPA was approximately 25 ft. A target value of 47 pools per mile, or approximately 9 pools per 1,000 feet, was used in previous studies for reaches with a specified wetted width of 25 ft. Although wetted widths differ among the assessed reaches in the LCFT-TPA, reaches with a pool frequency much below 9 pools/1,000 ft may have reduced aquatic habitat quality.

The pool frequencies per 1,000 ft for the reach types are presented in **Figure B3-8** and **Table B3-9**.

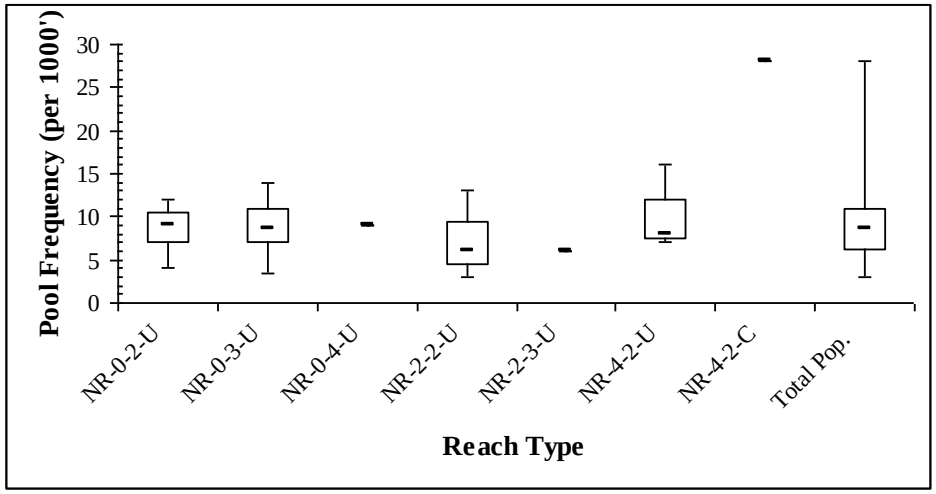


Figure B3-8. Pool Frequency (per 1,000 ft) by reach type.

Table B3-9. Summary of Pool Frequency statistics by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	4	8	2	3	1	3	1	22
Minimum	4.0	3.3	9.0	3.0	6.0	7.0	28.0	3.0
25th percentile	7.0	7.0	9.0	4.5	6.0	7.5	28.0	6.3
Median	9.0	8.5	9.0	6.0	6.0	8.0	28.0	8.5
75th percentile	10.5	11.0	9.0	9.5	6.0	12.0	28.0	11.0
Maximum	12.0	14.0	9.0	13.0	6.0	16.0	28.0	28.0

B3.2.10 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 more or less LWD is present than would be expected under optimal conditions. Too high or too low an LWD frequency may indicate riparian habitat impairment or upstream influences on habitat quality.

Target values for LWD span a broad range of values, even for streams of similar size. A guideline value of approximately 150 pieces of LWD per mile, or approximately 28 pieces of LWD per 1,000 ft, represents an average of target values from other studies with similar average reach width. Results for LWD should be interpreted with caution, as the guideline value for this parameter is tied to a high degree of variability due to land use, vegetative community, soils, among other factors.

The LWD frequency per 1,000 ft for the reach types are presented in **Figure B3-9** and **Table B3-10**.

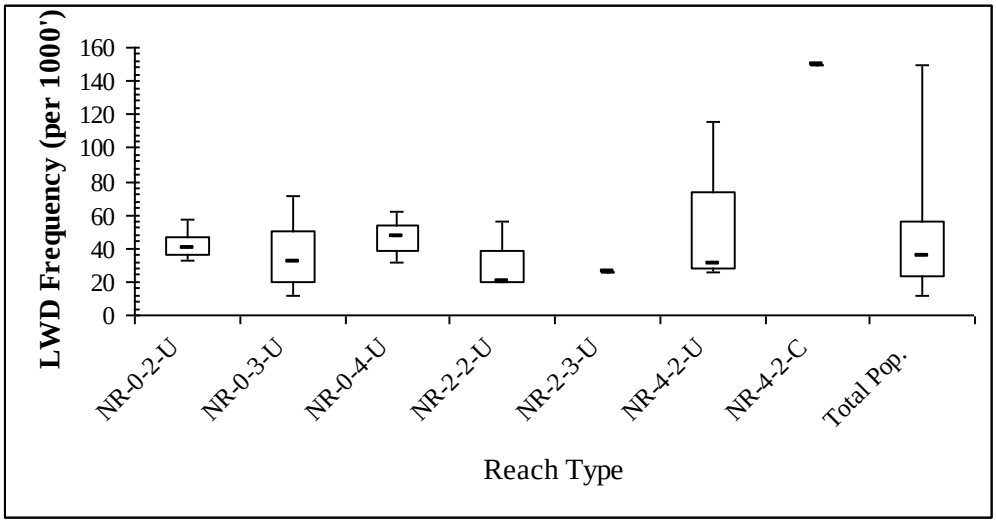


Figure B3-9. LWD Frequency (per 1,000 ft) by reach type.

Table B3-10. Summary of LWD frequency by reach type

Statistical Parameter	Reach Type							
	NR-0-2-U	NR-0-3-U	NR-0-4-U	NR-2-2-U	NR-2-3-U	NR-4-2-U	NR-4-2-C	Total Population
# Reaches Sampled	4	8	2	3	1	3	1	22
Sample Size	4	8	2	3	1	3	1	22
Minimum	33.0	11.3	31.0	20.0	26.0	26.0	149.0	11.3
25th percentile	36.0	19.8	38.8	20.0	26.0	28.0	149.0	23.0
Median	40.0	31.0	46.5	20.0	26.0	30.0	149.0	35.0
75th percentile	46.5	50.0	54.3	38.0	26.0	73.0	149.0	56.0
Maximum	57.0	71.0	62.0	56.0	26.0	116.0	149.0	149.0

Figure B3-10 presents the data for all of the measured variables for all of the reach types.

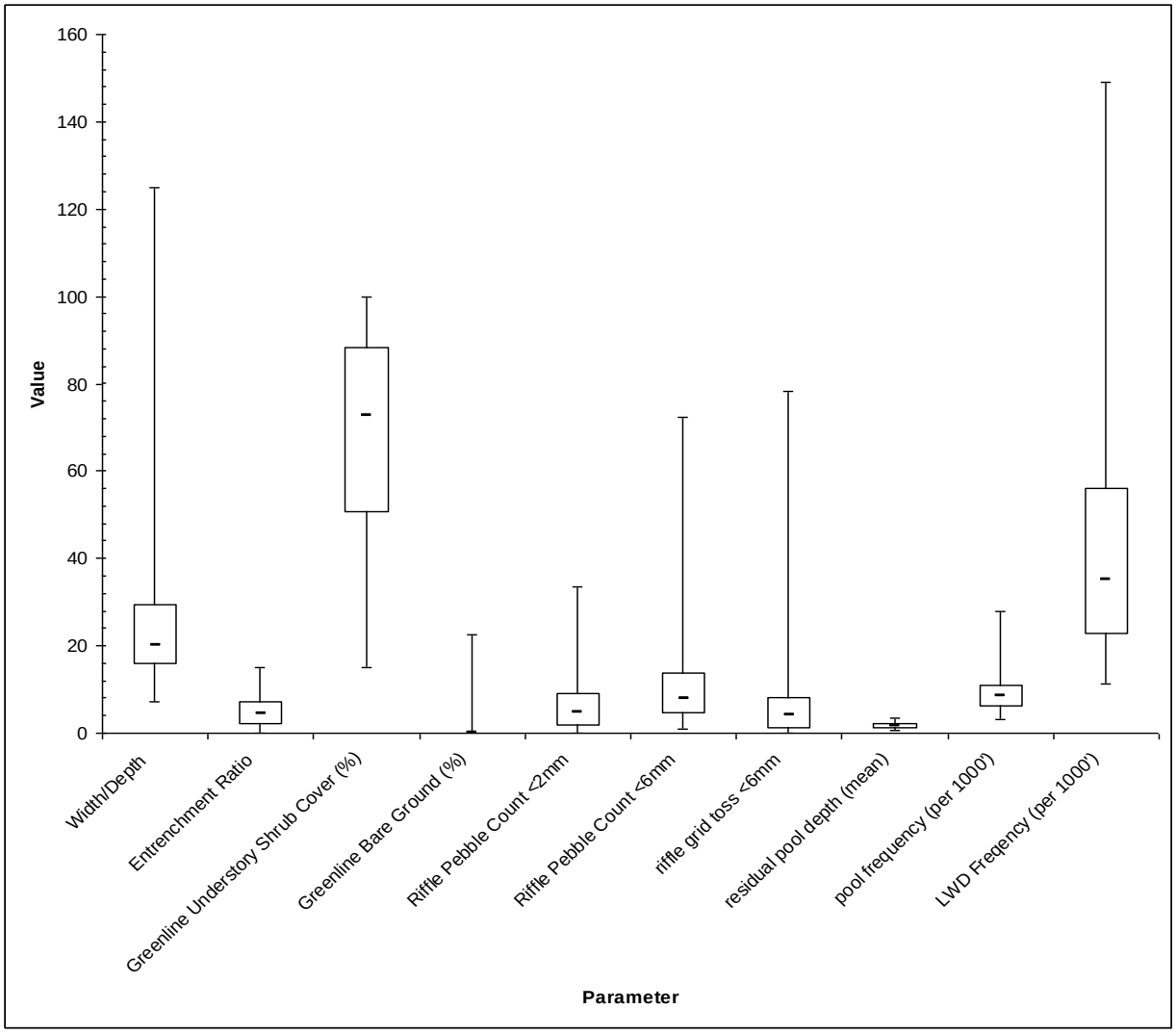


Figure B3-10. The measured variables by reach type.

B3.3 SAMPLED REACHES FIELD DESCRIPTIONS

The following sections provide brief descriptions for each reach. Descriptions are provided for the type and degree of human impacts, stream channel conditions, streambank erosion properties, and the composition of the riparian vegetation community.

B3.3.1 Bull River Reach 3-3

Description of Human Impacts and Severity

Human impacts related to clearing/conversion of riparian vegetation (woody shrub community conversion to reed canarygrass). Streambanks mostly stable with some sloughing of upper bank.

Description of Stream Channel Conditions

Stable C5 channel morphology with plane bed, dune-ripple bedforms. Channel bed sediment is mostly sand/silt with some small gravel content.

Description of Streambank Erosion Conditions

Stable silt-clay streambank content, very cohesive bank materials, low bank erodibility potential.

Description of Riparian Vegetation Conditions
Reed canarygrass dominates the riparian zone with willow and red osier dogwood forming narrow bands adjacent to streambanks.

B3.3.2 Bull River Reach 3-2

Description of Human Impacts and Severity
Riparian zone likely logged prior to ~circa 1990 wildfire. This reach was historically used for log drives when western red cedars were logged. No current active human impacts. Private residences upstream and downstream of survey reach.

Description of Stream Channel Conditions
C4 channel type with pool-riffle morphology with side channel development. Mid-channel and transverse bars present alluding to high sediment (coarse) supply from North Fork and South Fork Bull River. This is a transitional reach between the upper watershed transport reaches which are typically B stream types, and downstream depositional E stream type reaches. Abundant sediment deposits occur downstream of the surveyed reach, the gradient is lower, plus sinuosity and bed material fines are higher. The bankfull channel cross-section width is 30 ft to 90 ft (avg 50 ft).

Description of Streambank Erosion Conditions
Moderate bank erosion occurring along areas prone to high NBS, mainly streambanks on outside meanders with poor vegetation and rooting conditions. Streambanks are comprised of sandy, gravelly unconsolidated materials.

Description of Riparian Vegetation Conditions
The understory is dominated by alder, willow, and grass/forbs. The shrub community is recovering from ~1990s stand replacement wildfire. The entire riparian zone was affected by partial to full stand replacement (mixed severity burn). Burned cedar and spruce trees/stumps present. Overstory consists of patchy conifers with spruce and cedars along the channel margin. A shrub community dominated by Drummond and Bebb's willow is establishing on gravel deposits.

B3.3.3 Bull River Reach 5-1

Description of Human Impacts and Severity
The riparian zone may have been historically affected by agricultural operations, but is currently subject to only natural influences.

Description of Stream Channel Conditions
Slow-moving water and a C5 stream type channel morphology characterize this reach. Low gradient riffles and few, long pools are present in the reach.

Description of Streambank Erosion Conditions
Vegetative mats composing the streambanks are moderately undercut, with the underlying fine materials eroded. In numerous locations, vegetated blocks have slumped into the channel, exposed to further decomposition. Sparse cedars and shrubs line the banks with low to moderate percent cover.

Description of Riparian Vegetation Conditions

Riparian vegetation consists primarily of reed canary grass with scattered cedars and understory shrubs. Minimal overstory is present.

B3.3.4 Dry Creek Reach 9-2

Description of Human Impacts and Severity

This reach and the channel corridor are subject to major debris torrents in addition to active channel headcuts and avulsions. The processes influencing this reach are considered natural and originally dictated by the alluvial fan that forms the bed geomorphic surface. Natural influences are observed on similar adjacent streams including Star and Napoleon Gulches. There is evidence of historical logging practices such as an abandoned road along the North side of the valley that was relocated mid-slope due to chronic road failures.

Description of Stream Channel Conditions

Channel headcuts and avulsions are common, with the channel incised through the debris fan deposits. Fresh coarse sediment lag deposits are present (up to 4' diameter material), though the channel was dry at the time of the survey. Large Woody Debris loading to the channel forms localized gradient increases and knickpoints in the channel profile. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen B3.

Description of Streambank Erosion Conditions

Erosion conditions vary throughout the reach, but are generally characterized by high to extreme bank erodibility conditions, shallow rooting depth and high bank-to-height ratios.

Description of Riparian Vegetation Conditions

Conifer species dominate, and large LWD jams are prevalent, fromed by frequent channel shifts. The shallow rooting depth offers low or minimal bank protection.

B3.3.5 West Fork Elk Creek Reach 8-1

Description of Human Impacts and Severity

Evidence of historical logging includes cedar stumps throughout the reach. However, stream channel and riparian zone appear to be relatively stable. Logging may have been limited and there is no sign of recent activity.

Description of Stream Channel Conditions

The stream is intermittent. Deep pools and runs, with smaller sections of riffle throughout. Large diameter wood interspersed along stream channel helping to create pools and redirect flow. Small material gravel dominant at pool crests and depositional sections of stream with large size cobble (90-128 mm) frequent in stream bottom. Some embeddedness of larger cobble from finer material. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C3.

Description of Streambank Erosion Conditions

There is limited bank erosion. Bank erosion is natural where it occurs. Most bank erosion occurring near cedar stumps, roots, trunks or large woody debris knick points. Deep, curving bends – pool forming – also result in limited erosion at corners.

Description of Riparian Vegetation Conditions
Some large cedars throughout and small woody shrubs/vegetation in understory. Stumps are visible but mixed age class in cedar composition with interspersed deciduous trees. Good vegetation cover for the shaded, cedar sections of the reach. Cedars and conifers are sparsely distributed.

B3.3.6 East Fork Elk Creek Reach 9-1

Description of Human Impacts and Severity
Minimal evidence of human impacts near the stream however barbed wire was found along streambanks and within the channel suggesting previous fencing possibly for livestock. Gabion basket was also found in the streambank on Reach 2.

Description of Stream Channel Conditions
Long riffles and few pools, with pools typically influenced by LWD. Although topographic maps indicate a channel slope of <2%, the actual channel slope is 2-4%, exhibiting B4 stream type conditions. Based on the valley morphology, floodplain and vegetation characteristics, the probable historical stream type was likely a Rosgen B3. Large bedload suggests the reach is aggrading. The stream bed is elevated with deep channels along the edge of stream bottom. A shifting thalweg and channel bars forming midstream in some areas near LWD or upstream of bends.

Description of Streambank Erosion Conditions
Some areas of sand and small fines dominated substrate, easily eroding where channel shape shifts due to LWD or bends however not much bank erosion witnessed outside of these erosive soil type areas.

Description of Riparian Vegetation Conditions
Conifer-dominated forest although size class is uniform indicating past disturbance. Good riparian buffer width although vegetation density and diversity are average.

B3.3.7 East Fork Elk Creek Reach 8-1

Description of Human Impacts and Severity
Similar to EFELK 7-2, there is very little evidence of human impacts in the reach. Limited logging occurred a number of years ago about 3 miles upstream, but no evidence in the study reach. A forest fire approximately 20 years ago affected the vegetation community.

Description of Stream Channel Conditions
Large cobble substrate and long runs characterized the B stream reach. The few pools typically occur at meanders. There is a limited amount of in-channel coarse LWD possibly reflecting riparian age class and past disturbance regimes. Pools lack complexity and cover and are not well developed. Few pools are greater than 1/3 bankfull width. The substrate is dominated by coarse particles, limited sorting, and the channel bed is well armored. The stream is intermittent in the survey reach. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen B4.

Description of Streambank Erosion Conditions
Naturally occurring eroding banks, very limited in size and frequency are usually at outside meanders. Streambanks are armored with large cobble. One large eroding hillslope with stable toe is eroding about 8 ft up the bank. Channel intercepts flood lag deposits possibly deposited during the 1964 flood. Mature

cottonwoods buried up to 3 ft by sediment. Source of material to channel (natural), primarily heterogeneous mixture of sediment size classes.

Description of Riparian Vegetation Conditions
Diverse riparian zone dominated by conifer with some interspersed deciduous trees. No disturbance to understory or mid-story vegetation. There is moderate rooting density along streambanks. There are relatively young age classes, 12-16" DBH max diameter on floodplain. Large wood is limited in survey reach, low pool and large wood frequency. There is limited large wood recruitment potential and high stream energy (average slope 3-4%).

B3.3.8 East Fork Elk Creek Reach 7-2

Description of Human Impacts and Severity
Minimal human impacts though there is some logging (2.5-3 mi) upstream. Logged area is small, not much noticeable logging effect.

Description of Stream Channel Conditions
East Fork Elk Creek in Reach 7-2 is primarily a B stream type with A stream type and D stream type inclusions. Intermittent channel conditions appear to be due to sediment. Low wood frequency with marginal quality pools. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen B3a.

Description of Streambank Erosion Conditions
The armored channel exhibits minimal erosion.

Description of Riparian Vegetation Conditions
The riparian zone is characterized by a grass/forb, shrub understory with an overstory of conifers and patchy cottonwoods. Riparian condition looks good with stable vegetation and multiple age classes.

B3.3.9 East Fork Elk Creek Reach 10-3

Description of Human Impacts and Severity
Historically, valley bottoms similar to EFELK 10-3 in the Lower Clark Fork tributaries were dominated by western red cedar. Channel and floodplain instability is due to vegetation changes from cedar to alder. Other vegetation changes include shifts from stable cedar to reed canarygrass. Agricultural practices and livestock grazing have also affected vegetation conditions. The current landowner fences livestock from the stream and maintains a buffer, but woody vegetation is sparse and relatively ineffective for bank stabilization.

Description of Stream Channel Conditions
Bedload material very mobile (smaller cobbles dominate) with abundant fines in pool bottoms and slow areas. Moderately deep pools and riffles characterize the channel morphology. There is limited trout habitat with habitat mainly provided by pools formed by alders slumping from eroding banks. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4.

Description of Streambank Erosion Conditions
Streambanks are actively eroding. Some streambank stabilization projects have been installed including 2 engineered log jams and 1 rip-rap bank. High stream energy at meanders and streambank instability

due to riparian vegetation dominated by reed canarygrass and alder rather than historical vegetation that likely included denser species such as willow and dogwood. Bedload deposits influence the channel morphology at meanders. Large wood redirects flow into streambanks which is also affecting stability. Limited root density and sandy soils in some places also affect bank stability.

Description of Riparian Vegetation Conditions
The riparian zone includes reed canarygrass and alder. There are minimal woody species and virtually no conifers. There is a narrow riparian buffer.

B3.3.10 Elk Creek Reach 11-3

Description of Human Impacts and Severity
Historically, valley bottoms like this were dominated by western red cedar. Channel and floodplain instability is due to vegetation changes from cedar to alder. Other vegetation changes include shifts from stable cedar to reed canary grass via human influence of agricultural practices and livestock grazing. The current landowner fences livestock from the stream and maintains a buffer, but woody vegetation is sparse and relatively ineffective for bank stabilization. Some hay fields adjacent to stream but appear to be having limited impact.

Description of Stream Channel Conditions
Small cobble substrate dominates the mobile stream bed. Glacial Lake Missoula bed deposits visible in some areas. Deep pools are located through some meanders. Riffles are uncommon and the channel appears to be relatively unstable. Mid-channel bars and long depositional benches occur throughout the aggrading reach. Channel substrate and depositional bar substrate are of similar size class indicating very mobile, shifting materials. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4 or C5.

Description of Streambank Erosion Conditions
Large, long sandy streambanks are unstable due to lack of good riparian vegetation. Local haying but does not seem to be affecting the streambanks themselves. Minimal riparian vegetation remains.

Description of Riparian Vegetation Conditions
There is limited riparian vegetation in the reach. Some deciduous species, but mainly alders with a reed canarygrass understory. Slight buffer between stream and hayfields averages 5 ft. Cattle appear to be excluded from the channel. River right (opposite streambank from the hayfield) has more established riparian vegetation, but again limited in vegetation quality and diversity.

B3.3.11 Elk Creek Reach 11-6

Description of Human Impacts and Severity
Some residences and horses located near the stream, but livestock fenced from channel. At the upper end of the reach the left floodplain and streabank is mowed down and chairs and table are present. Channel over-widening appears to be mainly from channel mobility and the confluence of two channel threads. Past grazing and other land uses may have also affected channel stability.

Description of Stream Channel Conditions
The stream has a pool-riffle morphology, with the bed coarsening in a downstream direction. Riffles underdeveloped with long glide features associated with pools. Floodplain riparian vegetation primarily

consists of grass/forb, reed canarygrass, and pole-sized alders. The outside streambanks are characterized by a low and middle terrace. Streambank heights are approximately 2 ft to 3 ft above the bankfull stage. Lateral scour pool associated with large wood, mature alders, or the channel morphology. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4.

Description of Streambank Erosion Conditions
Alternating pool-riffle sequences associated with an inset floodplain surface and bracketing low and middle terraces that are prone to erosion on outside meander sequences. The 1997 flood appears to have affected the channel morphology. The channel generally downcut into the valley fill by as much as 2 ft relative to the low terrace which is the abandoned floodplain surface. The channel has limited meander belt width and is actively expanding the floodplain through erosion and accretion. Streambanks are generally comprised of fine gravel and lacustrine silt and clays. The rooting depth is relatively shallow and knapweed dominates several droughty terraces. Streambanks have high erosion potential.

Description of Riparian Vegetation Conditions
Knapweed occupies drier terraces adjacent to the stream. The understory vegetation, from 5 ft to 15 ft in height, is comprised of mature and decadent alder. No overstory canopy exists with the exception of mature alders. Streambank vegetation is comprised of alder which replaced the historical western red cedar cover type. The cedar were most likely logged in the early 1900s similar to practices in other tributaries. Vegetation conversion is due primarily to disturbance that is causing channel instability and increased sediment loading to the channel. Despite these conditions, the channel is primarily single threaded with deep pools at outside meanders and constrictions. Pools generally lack cover and complexity and depth. Undercut streambanks provide the primary cover. The channel bed sediment distribution is bi-modal with coarse gravel surface material and high embeddedness with interstitial fines in the sub-surface bed material.

B3.3.12 White Pine Creek Reach 9-2

Description of Human Impacts and Severity
Most impacts are related to historical logging, past grazing, agriculture and on-going road maintenance. Large stumps suggest historical canopy and past logging practices. Extensive knapweed inhabits drier floodplain surfaces.

Description of Stream Channel Conditions
The channel is dynamic with an abundant sediment load. Shallow pools are located where the stream interacts with large wood and alder bunches. There is considerable sediment recruitment from eroding streambanks. Most depositional features are colonized by vegetation. Meander cut-offs, floodplain scrolls, and extensive depositional bars suggest active channel processes. The channel profile includes pools, long glides and abrupt riffles. Algae is common throughout channel suggesting high nutrient levels. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4.

Description of Streambank Erosion Conditions
Considerable streambank erosion contributes sediment ranging from silts to medium cobble. Most erosion is occurring on outside streambanks with extreme bank heights. Alders provide some streambank stability but most eroding banks are dominated by grasses and knapweed.

Description of Riparian Vegetation Conditions
The vegetation community is characterized by an alder overstory with an understory including grasses, knapweed, and willows. Other shrubs include alder which are regenerating throughout the site. Sedges are common on depositional features parallel to channel. Areas of significant weed infestation include knapweed, oxeye daisy, purple loosestrife, and Canada thistle.

B3.3.13 White Pine Creek Reach 9-5

Description of Human Impacts and Severity
There is a recent subdivision on surrounding uplands. Riparian vegetation has been mowed. A newer bridge and low water ford have introduced fine sediment to the stream. Equipment was used to manipulate the channel potentially resulting in an active avulsion. Tractor tracks are apparent on the floodplain.

Description of Stream Channel Conditions
The entrenched channel has a relatively low sinuosity planform characterized by short riffles and long pools and glides. Some large wood and numerous alder thickets promote channel scour and pool diversity. Fine to medium gravels predominate the channel bed material. Fine sediment and flocculant cover the channel bed in most slow water areas. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4.

Description of Streambank Erosion Conditions
Bank erosion is relatively common at outside streambanks due to excessive bank heights. Reed canary grass colonizes failed streambank blocks. Point bars are largely colonized by reed canarygrass. Alders located on the floodplain as well as on the streambanks to the entrenched bankfull channel. A few other shrubs include spirea.

Description of Riparian Vegetation Conditions
Alder dominate the overstory and reed canarygrass dominates the understory. Vegetation is mowed to the top of bank. Alders shade >50% of the channel. No overstory canopy exists above the alders. Reed canarygrass is displacing sedges and rushes from low depositional areas.

B3.3.14 White Pine Creek Reach 8-3

Description of Human Impacts and Severity
No obvious impacts in the reach though the channel intersects the road at the top and bottom of WPC 8-3.

Description of Stream Channel Conditions
There are multiple channels and substantial bedload in the intermittent reach. The reach resembles fan morphology with poor habitat conditions and limited pools. Large wood present but infrequently influences channel morphology. Most of the large wood is in the form of single pieces with a few aggregates. White Pine Creek Reach 8-3 currently exhibits a Rosgen D3 channel morphology. Based on the valley morphology, floodplain, and vegetation characteristics, the probable historical stream type was likely a Rosgen C3.

Description of Streambank Erosion Conditions
Most streambanks exhibit erosion. BEHI was completed on both channels. There is considerable sediment, generally coarser substrate, generated within the reach from streambank and floodplain erosion. Large material is mobilized by larger flood events. Lag deposits vegetated by multi-age vegetation depending on age and disturbance regime of deposit.

Description of Riparian Vegetation Conditions
The riparian zone is characterized by a multi-species canopy of fir and cottonwood. Same species comprise the midstory and understory. There are limited shrubs, mainly small conifers. Shrubs include cottonwood, Rocky Mountain maple, mock orange, dogwood, ribes, and spirea. Noxious weed located on depositional features include knapweed and purple loosestrife.

B3.3.15 Swamp Creek Reach 18-1

Description of Human Impacts and Severity
No identifiable human impacts other than signs of livestock grazing.

Description of Stream Channel Conditions
The plane bed channel is characterized by riffle-step morphology. Shallow pocket pools are typically located in channel margins. The channel bed material is comprised of coarse material and minimal gravels. The reach is a migratory corridor with no spawning habitat due to the sizeable bed material and high stream energy. Beavers are active on the floodplain and influence the vegetation community. Dynamic channel in the upstream portion of the reach with floodplain overflow channels, coarse alluvium deposits and LWD. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C3b.

Description of Streambank Erosion Conditions
Minimal streambank erosion due to coarse bed and streambank material. Some erosion of floodplain areas due to flood channel scour.

Description of Riparian Vegetation Conditions
The riparian community is dense and diverse. Overstory species include cottonwood, cedar, aspen, and spruce. Understory species include willows, dogwood, alder, and snowberry. Beaver influence riparian vegetation especially along the channel and broader floodplain areas.

B3.3.16 Swamp Creek Reach 20-1

Description of Human Impacts and Severity
Grazing impacts include hoof shear and streambanks, vegetation disturbance and removal, and nutrient and sediment loading. There is a bridge at the downstream end of the survey reach.

Description of Stream Channel Conditions
The channel is dynamic with considerable bedload and instability. Large wood and alder thickets promote channel scour and provide habitat diversity. Beaver play an important role influencing channel morphology, sediment storage, water storage and the vegetation community. Grazing may be furthering the system's susceptibility to periodic disturbance. There is considerable off-channel habitat. Swamp Creek Reach 20-1 currently exhibits a Rosgen D4 channel morphology. Based on the valley morphology, floodplain, and vegetation characteristics, the probable historical stream type was likely a Rosgen C4.

Description of Streambank Erosion Conditions
Considerable bank erosion in reach is contributing sediment to the channel. Most eroding banks are less than 3 ft high. Glacial Lake Missoula deposits are contributing fine silts to stream. Most fine sediment is in the lower portion of the reach, especially downstream of a floodplain channel that joins the creek in Cell 1.

Description of Riparian Vegetation Conditions
There is a diffuse overstory with infrequent spruce, larch and cedar. The shrub understory and mid-story are dominated by spirea and alder, respectively. The vegetation community looks to be highly influenced by past and present beaver activity. A lack of a more complete overstory may be due to high water table related to beaver activity.

B3.3.17 Swamp Creek Reach 21-1

Description of Human Impacts and Severity
Obvious human impacts in the reach include bank rip-rap and grazing. One house is located in the reach. It also appears that the USFS portion of the reach is grazed. Bank erosion is common.

Description of Stream Channel Conditions
The channel morphology was characterized by long pools/glides and short riffles. Alder clumps and large wood influence pool scour and habitat. The channel appears to be over-widened through much of the reach due to grazing impacts. The upstream end of the reach has two channels. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4.

Description of Streambank Erosion Conditions
Bank erosion is common in the reach. Accelerated erosion is related to livestock grazing, hoof shear, and vegetation removal. The most severe erosion was due to bank toe failure and bank slumping.

Description of Riparian Vegetation Conditions
Riparian vegetation was characterized by an alder overstory and grass understory. Additional shrubs found in the USFS section included spirea, willows, and dogwood. Knapweed and mullein were located on depositional bars.

B3.3.18 Swamp Creek Reach 22-3

Description of Human Impacts and Severity
The uplands were previously logged. The most severe human influence is irrigation withdrawal. The stream was nearly dry in SWP 22-3. Numerous fish were stranded in the remaining pools. The downstream end of the reach may be influenced by reservoir operations.

Description of Stream Channel Conditions
The channel is bedrock controlled through the reach. Bedrock is either exposed at the channel surface or is covered by a thin veneer of sediment ranging from sand to boulders. The channel is relatively homogeneous with few moderate to large pools. A narrow floodplain separates the channel from adjacent hillslopes. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C4 or F4.

Description of Streambank Erosion Conditions
Erosion is moderate in the reach. Bedrock limits erosion in the upper portion of the reach. Failing reed canarygrass-dominated banks are fairly common. However, a good riparian shrub community limits the extent of lateral bank retreat.

Description of Riparian Vegetation Conditions
Vegetation conditions are relatively diverse with a dense shrub layer and moderate canopy. Reed canarygrass is common throughout the reach.

B3.3.19 Marten Creek Reach 6-2

Description of Human Impacts and Severity
No obvious human impacts. Large wood influences channel morphology and deposition. Bedorck forms much of the southern channel margin.

Description of Stream Channel Conditions
Downstream end of reach has intermittent conditions partially caused by sediment wedge. Large downstream jam is influencing sediment wedge. Water emerges upstream and downstream of the intermittent reach. Steeper reaches have coarser bed material including boulders that are unlikely to move except in uncommon flood events. Short meandering sections are influenced by large wood and have substantial mobile bedload deposits. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C3b.

Description of Streambank Erosion Conditions
In the lower reach, there is a bedrock outcrop on the southern bank. There is minimal bank erosion on the north bank. Bank erosion occurs on most streambanks lacking bedrock. Eroding banks are commonly 3 ft to 4 ft high.

Description of Riparian Vegetation Conditions
The overstory includes cottonwood, alder, fir, larch and cedar. The understory includes dogwood, mulberry, Rocky Mountain maple, snowberry, and thimbleberry. There is no apparent logging in the riparian zone. Large trees recruit to channel. Cedars are more common in the upper half of reach. Mature cottonwoods relatively common.

B3.3.20 Marten Creek Reach 9-1

Description of Human Impacts and Severity
No human impacts were identified.

Description of Stream Channel Conditions
The stream is dynamic with expansive alluvial deposits. Loose sediment suggests a mobile bed with limited larger material and LWD for channel stability. Channel changes may be relatively frequent based on overflow channels, moderately fresh deposition, and bank erosion. The habitat is generally homogeneous with limited pools and long riffles. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen C3.

Description of Streambank Erosion Conditions
Bank erosion is pervasive with most outside banks affected by scour. Flood-deposited coarse material is colonized by shrubs. Most of these surfaces are not stable enough to resist erosion. Eroding banks range from 2 ft to 4 ft in height.

Description of Riparian Vegetation Conditions
The canopy is less contiguous compared to upstream reaches. Cottonwoods are the primary overstory species with infrequent conifers. Understory species include snowberry, dogwood, Rocky Mountain maple, tansy, and cottonwoods. Flood deposits are colonized by pioneer species. The greater stable floodplain supports a dense understory.

B3.3.21 North Branch Marten Creek Reach 8-1

Description of Human Impacts and Severity
There is evidence of past logging activities within the channel migration zone. There is moderate potential for large wood recruitment. The stream interacts with USFS road hillslope in Cell 5 (~100 ft right bank). The fillslope is stable with grasses/shrubs. There is low sediment delivery potential.

Description of Stream Channel Conditions
The channel is characterized as having a plane bed, riffle/step (forced) pool morphology. The bed material is very coarse with gravel deposited in low energy interstitial areas between boulders. There is limited pool development and depths due to armored bed and lack of coarse large wood. The channel is classified as a Rosgen B3a type with steeper, more confined B2 inclusions.

Description of Streambank Erosion Conditions
Streambanks are generally stable with some discrete point sources located along meander outcurves and constrictions. Source areas are armored with large cobble-boulder sediment (low-mod BEHI ratings). Overall, there is low supply from eroding streambanks.

Description of Riparian Vegetation Conditions
The overstory is dominated by conifers and deciduous trees. There is evidence of past harvest activities within the stream migration zone. Mid-story conifers with Rocky Mountain maple, alder, dogwood and thimbleberry ground cover (grass/forbs).

B3.3.22 South Branch Marten Creek Reach 3-1

Description of Human Impacts and Severity
There does not appear to be any human impacts in the reach other than a fire. The riparian zone is intact with no signs of logging.

Description of Stream Channel Conditions
There is a considerable amount of wood in the reach, influencing channel morphology and habitat. Series of log steps store sediment and provide upstream deposition and downstream scour. Based on the valley morphology, floodplain, substrate and vegetation conditions, the existing stream type and probable historical stream type would be classified as a Rosgen B4a.

Description of Streambank Erosion Conditions
Dense vegetation, and rocky hillslope and bank materials result in minimal to moderate bank erosion.

Description of Riparian Vegetation Conditions

There is a multi-story riparian zone with a mature conifer canopy. The overstory is dominated by hemlock. The riparian understory includes alder, devils club, and Rocky Mountain maple. There is substantial large wood recruitment to the channel.

B3.4 GRAPHICAL PARAMETER SUMMARIES BY REACH

The following section provides graphs for stream channel and riparian zone metrics measured in each of the reaches described in **Section B3.5**.

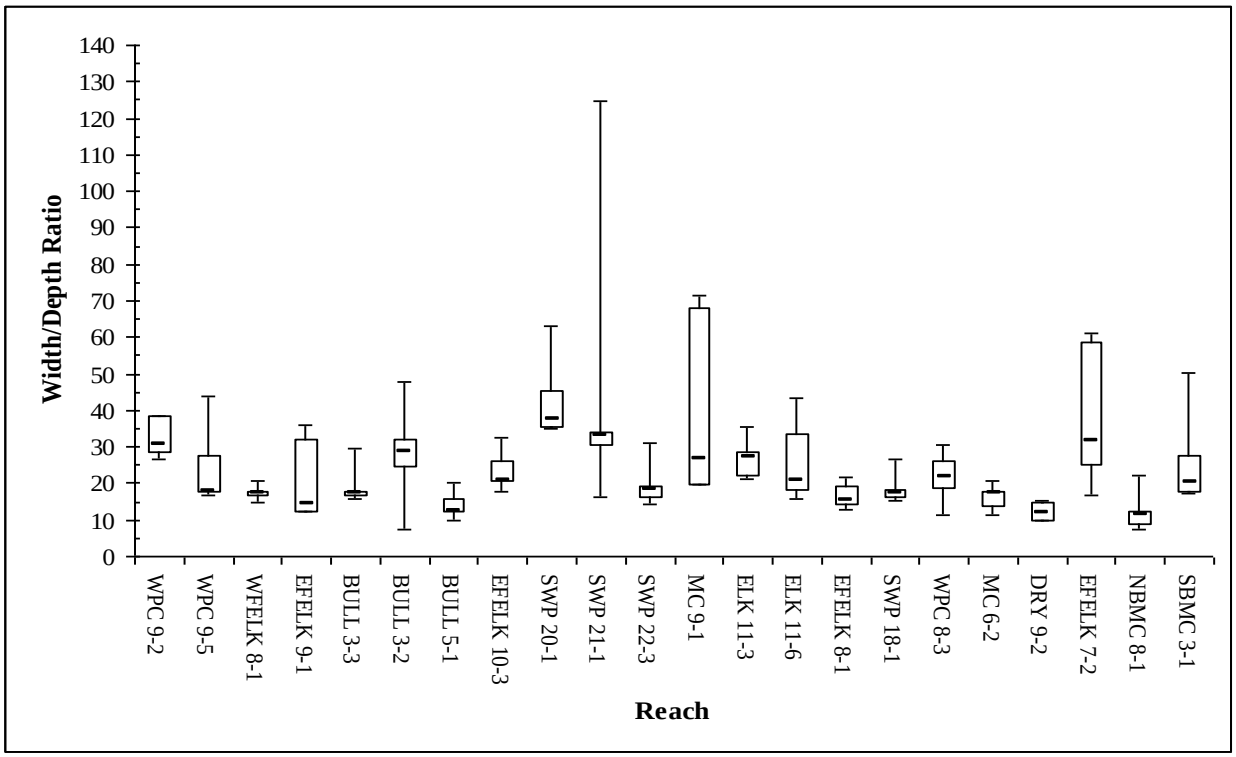


Figure B3-11. Width/Depth Ratio by reach.

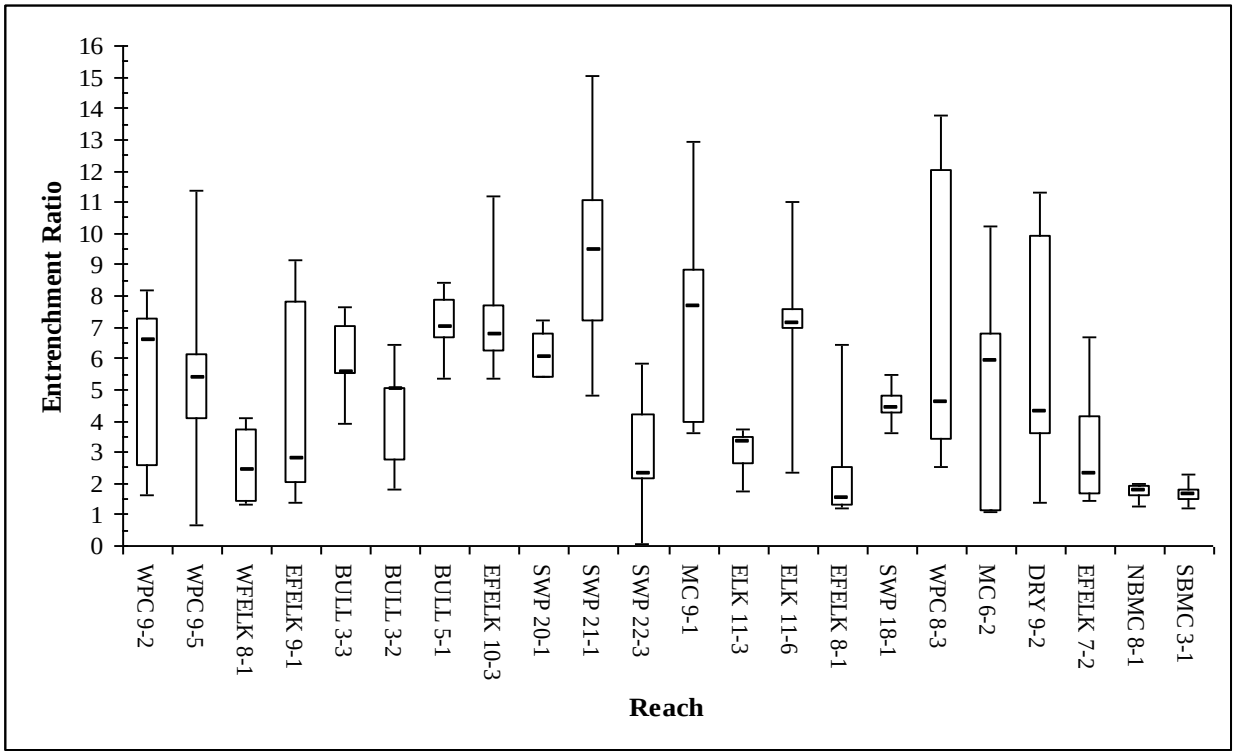


Figure B3-12. Entrenchment Ratio by reach.

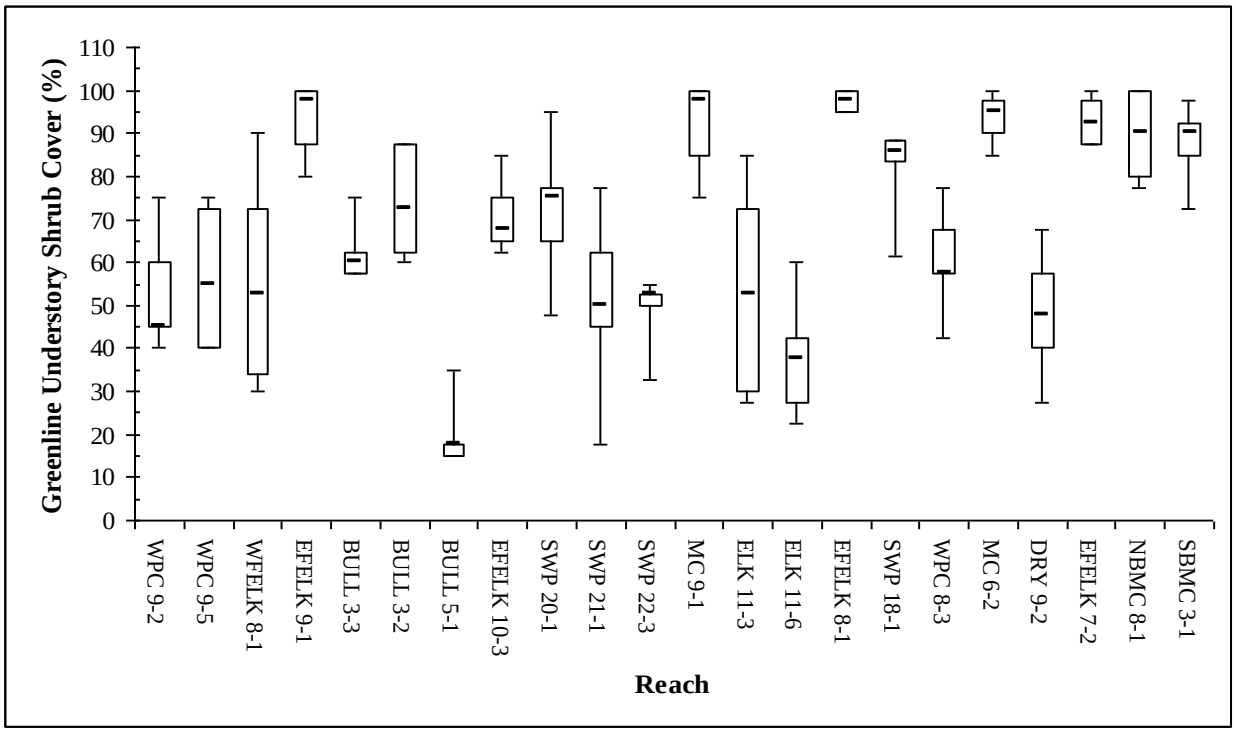


Figure B3-13. Greenline Understory Shrub Cover (%) by reach.

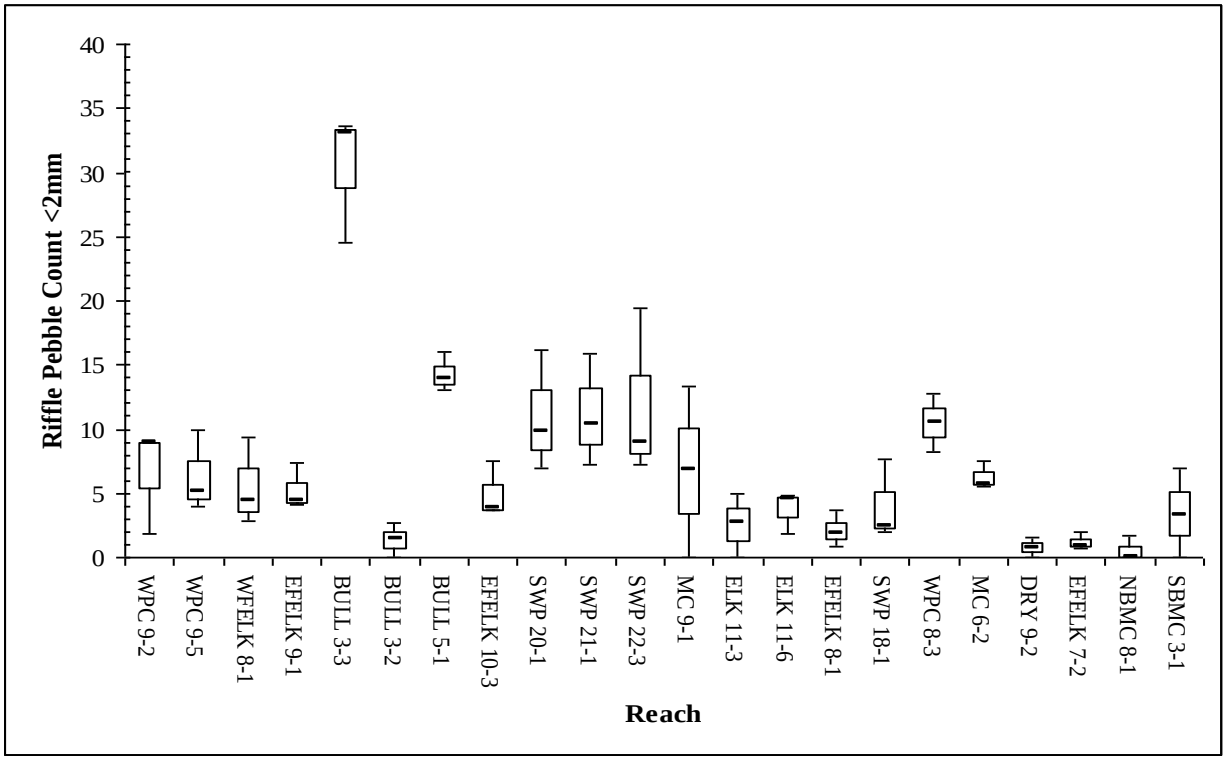


Figure B3-14. Riffle Pebble Count <2 mm by reach.

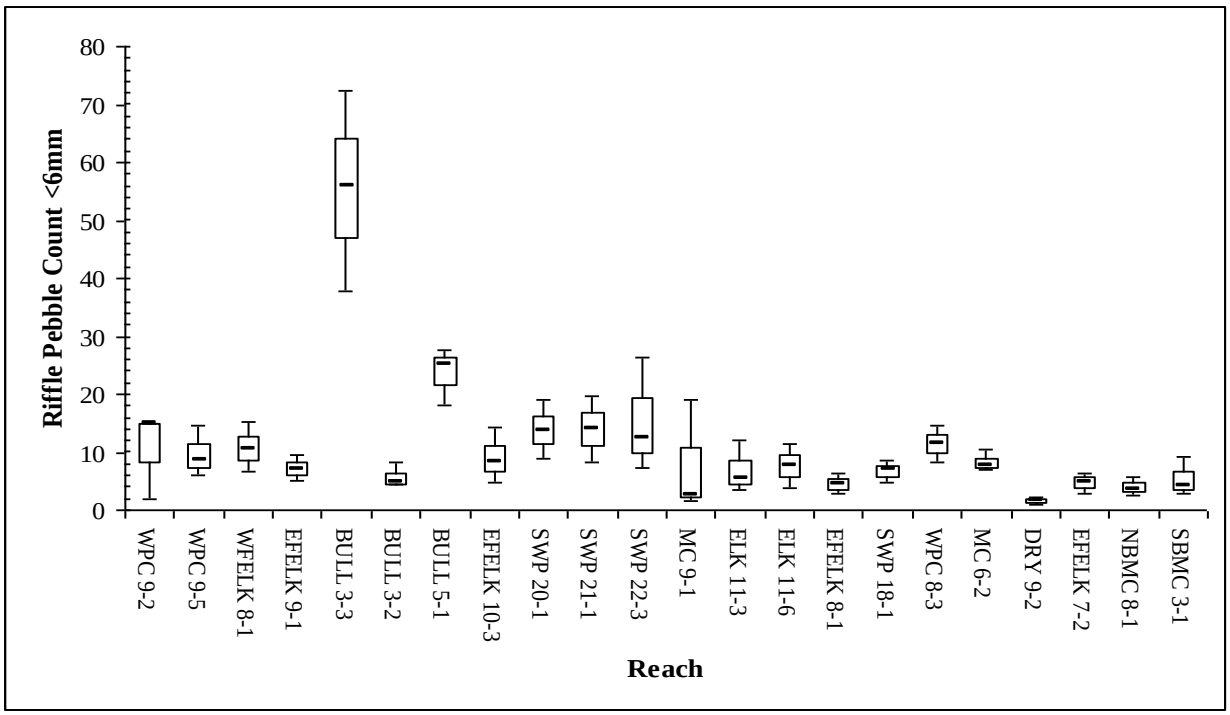


Figure B3-15. Riffle Pebble Count <6 mm by reach.

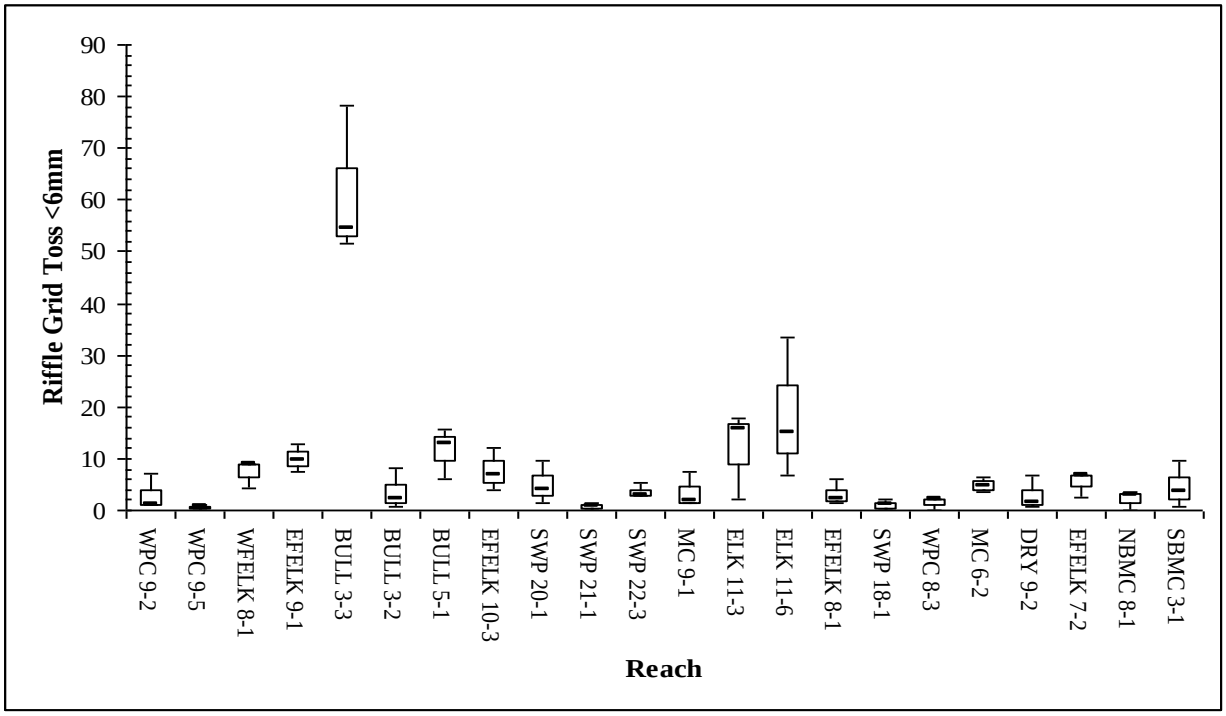


Figure B3-16. Riffle Grid Toss <6 mm by reach.

B4.0 STREAMBANK EROSION SOURCE ASSESSMENT

B4.1 OVERVIEW

For each monitoring reach selected in the aerial photo assessment, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), in accordance with the Watershed Assessment of River Stability and Sediment Supply guidelines (Rosgen 2006). These measurements were used in conjunction with streambank length and erosion source notes to determine sediment loads per 1,000 feet of channel within each surveyed reach.

The BEHI procedure integrates multiple factors which have a direct impact on streambank stability, including the following parameters.

- Ratio of streambank height to bankfull stage.
- Ratio of riparian vegetation rooting depth to streambank height.
- Degree of rooting density.
- Composition of streambank materials.
- Streambank angle.
- Bank material stratigraphy.
- Bank surface protection afforded by woody debris and vegetation.

The BEHI index incorporates these seven variables into a numerical reach score that is used to rank streambank erosion potential on a scale ranging from very low to extreme (**Table B4-1**). For the LCFT-TPA sites, several bank sites within each reach were evaluated for streambank integrity. The number of sites evaluated within each reach was based upon the variability of streambank conditions within the reach. Selected sites provided a representative sample of streambank conditions throughout the reach.

Table B4-1. BEHI score and rating matrix (Rosgen 1996).

Parameter		Very Low	Low	Moderate	High	Very High	Extreme
Bank Height Ratio	Value	1.0 – 1.1	1.11 – 1.19	1.2 – 1.5	1.6 – 2.0	2.1 – 2.8	> 2.8
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Root Depth Ratio	Value	1.0 – 0.9	0.89 – 0.5	0.49 – 0.3	0.29 – 0.15	0.14 – 0.05	<0.05
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Weighted Root Density	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 5	<5
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Bank Angle	Value	0 – 20	21 – 60	61 – 80	81 – 90	91 – 119	>119
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Surface Protection	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 10	<10
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10

After evaluating the core bank integrity parameters described above, bank material composition factors are considered. Depending upon bank materials, BEHI score are adjusted up or down (Rosgen 1996). Banks comprised of bedrock, boulders and cobble had very low erosion potential. Banks composed of cobble and/or gravel with a high fraction of sand had increased erosion potential. Stratified banks containing layers of unstable material also displayed greater erosion potential. After adjusting the core BEHI score for bank material composition factors, a final BEHI score and rating is derived (**Table B4-2**).

Table B4-2. BEHI score and rating following bank materials adjustment.

Rating	Very Low	Low	Moderate	High	Very High	Extreme
Score	5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

B4.2 FIELD MEASUREMENT OF BEHI

Within each sub-reach, eroding streambanks were identified and supporting BEHI measurements recorded. Measurements were completed for the following metrics:

- Bank condition including actively eroding, slowly eroding, undercut, or vegetated banks
- Bank height
- Bankfull height
- Root depth
- Root density
- Bank angle
- Surface protection
- Material adjustments
- Bankfull mean depth
- Near bank maximum depth
- Stationing
- Mean height
- Bank composition (size classes)
- Hoof shear presence
- Sources of streambank instability (percentage)

In addition to these measurements, photos were taken facing each streambank from a location perpendicular and a location upstream of the streambank. Photos were labeled according to the streambank site and position of the photograph.

B4.3 INDEX CALCULATIONS

To calculate the BEHI rating for each eroding streambank, the following parameters were used:

- Bank height/bankfull height
- Root depth/bank height
- Weighted root density
- Bank density
- Surface protection

Each parameter is matched to a corresponding index value, derived from statistical relations for sedimentary/metamorphic geologic substrata (Rosgen 1996; 2001a). Index values are summarized to create an overall BEHI rating number, which is then converted into a categorical rating (Very Low, Low, Moderate, High, Very High or Extreme).

To calculate the NBS rating for each bank, the following relationship is used:

NBS = Near Bank Maximum Bankfull Depth (ft) / Bankfull Mean Depth (ft)

As with the BEHI ratings, the resulting NBS value corresponds to a categorical rating.

B4.4 RETREAT RATE

The BEHI and NBS categorical ratings were matched to derive the average retreat rate of each streambank (ft/yr) (**Table B4-3**).

Table B4-3. BEHI and Near Bank Stress categories and rate of streambank retreat (ft/yr).

BEHI	Near Bank Stress					
	Very Low	Low	Moderate	High	Very High	Extreme
Very Low	NA	NA	NA	NA	NA	NA
Low	0.02	0.04	0.07	0.16	0.32	0.67
Moderate	0.09	0.15	0.25	0.42	0.70	1.16
High-Very High	0.17	0.25	0.38	0.58	0.87	1.32
Extreme	0.16	0.42	1.07	2.75	7.03	17.97

B4.5 BANK EROSION SEDIMENT LOADING

The mass eroded (tons/yr) from each streambank is calculated using the following equation:

Mass eroded = Streambank Length (ft)* Mean Streambank Height (ft) * Retreat Rate (ft/yr)

Mass eroded per each streambank is then filtered into two categories (actively eroding versus slowly eroding, undercut, or vegetated banks).

B4.6 BEHI RESULTS

The following sections provide the BEHI results by reach categories. Each reach category has two accompanying data tables.

B4.6.1 Bull River Reach 3-3

Streambanks in Bull River Reach 3-3 were stable. The silt-clay bank material is cohesive and resistant to scour. Vegetation conditions range from drier grasses to dense reed canarygrass and shrubs. Vegetated streambanks overhang the stream and provide debris inputs. Typical reach photographs are included in **Figure B4-1**. BEHI results for Reach 3-3 are included in **Table B4-4** and **Table B4-5**.



Figure B4-1. Typical streambank conditions in Bull River Reach 3-3.

Table B4-4. BEHI statistics for Bull River Reach 3-3.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
BULL 3-3	9/25/08	Active	35.6	661	22.0	104.3	69.5
BULL 3-3	9/25/08	Slow	36.6	93	3.1	5.5	3.7
BULL 3-3	9/25/08	Total		754	25.1	109.8	73.2

Table B4-5. BEHI statistics for Bull River Reach 3-3.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
BULL 3-3	9/25/08	Active	5.9	0.0	0.0	0.0	0.0	0.0	94.1	0.0
BULL 3-3	9/25/08	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
BULL 3-3	9/25/08	Total	5.6	0.0	0.0	0.0	0.0	0.0	94.4	0.0

B4.6.2 Bull River Reach 3-2

There was moderate bank erosion occurring along areas prone to high NBS. Streambanks on outside meanders with poor vegetation and rooting conditions typically experienced the greatest erosion. Streambanks are comprised of sandy, gravelly unconsolidated materials. Eroded blocks vegetated by reed canarygrass, grass, and shrubs were located throughout the reach. **Figure B4-2** includes typical bank erosion conditions in the reach. Summary data for Bull River Reach 3-2 are presented in **Table B4-6** and **Table B4-7**.



Figure B4-2. Typical eroding bank conditions in Bull River Reach 3-2.

Table B4-6. BEHI statistics for Bull River Reach 3-2.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
BULL 3-2	9/25/08	Actively	36.9	84	4.2	11.7	11.7
BULL 3-2	9/25/08	Slowly	27.8	152	7.6	8.9	8.9
BULL 3-2	9/25/08	Total		236	11.8	20.6	20.6

Table B4-7. BEHI statistics for Bull River Reach 3-2.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
BULL 3-2	9/25/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0
BULL 3-2	9/25/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	97.2	2.8
BULL 3-2	9/25/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	81.7	18.3

B4.6.3 Bull River Reach 5-1

The streambanks are primarily composed of sands and other fine materials, overlain by reed canarygrass, shrubs and scattered cedar roots. Vegetative cover is extensive throughout the reach, but the root mats are undercut and slumping on several banks. Bank structure may have been historically influenced by agriculture, but erosion is currently attributed to natural causes. **Figure B4-3** includes typical bank erosion conditions in the reach. Summary data for Bull River Reach 5-1 are presented in **Table B4-8** and **Table B4-9**.



Figure B4-3. Typical eroding bank conditions in Bull River Reach 5-1.

Table B4-8. BEHI statistics for Bull River Reach 5-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
BULL 5-1	9/25/08	Actively	32.3	280	9.3	16.2	10.8
BULL 5-1	9/25/08	Slowly	27.5	423	14.1	27.1	18.0
BULL 5-1	9/25/08	Total		703	23.4	43.2	28.8

Table B4-9. BEHI statistics for Bull River Reach 5-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
BULL 5-1	9/25/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
BULL 5-1	9/25/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	97.9	2.1
BULL 5-1	9/25/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	98.7	1.3

B4.6.4 Dry Creek Reach 9-2

Coarse cobbles and boulders form the streambank material in this reach, covered with a mat of forest roots and associated understory shrubs. The high bank height ratios and shallow rooting depths form the basis for erodability, further increased by historical silviculture activity. High near-bank stress ratings on all banks are moderated by the coarse bank material and vegetative cover. **Figure B4-4** includes typical bank erosion conditions in the reach. Summary data for Dry Creek Reach 9-2 are presented in **Table B4-10** and **Table B4-11**.



Figure B4-4. Typical eroding bank conditions in Dry Creek Reach 9-2.

Table B4-10. BEHI statistics for Dry Creek Reach 9-2.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
DRY 9-2	9/26/08	Actively	13.8	126	6.3	4.3	4.3
DRY 9-2	9/26/08	Slowly	16.9	208	10.4	8.1	8.1
DRY 9-2	9/26/08	Total		334	16.7	12.4	12.4

Table B4-11. BEHI statistics for Dry Creek Reach 9-2.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
DRY 9-2	9/26/08	Actively	0.0	0.0	0.0	0.0	40.0	0.0	60.0	0.0
DRY 9-2	9/26/08	Slowly	0.0	0.0	0.0	0.0	40.0	0.0	60.0	0.0
DRY 9-2	9/26/08	Total	0.0	0.0	0.0	0.0	40.0	0.0	60.0	0.0

B4.6.5 West Fork Elk Creek Reach 8-1

Limited bank erosion in this reach is related to natural influences. Bank erosion occurs primarily near cedar stumps, roots, trunks or large woody debris knick points. Deep, curving bends also result in limited erosion at corners. **Figure B4-5** includes typical bank erosion conditions in the reach. Summary data for West Fork Elk Creek Reach 8-1 are presented in **Table B4-12** and **Table B4-13**.



Figure B4-5. Typical eroding bank conditions in West Fork Elk Creek Reach 8-1.

Table B4-12. BEHI statistics for West Fork Elk Creek Reach 8-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WFELK 8-1	9/23/08	Actively	12.7	130	6.5	5.9	5.9
WFELK 8-1	9/23/08	Slowly	0.0	0	0.0	0.0	0.0
WFELK 8-1	9/23/08	Total		130	6.5	5.9	5.9

Table B4-13. BEHI statistics for West Fork Elk Creek Reach 8-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WFELK 8-1	9/23/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WFELK 8-1	9/23/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WFELK 8-1	9/23/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.6 East Fork Elk Creek Reach 9-1

Areas of sand and small fines dominate the substrate; locations where the channel shape shifts due to LWD or bends are responsible for the erosion of these materials. However, not much bank erosion was found outside of these erodible areas. Extensive vegetation cover is successfully mitigating erosion and providing cover. **Figure B4-6** includes typical bank erosion conditions in the reach. Summary data for East Fork Elk Creek Reach 9-1 are presented in **Table B4-14** and **Table B4-15**.



Figure B4-6. Typical eroding bank conditions in East Fork Elk Creek Reach 9-1.

Table B4-14. BEHI statistics for East Fork Elk Creek Reach 9-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFELK 9-1	9/23/08	Actively	32.4	102	5.1	4.0	4.0
EFELK 9-1	9/23/08	Slowly	28.5	57	2.9	1.9	1.9
EFELK 9-1	9/23/08	Total		159	8.0	5.9	5.9

Table B4-15. BEHI statistics for East Fork Elk Creek Reach 9-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFELK 9-1	9/23/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	84.8	15.2
EFELK 9-1	9/23/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFELK 9-1	9/23/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	89.7	10.3

B4.6.7 East Fork Elk Creek Reach 8-1

Naturally occurring eroding banks, very limited in size and frequency are usually at outside meanders. The streambanks are armored with large cobble, with a mat of shrub and tree cover on top. One large eroding hillslope with a stable toe is eroding about 8 ft up the bank. The channel intercepts flood lag deposits possibly deposited during the 1964 flood. Mature cottonwoods are buried up to 3 ft by sediment. A homogeneous mixture of sediment size classes is the primary source of material to the channel (natural). **Figure B4-7** includes typical bank erosion conditions in the reach. Summary data for East Fork Elk Creek Reach 8-1 are presented in **Table B4-16** and **Table B4-17**.



Figure B4-7. Typical eroding bank conditions in East Fork Elk Creek Reach 8-1.

Table B4-16. BEHI statistics for East Fork Elk Creek Reach 8-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFELK 8-1	9/22/08	Actively	23.6	104	5.2	3.2	3.2
EFELK 8-1	9/22/08	Slowly	32.2	112	5.6	8.4	8.4
EFELK 8-1	9/22/08	Total		216	10.8	11.6	11.6

Table B4-17. BEHI statistics for East Fork Elk Creek Reach 8-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFELK 8-1	9/22/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFELK 8-1	9/22/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFELK 8-1	9/22/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.8 East Fork Elk Creek Reach 7-2

The armored channel exhibits minimal erosion, all of which is attributable to natural causes. Vegetation extends to the channel margin, completely covering the mixed sizes of material that comprise the streambank. **Figure B4-8** includes typical bank erosion conditions in the reach. Summary data for East Fork Elk Creek Reach 7-2 are presented in **Table B4-18** and **Table B4-19**.



Figure B4-8. Typical eroding bank conditions in East Fork Elk Creek Reach 7-2.

Table B4-18. BEHI statistics for East Fork Elk Creek Reach 7-2.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFELK 7-2	9/22/08	Actively	31.8	49	2.5	1.9	1.9
EFELK 7-2	9/22/08	Slowly	22.1	41	2.1	1.2	1.2
EFELK 7-2	9/22/08	Total		90	4.5	3.1	3.1

Table B4-19. BEHI statistics for East Fork Elk Creek Reach 7-2.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFELK 7-2	9/22/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFELK 7-2	9/22/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFELK 7-2	9/22/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.9 East Fork Elk Creek Reach 10-3

Most streambanks in this reach are actively eroding. Some streambank stabilization projects have been installed including 2 engineered log jams and 1 rip-rap bank. High stream energy and bedload deposits occur at meanders, influencing channel morphology. The riparian vegetation is dominated by reed canarygrass and alder rather than historically dense species such as willow and dogwood, resulting in streambank instability. Large wood redirects flow into streambanks which is also affecting stability. Limited root density and sandy soils in some places also affect bank stability. **Figure B4-9** includes typical bank erosion conditions in the reach. Summary data for East Fork Elk Creek Reach 10-3 are presented in **Table B4-20** and **Table B4-21**.



Figure B4-9. Typical eroding bank conditions in East Fork Elk Creek Reach 10-3.

Table B4-20. BEHI statistics for East Fork Elk Creek Reach 10-3.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFELK 10-3	9/24/08	Actively	38.8	66	3.3	2.6	2.6
EFELK 10-3	9/24/08	Slowly	27.0	88	4.4	1.7	1.7
EFELK 10-3	9/24/08	Total		154	7.7	4.3	4.3

Table B4-21. BEHI statistics for East Fork Elk Creek Reach 10-3.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFELK 10-3	9/24/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0
EFELK 10-3	9/24/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	79.9	20.1
EFELK 10-3	9/24/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	74.0	26.0

B4.6.10 Elk Creek Reach 11-3

Large, long sandy streambanks are unstable due to lack of good riparian vegetation. Local haying occurs in this reach but does not seem to be affecting the streambanks themselves. Minimal riparian vegetation remains on eroding banks aside from reed canarygrass and small patches of alder. **Figure B4-10** includes typical bank erosion conditions in the reach. Summary data for Elk Creek Reach 11-3 are presented in **Table B4-22** and **Table B4-23**.



Figure B4-10. Typical eroding bank conditions in Elk Creek Reach 11-3.

Table B4-22. BEHI statistics for Elk Creek Reach 11-3.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
ELK 11-3	9/24/08	Actively	40.6	130	6.5	6.8	6.8
ELK 11-3	9/24/08	Slowly	37.7	142	7.1	9.2	9.2
ELK 11-3	9/24/08	Total		272	13.6	16.0	16.0

Table B4-23. BEHI statistics for Elk Creek Reach 11-3.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
ELK 11-3	9/24/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0
ELK 11-3	9/24/08	Slowly	0.0	9.3	0.0	0.0	0.0	0.0	61.2	29.5
ELK 11-3	9/24/08	Total	0.0	5.3	0.0	0.0	0.0	0.0	65.0	29.7

B4.6.11 Elk Creek Reach 11-6

Alternating pool-riffle sequences are associated with an inset floodplain surface and bracketing low and middle terraces that are prone to erosion on outside meander sequences. The 1997 flood appears to have affected the channel morphology. The channel generally down-cut into the valley fill by as much as 2 ft relative to the low terrace which is the abandoned floodplain surface. The channel has limited meander belt width and is actively expanding the floodplain through erosion and accretion. Streambanks are generally comprised of fine gravel and lacustrine silt and clays. The rooting depth is relatively shallow and knapweed dominates several droughty terraces. Streambanks have high erosion potential. **Figure B4-11** includes typical bank erosion conditions in the reach. Summary data for Elk Creek Reach 11-6 are presented in **Table B4-24** and **Table B4-25**.



Figure B4-11. Typical eroding bank conditions in Elk Creek Reach 11-6.

Table B4-24. BEHI statistics for Elk Creek Reach 11-6.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
ELK 11-6	9/24/08	Actively	33.9	372	18.6	19.9	19.9
ELK 11-6	9/24/08	Slowly	0.0	0	0.0	0.0	0.0
ELK 11-6	9/24/08	Total		372	18.6	19.9	19.9

Table B4-25. BEHI statistics for Elk Creek Reach 11-6.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
ELK 11-6	9/24/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0
ELK 11-6	9/24/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELK 11-6	9/24/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	70.0	30.0

B4.6.12 White Pine Creek Reach 9-2

Considerable streambank erosion contributes sediment ranging from silts to medium cobble. Most erosion is occurring on outside streambanks with extreme bank heights. Alders provide some streambank stability but most eroding banks are dominated by grasses and knapweed. Inside banks are characterized by point bar deposits and sparse vegetative cover. Reaches upstream and downstream are influenced by a forest road, active evulsions and shifting channel braids. **Figure B4-12** includes typical bank erosion conditions in the reach. Summary data for White Pine Creek Reach 9-2 are presented in **Table B4-26** and **Table B4-27**.



Figure B4-12. Typical eroding bank conditions in White Pine Creek Reach 9-2.

Table B4-26. BEHI statistics for White Pine Creek Reach 9-2.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WPC 9-2	10/1/08	Actively	37.3	711	35.6	42.6	42.6
WPC 9-2	10/1/08	Slowly	0.0	0	0.0	0.0	0.0
WPC 9-2	10/1/08	Total		711	35.6	42.6	42.6

Table B4-27. BEHI statistics for White Pine Creek Reach 9-2.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WPC 9-2	10/1/08	Actively	0.0	0.5	0.0	0.0	0.0	0.0	99.5	0.0
WPC 9-2	10/1/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WPC 9-2	10/1/08	Total	0.0	0.5	0.0	0.0	0.0	0.0	99.5	0.0

B4.6.13 White Pine Creek Reach 9-5

Bank erosion is relatively common at outside streambanks due to excessive bank heights. Reed canary grass colonizes failed streambank blocks. Point bars are largely colonized by reed canarygrass. Alders are located on the floodplain as well as on the streambanks of the entrenched bankfull channel. A few other shrubs are present in the reach, including spirea. The streambank has been anthropogenically altered (bulldozed and graded) on river-left near the downstream end of the reach. Haying is a dominant influence on river-left, which extends from the floodplain to the channel margin. **Figure B4-13** includes typical bank erosion conditions in the reach. Summary data for White Pine Creek Reach 9-5 are presented in **Table B4-28** and **Table B4-29**.



Figure B4-13. Typical eroding bank conditions in White Pine Creek Reach 9-5.

Table B4-28. BEHI statistics for White Pine Creek Reach 9-5.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WPC 9-5	10/1/08	Actively	35.9	215	10.8	9.5	9.5
WPC 9-5	10/1/08	Slowly	29.2	169	8.5	4.5	4.5
WPC 9-5	10/1/08	Total		384	19.2	14.1	14.1

Table B4-29. BEHI statistics for White Pine Creek Reach 9-5.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WPC 9-5	10/1/08	Actively	0.0	1.1	91.8	0.0	0.0	0.0	7.1	0.0
WPC 9-5	10/1/08	Slowly	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
WPC 9-5	10/1/08	Total	0.0	0.8	94.4	0.0	0.0	0.0	4.8	0.0

B4.6.14 White Pine Creek Reach 8-3

Most streambanks in the reach exhibit erosion. There is considerable sediment, generally coarser substrate, generated within the reach from streambank and floodplain erosion. Large material is mobilized by larger flood events. Lag deposits are vegetated by multi-age vegetation depending on age and disturbance regime of deposit. Multiple braided channels show evidence of scouring during floods then subsequent abandonment. **Figure B4-14** includes typical bank erosion conditions in the reach. Summary data for White Pine Creek Reach 8-3 are presented in **Table B4-30** and **Table B4-31**.



Figure B4-14. Typical eroding bank conditions in White Pine Creek Reach 8-3.

Table B4-30. BEHI statistics for White Pine Creek Reach 8-3.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WPC 8-3	10/1/08	Actively	19.0	747	37.4	11.4	11.4
WPC 8-3	10/1/08	Slowly	31.3	74	3.7	2.1	2.1
WPC 8-3	10/1/08	Total		821	41.1	13.5	13.5

Table B4-31. BEHI statistics for White Pine Creek Reach 8-3.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WPC 8-3	10/1/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WPC 8-3	10/1/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WPC 8-3	10/1/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.15 Swamp Creek Reach 18-1

Minimal streambank erosion is present due to coarse bed and streambank material. Some erosion of floodplain areas has occurred as a result of flood channel scour. Dense shrub cover including willow communities and forest understory anchors most of the streambanks while scattered cedar groves provide additional root cover. **Figure B4-15** includes typical bank erosion conditions in the reach. Summary data for Swamp Creek Reach 18-1 are presented in **Table B4-32** and **Table B4-33**.



Figure B4-15. Typical eroding bank conditions in Swamp Creek Reach 18-1.

Table B4-32. BEHI statistics for Swamp Creek Reach 18-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SWP 18-1	10/1/08	Actively	21.2	118	5.9	4.0	4.0
SWP 18-1	10/1/08	Slowly	18.6	55	2.8	0.3	0.3
SWP 18-1	10/1/08	Total		173	8.7	4.2	4.2

Table B4-33. BEHI statistics for Swamp Creek Reach 18-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SWP 18-1	10/1/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SWP 18-1	10/1/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SWP 18-1	10/1/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.16 Swamp Creek Reach 20-1

Considerable bank erosion in this reach is contributing sediment to the channel. Most eroding banks are less than 3 ft high. Glacial Lake Missoula deposits are contributing fine silts to the stream. Most of the fine sediment is in the lower portion of the reach, especially downstream of a floodplain channel that joins the creek in Cell 1. Grazing has significantly contributed to stream erosion throughout the reach, as shown by cropped grass and hoof shear. The channel appears to be actively shifting in the upstream cells, with relict point-bars, lack of vegetative cover and abandoned channels. **Figure B4-16** includes typical bank erosion conditions in the reach. Summary data for Swamp Creek Reach 20-1 are presented in **Table B4-34** and **Table B4-35**.



Figure B4-16. Typical eroding bank conditions in Swamp Creek Reach 20-1.

Table B4-34. BEHI statistics for Swamp Creek Reach 20-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SWP 20-1	9/30/08	Actively	34.0	245	12.3	17.1	17.1
SWP 20-1	9/30/08	Slowly	34.8	38	1.9	1.0	1.0
SWP 20-1	9/30/08	Total		283	14.2	18.1	18.1

Table B4-35. BEHI statistics for Swamp Creek Reach 20-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SWP 20-1	9/30/08	Actively	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
SWP 20-1	9/30/08	Slowly	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
SWP 20-1	9/30/08	Total	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

B4.6.17 Swamp Creek Reach 21-1

Bank erosion is common in the reach. Accelerated erosion is related to livestock grazing, hoof shear, and vegetation removal. The most severe erosion was due to bank toe failure and bank slumping. **Figure B4-17** includes typical bank erosion conditions in the reach. Summary data for Swamp Creek Reach 21-1 are presented in **Table B4-36** and **Table B4-37**.



Figure B4-17. Typical eroding bank conditions in Swamp Creek Reach 21-1.

Table B4-36. BEHI statistics for Swamp Creek Reach 21-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SWP 21-1	10/2/08	Actively	35.4	311	15.6	12.4	12.4
SWP 21-1	10/2/08	Slowly	23.6	216	10.8	3.1	3.1
SWP 21-1	10/2/08	Total		527	26.4	15.5	15.5

Table B4-37. BEHI statistics for Swamp Creek Reach 21-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SWP 21-1	10/2/08	Actively	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
SWP 21-1	10/2/08	Slowly	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
SWP 21-1	10/2/08	Total	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

B4.6.18 Swamp Creek Reach 22-3

Erosion is moderate in the reach. Bedrock limits erosion in the upper portion of the reach. Failing reed canarygrass-dominated banks are fairly common. However, a good riparian shrub community limits the extent of lateral bank retreat. **Figure B4-18** includes typical bank erosion conditions in the reach. Summary data for Swamp Creek Reach 22-3 are presented in **Table B4-38** and **Table B4-39**.



Figure B4-18. Typical eroding bank conditions in Swamp Creek Reach 22-3.

Table B4-38. BEHI statistics for Swamp Creek Reach 22-3.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SWP 22-3	10/2/08	Actively	27.5	200	10.0	4.8	4.8
SWP 22-3	10/2/08	Slowly	31.0	380	19.0	10.1	10.1
SWP 22-3	10/2/08	Total		580	29.0	14.8	14.8

Table B4-39. BEHI statistics for Swamp Creek Reach 22-3.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SWP 22-3	10/2/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	89.3	10.7
SWP 22-3	10/2/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SWP 22-3	10/2/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	96.6	3.4

B4.6.19 Marten Creek Reach 6-2

In the lower reach, there is a bedrock outcrop on the southern bank. There is minimal bank erosion on the north bank. Bank erosion occurs on most streambanks lacking bedrock. Eroding banks are commonly 3 ft to 4 ft high. **Figure B4-19** includes typical bank erosion conditions in the reach. Summary data for Marten Creek Reach 6-2 are presented in **Table B4-40** and **Table B4-41**.



Figure B4-19. Typical eroding bank conditions in Marten Creek Reach 6-2.

Table B4-40. BEHI statistics for Marten Creek Reach 6-2.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
MC 6-2	9/30/08	Actively	28.1	324	16.2	33.5	33.5
MC 6-2	9/30/08	Slowly	26.8	134	6.7	6.8	6.8
MC 6-2	9/30/08	Total		458	22.9	40.2	40.2

Table B4-41. BEHI statistics for Marten Creek Reach 6-2.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
MC 6-2	9/30/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
MC 6-2	9/30/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
MC 6-2	9/30/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.20 Marten Creek Reach 9-1

Bank erosion is pervasive with most outside banks affected by scour. Flood-deposited coarse material is colonized by shrubs and weeds. Most of these surfaces are not stable enough to resist erosion. Eroding banks range from 2 ft to 4 ft in height. **Figure B4-20** includes typical bank erosion conditions in the reach. Summary data for Marten Creek Reach 9-1 are presented in **Table B4-42** and **Table B4-43**.



Figure B4-20. Typical eroding bank conditions in Marten Creek Reach 9-1.

Table B4-42. BEHI statistics for Marten Creek Reach 9-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
MC 9-1	9/30/08	Actively	25.9	265	13.3	8.1	8.1
MC 9-1	9/30/08	Slowly	36.4	96	4.8	3.7	3.7
MC 9-1	9/30/08	Total		361	18.1	11.9	11.9

Table B4-43. BEHI statistics for Marten Creek Reach 9-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
MC 9-1	9/30/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
MC 9-1	9/30/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
MC 9-1	9/30/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.6.21 North Branch Marten Creek Reach 8-1

Streambanks are generally stable with some discrete point sources located along meander outcurves and constrictions. Source areas are armored with large cobble-boulder sediment (low-mod BEHI ratings). Overall, there is low supply from eroding streambanks, and high vegetative cover prevents erosion of the thin forest topsoil. **Figure B4-21** includes typical bank erosion conditions in the reach. Summary data for North Branch Marten Creek Reach 8-1 are presented in **Table B4-44** and **Table B4-45**.



Figure B4-21. Typical eroding bank conditions in North Branch Marten Creek 8-1.

Table B4-44. BEHI statistics for North Branch Marten Creek 8-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
NBMC 8-1	9/29/08	Actively	27.6	367	18.4	33.2	33.2
NBMC 8-1	9/29/08	Slowly	35.9	48	2.4	1.9	1.9
NBMC 8-1	9/29/08	Total		415	20.8	35.1	35.1

Table B4-45. BEHI statistics for North Branch Marten Creek 8-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
NBMC 8-1	9/29/08	Actively	7.2	0.0	0.0	0.0	0.0	0.0	91.8	0.9
NBMC 8-1	9/29/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
NBMC 8-1	9/29/08	Total	6.8	0.0	0.0	0.0	0.0	0.0	92.3	0.9

B4.6.22 South Branch Marten Creek Reach 3-1

Dense vegetation, a rocky hillslope and coarse bank materials result in minimal to moderate bank erosion. Numerous LWD and boulder deposits dissipate energy and prevent further scouring. **Figure B4-21** includes typical bank erosion conditions in the reach. Summary data for South Branch Marten Creek Reach 3-1 are presented in **Table B4-46** and **Table B4-47**.



Figure B4-22. Typical eroding bank conditions in South Branch Marten Creek 3-1.

Table B4-46. BEHI statistics for South Branch Marten Creek 3-1.

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SBMC 3-1	9/29/08	Actively	32.7	170	8.5	6.1	6.1
SBMC 3-1	9/29/08	Slowly	29.3	71	3.6	1.4	1.4
SBMC 3-1	9/29/08	Total		241	12.1	7.5	7.5

Table B4-47. BEHI statistics for South Branch Marten Creek 3-1.

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silviculture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SBMC 3-1	9/29/08	Actively	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SBMC 3-1	9/29/08	Slowly	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SBMC 3-1	9/29/08	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

B4.7 DATA SUMMARY

The following data summary tables are organized by stream reach category. The tables present the reach sediment load by category (actively eroding or slowly eroding) and the dominant influence (anthropogenic or natural). If <75% of the bank erosion-influenced load was attributed to natural sources, the load is considered to be anthropogenically-influenced.

Table B4-48. Summarized BEHI sediment loads for reaches categorized as NR-0-2-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
WPC 9-2	42.6	0	42.6		X
WPC 9-5	9.5	4.5	14.1	X	
WFELK 8-1	5.9	0.0	5.9		X
EFELK 9-1	4.0	1.9	5.9		X
Reach Category Avg Load	**15.5**	**1.6**	**17.1**	**14.1**	**18.1**

Table B4-49. Summarized BEHI sediment loads for reaches categorized as NR-0-3-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
BULL 3-2	69.5	3.7	73.2		X
BULL 3-3	11.7	8.9	20.6		X
BULL 5-1	10.8	18.0	28.8		X
EFELK 10-3	2.6	1.7	4.3	X	
SWP 20-1	17.1	1.0	18.1	X	
SWP 21-1	12.4	3.1	15.5	X	
SWP 22-3	4.8	10.1	14.8		X
MC 9-1	8.1	3.7	11.9		X
Reach Category Avg Load	**17.1**	**6.3**	**23.4**	**12.6**	**29.9**

Table B4-50. Summarized BEHI sediment loads for reaches categorized as NR-0-4-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
ELK 11-3	6.8	9.2	16.0	X	
ELK 11-6	19.9	0.0	19.9	X	
Reach Category Avg Load	**13.4**	**4.6**	**17.9**	**17.9**	**NA**

Table B4-51. Summarized BEHI sediment loads for reaches categorized as NR-2-2-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
EFELK 8-1	3.2	8.4	11.6		X
SWP 18-1	4.0	0.3	4.2		X
WPC 8-3	11.4	2.1	13.5		X
Reach Category Avg Load	**6.2**	**3.6**	**9.8**	**NA**	**9.8**

Table B4-52. Summarized BEHI sediment loads for reaches categorized as NR-2-3-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
MC 6-2	33.5	6.8	40.2		X
Reach Category Avg Load	**33.5**	**6.8**	**40.2**		**40.2**

Table B4-53. Summarized BEHI sediment loads for reaches categorized as NR-4-2-U.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
DRY 9-2	4.3	8.1	12.4	X	
EFELK 7-2	1.9	1.2	3.1		X
NBMC 8-1	33.2	1.9	35.1		X
Reach Category Avg Load	**13.1**	**3.8**	**16.9**	**12.4**	**19.1**

Table B4-54. Summarized BEHI sediment loads for reaches categorized as NR-4-2-C.

	Reach Sediment Load per 1000 ft			Dominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
SBMC 3-1	6.1	1.4	7.5		X
Reach Category Avg Load	**6.1**	**1.4**	**7.5**		**7.5**

Table B4-55. Summarized BEHI sediment loads for all reaches.

	Reach Sediment Load per 1000 ft		
	Actively Eroding	**Slowly Eroding**	**Total**
Average Load	14.7	4.4	19.1
Predominantly Anthropogenic Average Load	10.4	3.9	14.3
Predominantly Natural Average Load	16.7	4.6	21.3

B5.0 COMPLETE DATA TABLES

Table B5-1 Site Information

Reach ID	Estimated Potential Stream Type	Site	Date	Downstream End Latitude	Downstream End Longitude	Upstream End Latitude	Upstream End Longitude	Site Length (Feet)	Field Slope (Percent)	GIS Calculated Sinuosity
BULL 3-3	3b	1	9/25/08	48.18290	-115.85980	48.18475	-115.85946	1500	?	1.789417
BULL 3-2	3b	1	9/25/08	48.19190	-115.84073	48.19204	-115.83732	1000	1.2	1.290334
BULL 5-1	3d	1	9/25/08	48.13637	-115.86691	48.13881	-115.86826	1500	0 - .5	1.732135
DRY 9-2	2a	1	9/26/208	48.15430	-115.89391	48.15471	-115.89761	1000	5.5	1.044950
WFELK 8-1	2a	1	9/23/08	48.00419	-116.02782	48.00587	-116.02992	1000	1.9	1.170213
EFELK 9-1	2a	1	9/23/08	47.97232	-115.98622	47.97091	-115.98434	1000	2.3	1.176851
EFELK 8-1	2a	1	9/22/08	47.95076	-115.96153	47.94947	-115.95863	1000	3.4	1.093058
EFELK 7-2	2a	1	9/22/08	47.94256	-115.95217	47.94104	-115.95013	1000	4.4	1.088247
EFELK 10-3	3a	1	9/24/08	47.99864	-115.99221	47.99651	-115.9929	1000	1.0	1.100009
ELK 11-3	4a	1	9/24/08	48.02867	-115.96578	48.02722	-115.96811	1000	0.7	1.369215
ELK 11-6	4a	1	9/24/08	48.04345	-115.92021	48.0423	-115.91806	1000	0.7	1.389891
WPC 8-3	2a	1	10/1/08	47.76049	-115.60864	47.75895	-115.6115	1000	2.0	1.172609
WPC 9-2	2a	1	10/1/08	47.75223	-115.56216	47.75319	-115.56422	1000	1.0	1.188126
WPC 9-5	2a	1	10/1/08	47.75103	-115.51971	47.75079	-115.52259	1000	1.0	1.427827
SWP 18-1	2a	1	10/1/08	47.93712	-115.59932	47.93837	-115.59659	1000	2.3	1.143045
SWP 20-1	3a	1	9/30/08	47.90531	-115.62559	47.90669	-115.62405	1000	1.0	1.352212
SWP 21-1	3a	1	10/2/08	47.90189	-115.63107	47.90313	-115.62935	1000	1.0	1.496653
SWP 22-3	3a	1	10/2/08	47.91557	-115.66788	47.91636	-115.665	1000	1.1	1.393954
MC 6-2	3a	1	9/30/08	47.89019	-115.84001	47.88897	-115.8438	1000	2.0	1.019166
MC 9-1	3b	1	9/30/08	47.89231	-115.81169	47.89249	-115.81456	1000	1.8	1.285985
NBMC 8-1	2a	1	9/29/08	47.88479	-115.87954	47.88665	-115.88225	1000	5.3	1.048189
SBMC 3-1	2a	1	9/29/08	47.87459	-115.89573	47.87291	-115.89808	1000	7.5	1.040067

Values represent actual field results except in the following circumstances:

GIS calculated sinuosity measured in GIS using upstream and downstream coordinates and reach length

Table B5-2. Channel Cross Section Data

Reach ID	Site	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Notes
BULL 3-3	1	9/25/08	1	48.18290	-115.85980	pool	60.0	228.0	3.8	15.8	4.6	460	7.7	
BULL 3-3	1	9/25/08	2	48.18329	-115.86098	pool	51.0	154.7	3.0	16.8	3.8	283	5.5	
BULL 3-3	1	9/25/08	3	48.18363	-115.86068	pool	59.4	206.1	3.5	17.1	4.7	419	7.1	
BULL 3-3	1	9/25/08	4	48.18368	-115.85998	pool	76.0	196.8	2.6	29.3	2.9	296	3.9	
BULL 3-3	1	9/25/08	5	48.18420	-115.85949	pool	59.9	204.7	3.4	17.5	4.2	330	5.5	
BULL 3-2	1	9/25/08	1	48.19190	-115.84073	riffle	53.0	97.8	1.8	28.7	2.8	148	2.8	
BULL 3-2	1	9/25/08	2	48.19231	-115.84019	riffle	49.0	75.7	1.5	31.8	3.3	249	5.1	
BULL 3-2	1	9/25/08	3	48.19229	-115.83961	riffle	64.5	87.4	1.4	47.8	2.2	415	6.4	
BULL 3-2	1	9/25/08	4	48.19209	-115.83876	riffle	50.7	105.1	2.1	24.5	3.1	254	5.0	
BULL 3-2	1	9/25/08	5	48.19221	-115.83775	riffle	90.5	110.9	12.3	7.4	2.7	166	1.8	
BULL 5-1	1	9/25/08	1	48.13637	-115.86691	riffle	64.0	329.4	5.2	12.4	6.5	344	5.4	
BULL 5-1	1	9/25/08	2	48.13739	-115.86773	pool/ riffle	58.0	273.6	4.7	12.3	6.0	458	7.9	
BULL 5-1	1	9/25/08	3	48.13785	-115.86835	pool/ riffle	54.0	302.7	5.6	9.6	7.6	454	8.4	
BULL 5-1	1	9/25/08	4	48.13801	-115.86802	riffle	67.0	282.0	4.2	16.0	6.2	467	7.0	
BULL 5-1	1	9/25/08	5	48.1388	-115.8683	riffle	70.4	246.9	3.5	20.1	5.0	470	6.7	
DRY 9-2	1	9/26/08	1	48.15430	-115.89391	riffle	46.0	142.1	3.1	14.9	4.4	166	3.6	
DRY 9-2	1	9/26/08	2	48.15429	-115.89503	riffle	42.5	120.1	2.8	15.0	4.2	183	4.3	
DRY 9-2	1	9/26/08	3	48.15450	-115.89556	riffle	30.3	91.2	3.0	10.1	4.3	300	9.9	
DRY 9-2	1	9/26/08	4	48.15439	-115.89646	riffle	30.0	89.9	3.0	10.0	4.5	340	11.3	
DRY 9-2	1	9/26/08	5	48.15471	-115.89761	riffle	31.0	79.6	2.6	12.1	3.6	42	1.4	
WFELK 8-1	1	9/23/08	1	48.00425	-116.02784	riffle	22.6	24.0	1.1	20.5	1.9	33	1.4	
WFELK 8-1	1	9/23/08	2	48.00437	-116.02854	riffle	20.0	22.5	1.1	17.9	1.6	75	3.8	
WFELK 8-1	1	9/23/08	3	48.00497	-116.02902	riffle	16.5	18.5	1.1	14.7	1.6	68	4.1	
WFELK 8-1	1	9/23/08	4	48.00545	-116.02971	riffle	25.2	36.8	1.5	17.3	2.0	61	2.4	
WFELK 8-1	1	9/23/08	5	48.00587	-116.02992	riffle	17.0	17.3	1.0	16.7	1.6	23	1.3	
EFELK 9-1	1	9/23/08	1	47.97232	-115.98622	riffle	22.8	36.4	1.6	14.3	2.3	178	7.8	dry channel

Table B5-2. Channel Cross Section Data

Reach ID	Site	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Notes
EFELK 9-1	1	9/23/08	2	47.97201	-115.98585	riffle	39.0	42.5	1.1	35.8	1.9	357	9.2	dry channel
EFELK 9-1	1	9/23/08	3	47.97127	-115.98491	riffle	23.8	45.5	1.9	12.5	2.4	66	2.8	dry channel
EFELK 9-1	1	9/23/08	4	47.97158	-115.98494	riffle	22.1	39.5	1.8	12.3	2.2	30	1.4	dry channel
EFELK 9-1	1	9/23/08	5	47.97091	-115.98434	riffle	30.0	27.8	0.9	32.3	1.7	62	2.1	dry channel
EFELK 8-1	1	9/22/08	1	47.95076	-115.96153	riffle	29.4	44.9	1.5	19.3	2.2	75	2.5	
EFELK 8-1	1	9/22/08	2	47.95053	-115.96086	riffle	22.4	35.0	1.6	14.4	2.3	34	1.5	
EFELK 8-1	1	9/22/08	3	47.95017	-115.96044	riffle	21.1	30.2	1.4	15.1	2.3	26	1.2	
EFELK 8-1	1	9/22/08	4	47.94986	-115.95985	riffle	21.4	36.4	1.7	12.6	2.4	28	1.3	
EFELK 8-1	1	9/22/08	5	47.94961	-115.95880	riffle	29.7	40.8	1.4	21.7	2.2	192	6.5	
EFELK 7-2	1	9/22/08	1	47.94215	-115.95219	riffle	19.4	22.5	1.2	16.7	1.9	129	6.7	dry channel
EFELK 7-2	1	9/22/08	2	47.94188	-115.95166	riffle	29.0	33.4	1.2	25.2	1.6	121	4.2	dry channel
EFELK 7-2	1	9/22/08	3	47.94172	-115.95139	riffle	20.7	13.4	0.7	31.8	1.3	35	1.7	dry channel
EFELK 7-2	1	9/22/08	4	47.94137	-115.95064	riffle	34.8	20.6	0.6	58.9	1.6	50	1.4	
EFELK 7-2	1	9/22/08	5	47.94104	-115.95013	TOR to TOR	39.1	25.0	0.6	61.1	1.8	90	2.3	
EFELK 10-3	1	9/24/08	1	47.99864	-115.99221	riffle	38.3	71.6	1.9	20.5	2.4	428	11.2	
EFELK 10-3	1	9/24/08	2	47.99809	-115.99217	riffle	44.0	59.4	1.4	32.6	1.9	339	7.7	
EFELK 10-3	1	9/24/08	3	47.99752	-115.99237	riffle	28.8	46.6	1.6	17.8	2.0	154	5.3	
EFELK 10-3	1	9/24/08	4	47.99726	-115.99260	riffle	35.6	61.5	1.7	20.6	2.3	241	6.8	
EFELK 10-3	1	9/24/08	5	47.99690	-115.99306	riffle	37.0	52.0	1.4	26.2	1.8	231	6.2	
ELK 11-3	1	9/24/08	1	48.02867	-115.96578	riffle	47.9	64.9	1.4	35.5	2.1	159	3.3	
ELK 11-3	1	9/24/08	2	48.02868	-115.96649	riffle	36.5	59.8	1.6	22.3	2.8	127	3.5	
ELK 11-3	1	9/24/08	3	48.02830	-115.96709	riffle	48.0	85.3	1.8	27.1	3.0	178	3.7	
ELK 11-3	1	9/24/08	4	48.02775	-115.96717	riffle/ pool	42.0	84.0	2.0	21.0	2.8	74	1.8	
ELK 11-3	1	9/24/08	5	48.02751	-115.96781	riffle	44.5	68.9	1.6	28.7	2.3	119	2.7	
ELK 11-6	1	9/24/08	1	48.04345	-115.92021	pool (twg to	45.8	63.7	1.4	33.7	2.0	326	7.1	

Table B5-2. Channel Cross Section Data

Reach ID	Site	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Notes
						twg - mxd)								
ELK 11-6	1	9/24/08	2	48.04290	-115.92019	riffle	33.5	61.4	1.8	18.3	2.9	234	7.0	
ELK 11-6	1	9/24/08	3	48.04291	-115.91926	riffle	28.0	49.3	1.8	15.9	2.4	308	11.0	
ELK 11-6	1	9/24/08	4	48.04279	-115.91886	riffle	29.3	41.5	1.4	20.6	2.3	222	7.6	
ELK 11-6	1	9/24/08	5	48.04230	-115.91806	Twg (maxd to maxd)	60.2	83.6	1.4	43.3	2.1	143	2.4	
WPC 8-3	1	10/1/08	1	47.75965	-115.61098	riffle	54.0	96.3	1.8	30.3	2.8	245	4.5	
WPC 8-3	1	10/1/08	2 (RL)	47.75937	-115.61128	riffle	38.0	55.5	1.5	26.0	2.2	120	3.2	
WPC 8-3	1	10/1/08	2 (RR)	47.76001	-115.60983	riffle	26.4	30.8	1.2	22.0	1.7	120	4.5	
WPC 8-3	1	10/1/08	3 (RL)	47.75992	-115.61072	riffle	21.5	40.1	1.9	11.5	2.4	296	13.8	
WPC 8-3	1	10/1/08	3 (RR)	47.75992	-115.61072	riffle	24.6	32.7	1.3	18.5	1.7	296	12.0	
WPC 8-3	1	10/1/08	4 (RL)	47.75965	-115.61098	riffle	20.0	29.0	1.5	13.8	2.1	268	13.4	
WPC 8-3	1	10/1/08	4 (RR)	47.75965	-115.61098	riffle	22.6	24.5	1.1	20.9	1.9	268	11.8	
WPC 8-3	1	10/1/08	5	47.75937	-115.61128	riffle	26.0	31.0	1.2	21.8	1.9	89	3.4	
WPC 8-3	1	10/1/08	5 (RR)	47.75913	-115.61119	riffle	35.0	45.5	1.3	26.9	1.7	89	2.5	
WPC 9-2	1	10/1/08	1	47.75223	-115.56216	riffle	32.5	39.9	1.2	26.6	1.6	238	7.3	
WPC 9-2	1	10/1/08	2	47.75235	-115.56273	riffle	40.3	42.4	1.1	38.4	1.6	65	1.6	
WPC 9-2	1	10/1/08	3	47.75235	-115.56273	riffle	40.3	32.4	1.1	38.4	1.6	105	2.6	
WPC 9-2	1	10/1/08	4	47.75294	-115.56353	riffle	36.7	44.5	1.2	30.3	1.9	240	6.5	
WPC 9-2	1	10/1/08	5	47.75273	-115.56319	riffle	30.4	32.5	1.1	28.4	1.6	248	8.2	
WPC 9-5	1	10/1/08	1	47.75103	-115.51971	riffle	38.1	52.4	1.4	27.8	2.0	25	0.7	
WPC 9-5	1	10/1/08	2	47.75042	-115.51991	pool	51.5	60.7	1.2	44.0	2.0	210	4.1	
WPC 9-5	1	10/1/08	3	47.75037	-115.52094	riffle	30.8	57.3	1.9	16.6	2.5	350	11.4	
WPC 9-5	1	10/1/08	4	47.75041	-115.52145	riffle	31.7	56.1	1.8	17.9	2.3	170	5.4	
WPC 9-5	1	10/1/08	5	47.75078	-115.52244	riffle	36.6	76.3	2.1	17.6	2.4	225	6.1	

Table B5-2. Channel Cross Section Data

Reach ID	Site	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Notes
SWP 18-1	1	10/2/08	1	47.93712	-115.59932	riffle	30.0	54.9	1.8	16.4	3.0	145	4.8	
SWP 18-1	1	10/2/08	2	47.93739	-115.59792	riffle	36.9	51.5	1.4	26.4	2.1	157	4.3	
SWP 18-1	1	10/2/08	3	47.93728	-115.59750	riffle	33.5	63.7	1.9	18.0	3.3	184	5.5	
SWP 18-1	1	10/2/08	4	47.93751	-115.59771	riffle	28.2	46.0	1.6	17.3	2.7	123	4.4	
SWP 18-1	1	10/2/08	5	47.93837	-115.59659	riffle	25.5	43.1	1.7	15.2	2.2	92	3.6	
SWP 20-1	1	9/30/08	1	47.90566	-115.62511	riffle	51.4	75.7	1.5	35.0	2.2	371	7.2	
SWP 20-1	1	9/30/08	2	47.90592	-115.62478	riffle	49.0	38.1	0.8	63.0	1.9	264	5.4	divided channel
SWP 20-1	1	9/30/08	3	no riffle - braided channel (see photos 373 & 374)										no riffle - braided channel - no good place to get slope
SWP 20-1	1	9/30/08	4	47.90598	-115.62401	riffle	47.6	57.1	1.2	39.7	1.5	258	5.4	
SWP 20-1	1	9/30/08	5	47.90634	-115.62401	riffle	42.7	51.4	1.2	35.6	1.6	284	6.7	
SWP 21-1	1	10/2/08	1	47.90189	-115.63107	riffle	47.5	68.7	1.4	33.0	2.4	448	9.4	
SWP 21-1	1	10/2/08	2	47.90191	-115.62992	riffle	28.5	49.3	1.7	16.5	2.4	429	15.0	
SWP 21-1	1	10/2/08	3	47.90212	-115.62946	riffle	70.9	40.3	0.6	124.8	2.0	341	4.8	
SWP 21-1	1	10/2/08	4	47.90253	-115.62930	riffle/ pool	37.7	46.5	1.2	30.7	2.1	418	11.1	very marginal riffle/slow moving water
SWP 21-1	1	10/2/08	5	47.90289	-115.62929	riffle/ pool	40.3	48.0	1.2	33.9	1.2	290	7.2	greater depths include side pool measurements
SWP 22-3	1	10/2/08	1	47.91571	-115.66749	riffle	40.5	116.0	2.9	14.1	3.6	171	4.2	
SWP 22-3	1	10/2/08	2	47.91596	-115.66708	riffle	35.0	75.1	2.1	16.3	2.8	205	5.9	
SWP 22-3	1	10/2/08	3	47.91632	-115.66658	riffle	38.2	79.3	2.1	18.4	2.7	88	2.3	
SWP 22-3	1	10/2/08	4	47.91658	-115.66617	riffle	38.9	49.4	1.3	30.9	1.9	84	2.2	

Table B5-2. Channel Cross Section Data

Reach ID	Site	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Notes
SWP 22-3	1	10/2/08	5	47.91668	-115.66507	riffle	914.0	1.5	47.9	19.1	73.9	82	0.1	
MC 6-2	1	9/30/08	1	47.89019	-115.84001	riffle	35.8	61.5	1.7	20.9	2.4	244	6.8	
MC 6-2	1	9/30/08	2	47.88995	-115.84078	riffle	30.4	52.4	1.7	17.7	2.2	33	1.1	
MC 6-2	1	9/30/08	3	47.88984	-115.84148	riffle	32.6	76.6	2.4	13.9	3.1	192	5.9	
MC 6-2	1	9/30/08	4	47.88963	-115.84235	riffle	29.6	51.5	1.7	17.1	2.4	35	1.2	
MC 6-2	1	9/30/08	5	47.88897	-115.84380	riffle	25.0	54.3	2.2	11.5	2.6	255	10.2	
MC 9-1	1	9/30/08	1	47.89231	-115.81169	riffle	41.7	66.3	1.6	26.4	2.3	167	4.0	
MC 9-1	1	9/30/08	2	47.89244	-115.81255	riffle	73.9	80.6	1.16/ 1.02	67.8	2.1	269	3.6	divided channel
MC 9-1	1	9/30/08	3	47.89202	-115.81318	riffle	35.0	61.8	1.8	19.9	2.1	310	8.9	
MC 9-1	1	9/30/08	4	47.89211	-155.81344	riffle	33.5	57.6	1.7	19.5	2.4	434	12.9	
MC 9-1	1	9/30/08	5	47.89244	-115.81417	riffle	60.4	51.2	0.8	71.3	1.6	460	7.6	
NBMC 8-1	1	10/1/08	1	47.88472	-115.88026	riffle	30.6	41.9	1.4	22.3	1.9	53	1.7	
NBMC 8-1	1	10/1/08	2	47.88522	-115.88061	riffle	20.1	34.9	1.7	11.6	2.2	40	2.0	
NBMC 8-1	1	10/1/08	3	47.88581	-115.88103	riffle	21.2	36.3	1.7	12.4	2.0	27	1.3	
NBMC 8-1	1	10/1/08	4	47.88602	-115.88192	riffle	17.0	39.8	2.3	7.3	39.8	33	1.9	
NBMC 8-1	1	10/1/08	5	47.8866	-115.8823	riffle	18.0	36.3	2.0	9.0	2.5	29	1.6	
SBMC 3-1	1	9/29/08	1	47.87455	-115.89579	riffle	23.8	27.8	1.2	20.2	1.7	36	1.5	Lat/Long from GIS
SBMC 3-1	1	9/29/08	2	47.87411	-115.89632	riffle	26.5	26.5	1.0	27.6	2.3	61	2.3	Lat/Long from GIS
SBMC 3-1	1	9/29/08	3	47.87371	-115.89678	riffle	53.0	55.7	1.1	50.5	1.9	64	1.2	Lat/Long from GIS
SBMC 3-1	1	9/29/08	4	47.87350	-115.89703	riffle	31.5	56.5	1.8	17.6	2.6	58	1.8	Lat/Long from GIS
SBMC 3-1	1	9/29/08	5	47.87334	-115.89748	riffle	22.2	28.6	1.3	17.3	1.7	36	1.6	Lat/Long from GIS

Table B5-3. Riffle Substrate Data

Reach ID	Site	Date	Cell	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index
BULL 3-3	1	9/25/08	1	7.2	25	38	78	NA
BULL 3-3	1	9/25/08	3	2.8	34	72	52	NA
BULL 3-3	1	9/25/08	5	5	33	56	54	NA
BULL 3-2	1	9/25/08	1	66	3	5	8	94
BULL 3-2	1	9/25/08	3	68	1	5	1	NA
BULL 3-2	1	9/25/08	5	46	0	8	2	97
BULL 5-1	1	9/25/08	1	16	16	25	13	NA
BULL 5-1	1	9/25/08	3	30	14	18	6	NA
BULL 5-1	1	9/25/08	5	12	13	28	16	NA
DRY 9-2	1	9/26/08	1	167	1	2	7	NA
DRY 9-2	1	9/26/08	3	119	2	2	1	NA
DRY 9-2	1	9/26/08	5	145	0	1	1	NA
WFELK 8-1	1	9/23/08	1	49	3	7	9	NA
WFELK 8-1	1	9/23/08	3	44	9	15	4	NA
WFELK 8-1	1	9/23/08	5	59	4	11	9	NA
EFELK 9-1	1	9/23/08	1	49	4	7	7	NA
EFELK 9-1	1	9/23/08	3	40	7	9	10	NA
EFELK 9-1	1	9/23/08	5	51	4	5	13	NA
EFELK 8-1	1	9/22/08	1	91	2	5	2	NA
EFELK 8-1	1	9/22/08	3	100	4	6	1	NA
EFELK 8-1	1	9/22/08	5	94	1	3	6	NA
EFELK 7-2	1	9/22/08	1	87	1	3	7	NA
EFELK 7-2	1	9/22/08	3	93	1	6	3	NA
EFELK 7-2	1	9/22/08	5	59	2	5	7	NA
EFELK 10-3	1	9/22/08	1	43	4	5	7	96
EFELK 10-3	1	9/22/08	3	31	8	14	12	96
EFELK 10-3	1	9/22/08	5	47	4	8	4	94
ELK 11-3	1	9/24/08	1	25	5	12	16	99
ELK 11-3	1	9/24/08	3	25	0	5	18	99
ELK 11-3	1	9/24/08	5	36	3	4	2	89
ELK 11-6	1	9/24/08	1	33	5	8	15	83
ELK 11-6	1	9/24/08	3	33	2	4	33	94

Table B5-3. Riffle Substrate Data

Reach ID	Site	Date	Cell	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index
ELK 11-6	1	9/24/08	5	45	5	11	7	NA
WPC 8-3	1	10/1/08	1	69.6	13	15	0	NA
WPC 8-3	1	10/1/08	3	94 (RL); 64 (RR)	1.39 (RL); 8 (RR)	5.56 (RL); 8 (RR)	2	NA
WPC 8-3	1	10/1/08	5	62 (RL)	8	8	2	NA
WPC 9-2	1	10/1/08	1	72	2	2	1	74
WPC 9-2	1	10/1/08	3	39	9	15	1	95
WPC 9-2	1	10/1/08	5	41	9	15	7	NA
WPC 9-5	1	10/1/08	1	35	4	6	1	97
WPC 9-5	1	10/1/08	3	20	10	15	0	NA
WPC 9-5	1	10/1/08	5	43.7	5	9	1	NA
SWP 18-1	1	10/1/08	1	84	2	5	2	NA
SWP 18-1	1	10/1/08	3	100	8	9	0	NA
SWP 18-1	1	10/1/08	5	76	2	7	?	NA
SWP 20-1	1	9/30/08	1	30	10	14	10	NA
SWP 20-1	1	9/30/08	3	42	7	9	1	NA
SWP 20-1	1	9/30/08	5	33	16	19	4	NA
SWP 21-1	1	10/2/08	1	36	10	14	0	NA
SWP 21-1	1	10/2/08	3	45	16	20	1	NA
SWP 21-1	1	10/2/08	5	36	7	8	1	NA
SWP 22-3	1	10/2/08	1	18	20	27	5	NA
SWP 22-3	1	10/2/08	3	44	9	12	3	NA
SWP 22-3	1	10/2/08	5	38	7	7	3	NA
MC 6-2	1	9/30/08	1	50	6	7	5	NA
MC 6-2	1	9/30/08	3	95	6	8	3	NA
MC 6-2	1	9/30/08	5	44	8	10	6	NA
MC 9-1	1	9/30/08	1	35	13	19	7	93
MC 9-1	1	9/30/08	3	78	7	2	2	87
MC 9-1	1	9/30/08	5	76	0	3	1	NA
NBMC 8-1	1	9/29/08	1	73	0	4	3	NA
NBMC 8-1	1	9/29/08	3	100	0	2	0	NA
NBMC 8-1	1	9/29/08	5	62	2	6	3	NA
SBMC 3-1	1	9/29/08	1	44	0	3	10	NA
SBMC 3-1	1	9/29/08	3	49	7	9	1	NA

Table B5-3. Riffle Substrate Data

Reach ID	Site	Date	Cell	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index
SBMC 3-1	1	9/29/08	5	50	3	4	3	NA

Values represent actual field results except in the following circumstances:

RSI is calculated based on the geometric mean of the sample and the cumulative particle size distribution of the nearest riffle pebble count

Table B5-4. Pool and Large Woody Debris Data

Reach ID	Site	Date	Cell	Mean Residual Pool Depth	Number of Pools per 500 Feet	Number of Individual Pieces of LWD per 500 Feet	Number of LWD Aggregates per 500 Feet	Total Number of LWD per 500 Feet	Number of Pools per 1000 Feet	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet
BULL 3-3	1	9/25/08	1-5	3.5	2	2.3	0.5	5.7	4	5	1	11
BULL 3-2	1	9/25/08	1-5	2.8	4	4.5	1.0	9.5	8	9	2	19
BULL 5-1	1	9/25/08	1-5	3.5	1.6	7.3	1.0	11.0	3	15	2	22
DRY 9-2	1	9/26/08	1-5	1.7	4	11.5	6.5	58.0	8	23	13	116
WFELK 8-1	1	9/23/08	1-5	1.3	5	11.5	2.5	21.5	10	23	5	43
EFELK 9-1	1	9/23/08	1-5	1.1	2	4.5	2.5	18.5	4	9	5	37
EFELK 8-1	1	9/22/08	1-5	1.3	1.5	8.5	0.5	10.0	3	17	1	20
EFELK 7-2	1	9/22/08	1-5	1.1	3.5	4.5	3.0	13.0	7	9	6	26
EFELK 10-3	1	9/22/08	1-5	1.0	4.5	19.0	2.0	28.0	9	38	4	56
ELK 11-3	1	9/24/08	1-5	2.7	4.5	8.5	4.0	31.0	9	17	8	62
ELK 11-6	1	9/24/08	1-5	3.2	4.5	4.5	3.0	15.5	9	9	6	31
WPC 8-3	1	10/1/08	1-5	1 (dry bed)	3.0	21.0	0.5	22.0	6	42	1	56
WPC 9-2	1	10/1/08	1-5	1.5	6.0	3.5	2.5	15.0	12	7	5	33
WPC 9-5	1	10/1/08	1-5	1.7	4.0	12.0	5.0	22.0	8	24	10	57
SWP 18-1	1	10/1/08	1-5	0.6	6.5	5.5	1.0	8.5	13	11	2	20
SWP 20-1	1	9/30/08	1-5	1.7	7.0	4.5	2.0	18.5	14	9	4	71
SWP 21-1	1	10/2/08	1-5	1.8	5.5	4.0	4.0	15.0	11	8	8	48
SWP 22-3	1	10/2/08	1-5	1.33 (dry bed)	5.5	9.5	2.0	11.5	11	19	4	40
MC 6-2	1	9/30/08	1-5	1.5	3.0	11.0	2.5	11.5	6	22	5	26
MC 9-1	1	9/30/08	1-5	1.4	4.0	4.5	1.0	7.5	8	9	2	20

Table B5-4. Pool and Large Woody Debris Data

Reach ID	Site	Date	Cell	Mean Residual Pool Depth	Number of Pools per 500 Feet	Number of Individual Pieces of LWD per 500 Feet	Number of LWD Aggregates per 500 Feet	Total Number of LWD per 500 Feet	Number of Pools per 1000 Feet	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet
NBMC 8-1	1	9/29/08	1-5	1.0	8.0	4.0	3.0	14.5	16	8	6	30
SBMC 3-1	1	9/29/08	1-5	1.3	14.0	22.5	8.5	74.5	28	45	17	149

Table B5-5. Fine Sediment in Pool Tail-outs

Reach ID	Site	Date	Cell	Pool Grid Toss Percent <6mm
WPC 9-2	1	10/1/08	1	4
WPC 9-2	1	10/1/08	1	5
WPC 9-2	1	10/1/08	2	8
WPC 9-2	1	10/1/08	2	0
WPC 9-2	1	10/1/08	3	10
WPC 9-2	1	10/1/08	3	12
WPC 9-2	1	10/1/08	4	16
WPC 9-2	1	10/1/08	4	20
WPC 9-5	1	10/1/08	1	10
WPC 9-5	1	10/1/08	1	38
WPC 9-5	1	10/1/08	2	7
WPC 9-5	1	10/1/08	2	4
WPC 9-5	1	10/1/08	4	6
WPC 9-5	1	10/1/08	5	26
WPC 9-5	1	10/1/08	5	31
WPC 8-3	1	10/1/08	1	1
WPC 8-3	1	10/1/08	2	3
WPC 8-3	1	10/1/08	2	10
WPC 8-3	1	10/1/08	4	3
WPC 8-3	1	10/1/08	5	?
WPC 8-3	1	10/1/08	5	4
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	3	0
SWP 18-1	1	10/1/08	3	0
SWP 18-1	1	10/1/08	4	11
SWP 18-1	1	10/1/08	4	0
SWP 18-1	1	10/1/08	4	0
SWP 18-1	1	10/1/08	5	0
SWP 18-1	1	10/1/08	5	0
SWP 21-1	1	10/2/08	1	12
SWP 21-1	1	10/2/08	1	1
SWP 21-1	1	10/2/08	3	2
SWP 21-1	1	10/2/08	3	10
SWP 21-1	1	10/2/08	4	6
SWP 21-1	1	10/2/08	4	15
SWP 21-1	1	10/2/08	5	5
SWP 20-1	1	9/30/08	1	71
SWP 20-1	1	9/30/08	1	12
SWP 20-1	1	9/30/08	2	8
SWP 20-1	1	9/30/08	2	1
BULL 3-3	1	9/25/08	2	8
BULL 3-3	1	9/25/08	2	32
BULL 3-3	1	9/25/08	4	37
BULL 3-3	1	9/25/08	4	6

Table B5-5. Fine Sediment in Pool Tail-outs

Reach ID	Site	Date	Cell	Pool Grid Toss Percent <6mm
BULL 3-3	1	9/25/08	5	0
BULL 3-2	1	9/25/08	1	0
BULL 3-2	1	9/25/08	2	10
BULL 3-2	1	9/25/08	3	3
BULL 3-2	1	9/25/08	4	5
BULL 3-2	1	9/25/08	4	7
BULL 3-2	1	9/25/08	5	9
BULL 3-2	1	9/25/08	5	5
BULL 5-1	1	9/25/08	1	51
BULL 5-1	1	9/25/08	3	13
BULL 5-1	1	9/25/08	4	14
DRY 9-2	1	9/26/08	1	0
DRY 9-2	1	9/26/08	2	0
DRY 9-2	1	9/26/08	2	0
DRY 9-2	1	9/26/08	3	0
DRY 9-2	1	9/26/08	3	0
DRY 9-2	1	9/26/08	4	8
DRY 9-2	1	9/26/08	5	8
WFELK 8-1	1	9/23/08	1	16
WFELK 8-1	1	9/23/08	2	11
WFELK 8-1	1	9/23/08	2	5
WFELK 8-1	1	9/23/08	3	18
WFELK 8-1	1	9/23/08	4	8
WFELK 8-1	1	9/23/08	4	18
WFELK 8-1	1	9/23/08	5	13
WFELK 8-1	1	9/23/08	5	27
EFELK 9-1	1	9/23/08	1	14
EFELK 9-1	1	9/23/08	2	10
EFELK 9-1	1	9/23/08	4	27
EFELK 8-1	1	9/22/08	1	22
EFELK 8-1	1	9/22/08	4	24
EFELK 7-2	1	9/22/08	1	40
EFELK 7-2	1	9/22/08	1	13
EFELK 7-2	1	9/22/08	5	21
EFELK 10-3	1	9/22/08	1	13
EFELK 10-3	1	9/22/08	1	13
EFELK 10-3	1	9/22/08	2	5
EFELK 10-3	1	9/22/08	2	5
EFELK 10-3	1	9/22/08	3	10
EFELK 10-3	1	9/22/08	4	16
EFELK 10-3	1	9/22/08	5	3
ELK 11-3	1	9/24/08	1	3
ELK 11-3	1	9/24/08	2	4
ELK 11-3	1	9/24/08	2	5
ELK 11-3	1	9/24/08	3	6
ELK 11-3	1	9/24/08	3	6
ELK 11-3	1	9/24/08	4	29

Table B5-5. Fine Sediment in Pool Tail-outs

Reach ID	Site	Date	Cell	Pool Grid Toss Percent <6mm
ELK 11-3	1	9/24/08	4	3
ELK 11-3	1	9/24/08	5	3
ELK 11-6	1	9/24/08	1	1
ELK 11-6	1	9/24/08	1	4
ELK 11-6	1	9/24/08	2	1
ELK 11-6	1	9/24/08	2	6
ELK 11-6	1	9/24/08	3	2
ELK 11-6	1	9/24/08	3	7
ELK 11-6	1	9/24/08	4	7
ELK 11-6	1	9/24/08	4	4
ELK 11-6	1	9/24/08	5	2
WPC 8-3	1	10/1/08	1	1
WPC 8-3	1	10/1/08	2	3
WPC 8-3	1	10/1/08	2	10
WPC 8-3	1	10/1/08	4	3
WPC 8-3	1	10/1/08	5	?
WPC 8-3	1	10/1/08	5	4
WPC 9-2	1	10/1/08	1	4
WPC 9-2	1	10/1/08	1	5
WPC 9-2	1	10/1/08	2	8
WPC 9-2	1	10/1/08	2	0
WPC 9-2	1	10/1/08	3	10
WPC 9-2	1	10/1/08	3	12
WPC 9-2	1	10/1/08	4	16
WPC 9-2	1	10/1/08	4	20
WPC 9-5	1	10/1/08	1	10
WPC 9-5	1	10/1/08	1	38
WPC 9-5	1	10/1/08	2	7
WPC 9-5	1	10/1/08	2	4
WPC 9-5	1	10/1/08	4	6
WPC 9-5	1	10/1/08	5	26
WPC 9-5	1	10/1/08	5	31
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	1	0
SWP 18-1	1	10/1/08	3	0
SWP 18-1	1	10/1/08	3	0
SWP 18-1	1	10/1/08	4	11
SWP 18-1	1	10/1/08	4	0
SWP 18-1	1	10/1/08	4	0
SWP 18-1	1	10/1/08	5	0
SWP 18-1	1	10/1/08	5	0
SWP 20-1	1	9/30/08	1	71
SWP 20-1	1	9/30/08	1	12
SWP 20-1	1	9/30/08	2	8
SWP 20-1	1	9/30/08	2	1
SWP 20-1	1	9/30/08	3	0

Table B5-5. Fine Sediment in Pool Tail-outs

Reach ID	Site	Date	Cell	Pool Grid Toss Percent <6mm
SWP 20-1	1	9/30/08	3	18
SWP 20-1	1	9/30/08	4	11
SWP 20-1	1	9/30/08	4	3
SWP 20-1	1	9/30/08	5	4
SWP 21-1	1	10/2/08	1	12
SWP 21-1	1	10/2/08	1	1
SWP 21-1	1	10/2/08	3	2
SWP 21-1	1	10/2/08	3	10
SWP 21-1	1	10/2/08	4	6
SWP 21-1	1	10/2/08	4	15
SWP 21-1	1	10/2/08	5	5
SWP 22-3	1	10/2/08	1	4
SWP 22-3	1	10/2/08	2	6
SWP 22-3	1	10/2/08	2	21
SWP 22-3	1	10/2/08	3	10
SWP 22-3	1	10/2/08	3	23
SWP 22-3	1	10/2/08	4	17
SWP 22-3	1	10/2/08	4	5
SWP 22-3	1	10/2/08	5	9
SWP 22-3	1	10/2/08	5	0
MC 6-2	1	9/30/08	2	15
MC 6-2	1	9/30/08	3	5
MC 6-2	1	9/30/08	4	10.96
MC 6-2	1	9/30/08	5	7
MC 6-2	1	9/30/08	5	8
MC 9-1	1	9/30/08	1	10
MC 9-1	1	9/30/08	2	3
MC 9-1	1	9/30/08	2	0
MC 9-1	1	9/30/08	3	20
MC 9-1	1	9/30/08	3	0
MC 9-1	1	9/30/08	4	37
MC 9-1	1	9/30/08	4	0
MC 9-1	1	9/30/08	5	0
NBMC 8-1	1	9/29/08	1	2
NBMC 8-1	1	9/29/08	1	3
NBMC 8-1	1	9/29/08	2	0
NBMC 8-1	1	9/29/08	2	4
NBMC 8-1	1	9/29/08	3	0
NBMC 8-1	1	9/29/08	3	2
NBMC 8-1	1	9/29/08	4	0
NBMC 8-1	1	9/29/08	4	0
NBMC 8-1	1	9/29/08	5	1
NBMC 8-1	1	9/29/08	5	3
SBMC 3-1	1	9/29/08	1	8
SBMC 3-1	1	9/29/08	1	3
SBMC 3-1	1	9/29/08	2	6
SBMC 3-1	1	9/29/08	2	5

Table B5-5. Fine Sediment in Pool Tail-outs

Reach ID	Site	Date	Cell	Pool Grid Toss Percent <6mm
SBMC 3-1	1	9/29/08	3	16
SBMC 3-1	1	9/29/08	3	30
SBMC 3-1	1	9/29/08	4	0
SBMC 3-1	1	9/29/08	5	9
SBMC 3-1	1	9/29/08	5	3

Pool grid toss percent fines <6mm is the average of 3 grid tosses

Table B5-6. Riparian Greenline Data

Reach ID	Site	Date	Cell	Percent Understory Shrub Cover	Percent Bare/ Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
BULL 3-3	1	9/25/08	1	75	3	0	18	19	>100
BULL 3-3	1	9/25/08	2	63	20	0	3	75	>100
BULL 3-3	1	9/25/08	3	58	23	0	0	>100	>100
BULL 3-3	1	9/25/08	4	60	23	0	13	>100	>100
BULL 3-3	1	9/25/08	5	58	13	0	0	>100	>100
BULL 3-2	1	9/25/08	1	73	0	0	38	27.5	>100
BULL 3-2	1	9/25/08	2	60	0	0	15	81.25	>100
BULL 3-2	1	9/25/08	3	63	0	0	28	>100	>100
BULL 3-2	1	9/25/08	4	88	0	0	20	>100	>100
BULL 3-2	1	9/25/08	5	88	0	0	60	>100	>100
BULL 5-1	1	9/25/08	1	18	0	0	8	>100	>100
BULL 5-1	1	9/25/08	2	35	0	0	28	>100	>100
BULL 5-1	1	9/25/08	3	18	0	0	3	>100	>100
BULL 5-1	1	9/25/08	4	15	0	0	0	>100	>100
BULL 5-1	1	9/25/08	5	15	0	0	0	>100	>100
DRY 9-2	1	9/26/08	1	68	0	0	85	>100	35
DRY 9-2	1	9/26/08	2	40	0	0	78	>100	>100
DRY 9-2	1	9/26/08	3	28	0	0	78	>100	>100
DRY 9-2	1	9/26/08	4	48	0	0	88	>100	>100
DRY 9-2	1	9/26/08	5	58	0	0	83	>100	>100
WFELK 8-1	1	9/23/08	1	90	0	0	95	>100	>100
WFELK 8-1	1	9/23/08	2	30	0	0	68	>100	>100
WFELK 8-1	1	9/23/08	3	53	0	0	55	>100	>100
WFELK 8-1	1	9/23/08	4	73	0	0	63	>100	>100
WFELK 8-1	1	9/23/08	5	34	0	0	73	>100	>100
EFELK 9-1	1	9/23/08	1	100	0	0	45	>100	>100
EFELK 9-1	1	9/23/08	2	80	0	0	28	>100	>100
EFELK 9-1	1	9/23/08	3	88	0	0	75	>100	>100
EFELK 9-1	1	9/23/08	4	100	0	0	40	>100	>100

Table B5-6. Riparian Greenline Data

Reach ID	Site	Date	Cell	Percent Understory Shrub Cover	Percent Bare/ Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
EFELK 9-1	1	9/23/08	5	98	0	0	38	>100	>100
EFELK 8-1	1	9/22/08	1	98	0	0	63	>100	>100
EFELK 8-1	1	9/22/08	2	95	0	0	35	>100	>100
EFELK 8-1	1	9/22/08	3	100	0	0	58	>100	18.75
EFELK 8-1	1	9/22/08	4	100	0	0	75	>100	17.5
EFELK 8-1	1	9/22/08	5	95	0	0	70	>100	60
EFELK 7-2	1	9/22/08	1	88	0	0	58	>100	51.25
EFELK 7-2	1	9/22/08	2	88	0	0	50	>100	>100
EFELK 7-2	1	9/22/08	3	100	0	0	60	?	?
EFELK 7-2	1	9/22/08	4	98	0	0	45	?	?
EFELK 7-2	1	9/22/08	5	93	0	0	63	>100	>100
EFELK 10-3	1	9/22/08	1	75	0	0	35	33	41
EFELK 10-3	1	9/22/08	2	85	0	0	33	45	55
EFELK 10-3	1	9/22/08	3	65	0	0	25	33	83
EFELK 10-3	1	9/22/08	4	63	0	0	33	35	22
EFELK 10-3	1	9/22/08	5	68	0	0	8	24	28
ELK 11-3	1	9/24/08	1	28	0	0	8	>100	35
ELK 11-3	1	9/24/08	2	30	8	0	8	>100	20
ELK 11-3	1	9/24/08	3	73	0	0	30	>100	25
ELK 11-3	1	9/24/08	4	85	0	0	35	>100	29
ELK 11-3	1	9/24/08	5	53	8	0	23	>100	13
ELK 11-6	1	9/24/08	1	43	0	0	3	>100	>100
ELK 11-6	1	9/24/08	2	23	8	23	3	>100	>100
ELK 11-6	1	9/24/08	3	38	0	0	13	>100	>100
ELK 11-6	1	9/24/08	4	60	0	0	45	>100	>100
ELK 11-6	1	9/24/08	5	28	20	0	23	10	>100
WPC 8-3	1	10/1/08	1	43	0	0	25	>100	90
WPC 8-3	1	10/1/08	2	58	0	0	15	95	60
WPC 8-3	1	10/1/08	3	78	0	0	20	>100	35
WPC 8-3	1	10/1/08	4	68	0	0	20	65	19

Table B5-6. Riparian Greenline Data

Reach ID	Site	Date	Cell	Percent Understory Shrub Cover	Percent Bare/ Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
WPC 8-3	1	10/1/08	5	58	0	0	53	60	>100
WPC 9-2	1	10/1/08	1	75	0	0	3	>100	>100
WPC 9-2	1	10/1/08	2	45	0	0	5	>100	>100
WPC 9-2	1	10/1/08	3	60	0	0	3	>100	>100
WPC 9-2	1	10/1/08	4	45	0	0	5	>100	>100
WPC 9-2	1	10/1/08	5	40	0	0	0	>100	>100
WPC 9-5	1	10/1/08	1	40	10	0	10	>100	>100
WPC 9-5	1	10/1/08	2	40	10	0	10	>100	>100
WPC 9-5	1	10/1/08	3	73	0	0	55	>100	>100
WPC 9-5	1	10/1/08	4	55	0	0	23	>100	>100
WPC 9-5	1	10/1/08	5	75	8	0	33	>100	>100
SWP 18-1	1	10/1/08	1	62	0	0	15	>100	>100
SWP 18-1	1	10/1/08	2	89	0	0	27	>100	85
SWP 18-1	1	10/1/08	3	86	0	0	32	>100	76
SWP 18-1	1	10/1/08	4	89	0	0	50	>100	35
SWP 18-1	1	10/1/08	5	83	0	0	63	>100	>100
SWP 20-1	1	9/30/08	1	78	0	0	13	>100	>100
SWP 20-1	1	9/30/08	2	65	0	0	8	>100	>100
SWP 20-1	1	9/30/08	3	48	0	0	8	>100	>100
SWP 20-1	1	9/30/08	4	75	0	0	13	>100	>100
SWP 20-1	1	9/30/08	5	95	0	0	20	>100	>100
SWP 21-1	1	10/2/08	1	78	0	0	30	>100	>100
SWP 21-1	1	10/2/08	2	63	0	0	18	>100	>100
SWP 21-1	1	10/2/08	3	45	0	0	13	>100	>100
SWP 21-1	1	10/2/08	4	18	0	5	0	>100	>100
SWP 21-1	1	10/2/08	5	50	0	0	8	>100	>100
SWP 22-3	1	10/2/08	1	53	0	0	23	>100	67.5
SWP 22-3	1	10/2/08	2	55	0	0	10	>100	>100
SWP 22-3	1	10/2/08	3	53	0	0	5	41.25	>100
SWP 22-3	1	10/2/08	4	33	0	0	13	5	>100

Table B5-6. Riparian Greenline Data

Reach ID	Site	Date	Cell	Percent Understory Shrub Cover	Percent Bare/ Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
SWP 22-3	1	10/2/08	5	50	0	0	18	62.5	>100
MC 6-2	1	9/30/08	1	100	0	0	50	20	>100
MC 6-2	1	9/30/08	2	95	0	0	60	18	>100
MC 6-2	1	9/30/08	3	90	0	0	65	19	>100
MC 6-2	1	9/30/08	4	98	0	0	60	15	>100
MC 6-2	1	9/30/08	5	85	0	0	58	56	>100
MC 9-1	1	9/30/08	1	85	0	0	10	>100	>100
MC 9-1	1	9/30/08	2	100	0	0	10	>100	>100
MC 9-1	1	9/30/08	3	75	0	0	25	88	>100
MC 9-1	1	9/30/08	4	100	0	0	25	90	>100
MC 9-1	1	9/30/08	5	98	0	0	18	>100	>100
NBMC 8-1	1	9/29/08	1	100	0	0	38	58	>100
NBMC 8-1	1	9/29/08	2	100	0	0	40	50	>100
NBMC 8-1	1	9/29/08	3	90	0	0	38	>100	>100
NBMC 8-1	1	9/29/08	4	78	0	3	45	40	>100
NBMC 8-1	1	9/29/08	5	80	0	18	28	55	>100
SBMC 3-1	1	9/29/08	1	98	0	0	75	15	50
SBMC 3-1	1	9/29/08	2	90	0	0	68	15	50
SBMC 3-1	1	9/29/08	3	93	0	0	58	15	50
SBMC 3-1	1	9/29/08	4	73	0	0	63	15	50
SBMC 3-1	1	9/29/08	5	85	0	0	50	15	50

All greenline measurements are averaged by cell

Table B5-7. Bank Erosion Hazard Index (BEHI) Data

Stream	Ecoregion	Reach ID	Reach Type	Bankfull Width	Estimated Potential Stream Type	Site	Date	Cell	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)	Reach Transporation Load (Tons/Year)	Transporation Load (Percent)	Reach Riparian Grazing Load (Tons/Year)	Riparian Grazing Load (Percent)	Reach Cropland Load (Tons/Year)	Cropland Load (Percent)	Reach Mining Load (Tons/Year)	Mining Load (Percent)	Reach Silviculture Load (Tons/Year)	Silviculture Load (Percent)	Reach Irrigation Load (Tons/Year)	Irrigation Load (Percent)	Reach Natural Load (Tons/Year)	Natural Load (Percent)	Reach "Other" Load (Tons/Year)	"Other" Load (Percent)
Bull	15q	BULL 3-2	3-U-0	61.5	3b	1	9/25/08	1-5	Actively/ Visually Eroding	36.9	84	4.2	11.7	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.1	70.0	35.2	30.0
Bull	15q	BULL 3-2	3-U-0	61.5	3b	1	9/25/08	1-5	Slowly Eroding/ Undercut/ Vegetated	27.8	152	7.6	8.9	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	93.8	0.2	6.2
Bull	15q	BULL 3-2	3-U-0	61.5	3b	1	9/25/08	1-5	Total		236	11.8	20.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.9	70.8	35.4	29.2
Bull	15q	BULL 3-3	3-U-0	61.3	3b	1	9/25/08	1-5	Actively/ Visually Eroding	35.6	661	22.0	104.3	69.5	6.2	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.1	94.1	0.0	0.0
Bull	15q	BULL 3-3	3-U-0	61.3	3b	1	9/25/08	1-5	Slowly Eroding/ Undercut/ Vegetated	36.6	93	3.1	5.5	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	100.0	0.0	0.0
Bull	15q	BULL 3-3	3-U-0	61.3	3b	1	9/25/08	1-5	Total		754	25.1	109.8	73.2	6.2	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	111.3	94.8	0.0	0.0
Bull	15q	BULL 5-1	3-U-0	62.7	3d	1	9/25/08	1-5	Actively/ Visually Eroding	32.3	280	9.3	16.2	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	100.0	0.0	0.0
Bull	15q	BULL 5-1	3-U-0	62.7	3d	1	9/25/08	1-5	Slowly Eroding/ Undercut/ Vegetated	27.5	423	14.1	27.1	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6	98.7	0.3	1.3
Bull	15q	BULL 5-1	3-U-0	62.7	3d	1	9/25/08	1-5	Total		703	23.4	43.2	28.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.9	99.1	0.3	0.9
Dry	15q	DRY 9-2	2-U-0	36	2a	1	9/26/08	1-5	Actively/ Visually Eroding	13.2	126	6.3	4.3	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	40.0	0.0	0.0	2.6	60.0	0.0	0.0
Dry	15q	DRY 9-2	2-U-0	36	2a	1	9/26/08	1-5	Slowly Eroding/ Undercut/ Vegetated	15.7	208	10.4	8.1	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	40.0	0.0	0.0	4.9	60.0	0.0	0.0
Dry	15q	DRY 9-2	2-U-0	36	2a	1	9/26/08	1-5	Total		334	16.7	12.4	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	40.0	0.0	0.0	7.4	60.0	0.0	0.0
Elk	15k	EFELK 10-3	3-U-0	36.7	3a	1	9/24/08	1-5	Total		154	7.7	5.9	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	72.9	1.6	27.1
Elk	15k	EFELK 10-3	3-U-0	36.7	3a	1	9/24/08	1-5	Actively/ Visually Eroding	37.8	20	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	70.0	0.2	30.0
Elk	15k	EFELK 10-3	3-U-0	36.7	3a	1	9/24/08	1-5	Slowly Eroding/ Undercut/ Vegetated	31.7	134	6.7	5.2	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	73.3	1.4	26.7
Elk	15k	EFELK 7-2	2-U-4	28.5	2a	1	9/22/08	1-5	Total		90	4.5	3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	100.0	0.0	0.0
Elk	15k	EFELK 7-2	2-U-4	28.5	2a	1	9/22/08	1-5	Actively/ Visually Eroding	31.8	49	2.5	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	100.0	0.0	0.0
Elk	15k	EFELK 7-2	2-U-4	28.5	2a	1	9/22/08	1-5	Slowly Eroding/ Undercut/ Vegetated	22.1	41	2.1	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	100.0	0.0	0.0

Table B5-7. Bank Erosion Hazard Index (BEHI) Data

Stream	Ecoregion	Reach ID	Reach Type	Bankfull Width	Estimated Potential Stream Type	Site	Date	Cell	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)	Reach Transporation Load (Tons/Year)	Transporation Load (Percent)	Reach Riparian Grazing Load (Tons/Year)	Riparian Grazing Load (Percent)	Reach Cropland Load (Tons/Year)	Cropland Load (Percent)	Reach Mining Load (Tons/Year)	Mining Load (Percent)	Reach Silviculture Load (Tons/Year)	Silviculture Load (Percent)	Reach Irrigation Load (Tons/Year)	Irrigation Load (Percent)	Reach Natural Load (Tons/Year)	Natural Load (Percent)	Reach "Other" Load (Tons/Year)	"Other" Load (Percent)
Elk	15k	EFELK 8-1	2-U-2	24.8	2a	1	9/22/08	1-5	Total		216	10.8	9.9	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	100.0	0.0	0.0
Elk	15k	EFELK 8-1	2-U-2	24.8	2a	1	9/22/08	1-5	Actively/ Visually Eroding	23.6	104	5.2	5.4	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	100.0	0.0	0.0
Elk	15k	EFELK 8-1	2-U-2	24.8	2a	1	9/22/08	1-5	Slowly Eroding/ Undercut/ Vegetated	32.7	112	5.6	4.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	100.0	0.0	0.0
Elk	15k	EFELK 9-1	2-U-0	27.5	2a	1	9/23/08	1-5	Total		159	8.0	6.4	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	90.5	0.6	9.5
Elk	15k	EFELK 9-1	2-U-0	27.5	2a	1	9/23/08	1-5	Actively/ Visually Eroding	32.4	102	5.1	4.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	86.6	0.6	13.4
Elk	15k	EFELK 9-1	2-U-0	27.5	2a	1	9/23/08	1-5	Slowly Eroding/ Undercut/ Vegetated	28.4	57	2.9	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	100.0	0.0	0.0
Elk	15k	ELK 11-3	4-U-0	43.8	4a	1	9/24/08	1-5	Actively/ Visually Eroding	40.6	130	6.5	6.8	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	70.0	2.1	30.0
Elk	15k	ELK 11-3	4-U-0	43.8	4a	1	9/24/08	1-5	Slowly Eroding/ Undercut/ Vegetated	37.2	142	7.1	9.8	9.8	0.0	0.0	1.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	62.3	2.8	28.9
Elk	15k	ELK 11-3	4-U-0	43.8	4a	1	9/24/08	1-5	Total		272	13.6	16.6	16.6	0.0	0.0	1.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	65.5	4.9	29.4
Elk	15k	ELK 11-6	4-U-0	39.4	4a	1	9/24/08	1-5	Actively/ Visually Eroding	33.9	372	18.6	19.9	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.9	70.0	6.0	30.0
Elk	15k	ELK 11-6	4-U-0	39.4	4a	1	9/24/08	1-5	Slowly Eroding/ Undercut/ Vegetated	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elk	15k	ELK 11-6	4-U-0	39.4	4a	1	9/24/08	1-5	Total		372	18.6	19.9	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.9	70.0	6.0	30.0
Marten	15o	MC 6-2	3-U-2	30.7	3a	1	9/30/08	1-5	Total		458	22.9	40.2	40.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.2	100.0	0.0	0.0
Marten	15o	MC 6-2	3-U-2	30.7	3a	1	9/30/08	1-5	Actively/ Visually Eroding	28.1	324	16.2	33.5	33.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.5	100.0	0.0	0.0
Marten	15o	MC 6-2	3-U-2	30.7	3a	1	9/30/08	1-5	Slowly Eroding/ Undercut/ Vegetated	26.8	134	6.7	6.8	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	100.0	0.0	0.0
Marten	15k	MC 9-1	3-U-0	48.9	3b	1	9/30/08	1-5	Total		361	18.1	11.9	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	100.0	0.0	0.0
Marten	15k	MC 9-1	3-U-0	48.9	3b	1	9/30/08	1-5	Actively/ Visually Eroding	25.4	265	13.3	8.1	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	100.0	0.0	0.0
Marten	15k	MC 9-1	3-U-0	48.9	3b	1	9/30/08	1-5	Slowly Eroding/ Undercut/ Vegetated	36.4	96	4.8	3.7	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	100.0	0.0	0.0
Marten	15o	NBMC 8-1	2-U-4	21.4	2a	1	9/29/08	1-5	Total		415	20.8	35.1	35.1	2.4	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.4	92.3	0.3	0.9

Table B5-7. Bank Erosion Hazard Index (BEHI) Data

Stream	Ecoregion	Reach ID	Reach Type	Bankfull Width	Estimated Potential Stream Type	Site	Date	Cell	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)	Reach Transporation Load (Tons/Year)	Transporation Load (Percent)	Reach Riparian Grazing Load (Tons/Year)	Riparian Grazing Load (Percent)	Reach Cropland Load (Tons/Year)	Cropland Load (Percent)	Reach Mining Load (Tons/Year)	Mining Load (Percent)	Reach Silviculture Load (Tons/Year)	Silviculture Load (Percent)	Reach Irrigation Load (Tons/Year)	Irrigation Load (Percent)	Reach Natural Load (Tons/Year)	Natural Load (Percent)	Reach "Other" Load (Tons/Year)	"Other" Load (Percent)
Marten	15o	NBMC 8-1	2-U-4	21.4	2a	1	9/29/08	1-5	Actively/ Visually Eroding	27.6	367	18.4	33.2	33.2	2.4	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	91.8	0.3	0.9
Marten	15o	NBMC 8-1	2-U-4	21.4	2a	1	9/29/08	1-5	Slowly Eroding/ Undercut/ Vegetated	35.9	48	2.4	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	100.0	0.0	0.0
Marten	15o	SBMC 3-1	2-C-4	31.4	2a	1	9/29/08	1-5	Total		241	12.1	7.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	100.0	0.0	0.0
Marten	15o	SBMC 3-1	2-C-4	31.4	2a	1	9/29/08	1-5	Actively/ Visually Eroding	32.7	170	8.5	6.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	100.0	0.0	0.0
Marten	15o	SBMC 3-1	2-C-4	31.4	2a	1	9/29/08	1-5	Slowly Eroding/ Undercut/ Vegetated	29.3	71	3.6	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	100.0	0.0	0.0
Swamp	15q	SWP 18-1	2-U-2	33.5	2a	1	10/1/08	1-5	Actively/ Visually Eroding	21.2	118	5.9	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	100.0	0.0	0.0
Swamp	15q	SWP 18-1	2-U-2	33.5	2a	1	10/1/08	1-5	Slowly Eroding/ Undercut/ Vegetated	18.6	55	2.8	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	100.0	0.0	0.0
Swamp	15q	SWP 18-1	2-U-2	33.5	2a	1	10/1/08	1-5	Total		173	8.7	4.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	100.0	0.0	0.0
Swamp	15q	SWP 20-1	3-U-0	47.7	3a	1	9/30/08	1-5	Actively/ Visually Eroding	34.0	245	12.3	17.1	17.1	0.0	0.0	17.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15q	SWP 20-1	3-U-0	47.7	3a	1	9/30/08	1-5	Slowly Eroding/ Undercut/ Vegetated	29.3	38	1.9	0.6	0.6	0.0	0.0	0.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15q	SWP 20-1	3-U-0	47.7	3a	1	9/30/08	1-5	Total		283	14.2	17.7	17.7	0.0	0.0	17.7	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15k	SWP 21-1	3-U-0	45	3a	0	10/2/08	1-5	Total		527	26.4	14.6	14.6	0.0	0.0	14.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15k	SWP 21-1	3-U-0	45	3a	1	10/2/08	1-5	Actively/ Visually Eroding	34.2	311	15.6	12.4	12.4	0.0	0.0	12.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15k	SWP 21-1	3-U-0	45	3a	0	10/2/08	1-5	Slowly Eroding/ Undercut/ Vegetated	21.9	216	10.8	2.2	2.2	0.0	0.0	2.2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp	15q	SWP 22-3	3-U-0	40.1	3a	1	10/2/08	1-5	Actively/ Visually Eroding	26.2	200	10.0	4.6	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	88.9	0.5	11.1
Swamp	15q	SWP 22-3	3-U-0	40.1	3a	1	10/2/08	1-5	Slowly Eroding/ Undercut/ Vegetated	30.1	380	19.0	9.7	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	100.0	0.0	0.0
Swamp	15q	SWP 22-3	3-U-0	40.1	3a	1	10/2/08	1-5	Total		580	29.0	14.3	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	96.4	0.5	3.6
Elk	15o	WFELK 8-1	2-U-0	20.3	2a	1	9/23/08	1-5	Actively/ Visually Eroding	13.6	130	6.5	6.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	100.0	0.0	0.0

Table B5-7. Bank Erosion Hazard Index (BEHI) Data

Stream	Ecoregion	Reach ID	Reach Type	Bankfull Width	Estimated Potential Stream Type	Site	Date	Cell	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)	Reach Transporation Load (Tons/Year)	Transporation Load (Percent)	Reach Riparian Grazing Load (Tons/Year)	Riparian Grazing Load (Percent)	Reach Cropland Load (Tons/Year)	Cropland Load (Percent)	Reach Mining Load (Tons/Year)	Mining Load (Percent)	Reach Silviculture Load (Tons/Year)	Silviculture Load (Percent)	Reach Irrigation Load (Tons/Year)	Irrigation Load (Percent)	Reach Natural Load (Tons/Year)	Natural Load (Percent)	Reach "Other" Load (Tons/Year)	"Other" Load (Percent)
Elk	15o	WFELK 8-1	2-U-0	20.3	2a	1	9/23/08	1-5	Slowly Eroding/ Undercut/ Vegetated	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elk	15o	WFELK 8-1	2-U-0	20.3	2a	1	9/23/08	1-5	Total		130	6.5	6.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	100.0	0.0	0.0
White Pine	15k	WPC 8-3	2-U-2	31.9	2a	1	10/1/08	1-5	Total		821	41.1	13.5	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	100.0	0.0	0.0
White Pine	15k	WPC 8-3	2-U-2	31.9	2a	1	10/1/08	1-5	Actively/ Visually Eroding	17.9	747	37.4	11.4	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	100.0	0.0	0.0
White Pine	15k	WPC 8-3	2-U-2	31.9	2a	1	10/1/08	1-5	Slowly Eroding/ Undercut/ Vegetated	31.3	74	3.7	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	100.0	0.0	0.0
White Pine	15k	WPC 9-2	2-U-0	35.3	2a	1	10/1/08	1-5	Total		711	35.6	42.6	42.6	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.4	99.5	0.0	0.0
White Pine	15k	WPC 9-2	2-U-0	35.3	2a	1	10/1/08	1-5	Actively/ Visually Eroding	37.3	711	35.6	42.6	42.6	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.4	99.5	0.0	0.0
White Pine	15k	WPC 9-2	2-U-0	35.3	2a	1	10/1/08	1-5	Slowly Eroding/ Undercut/ Vegetated	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Pine	15k	WPC 9-5	2-U-0	37.7	2a	1	10/1/08	1-5	Total		384	19.2	14.9	14.9	0.0	0.0	0.1	0.7	14.1	94.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.5	0.0	0.0
White Pine	15k	WPC 9-5	2-U-0	37.7	2a	1	10/1/08	1-5	Actively/ Visually Eroding	35.5	215	10.8	9.5	9.5	0.0	0.0	0.1	1.1	8.8	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.7	7.1	0.0	0.0
White Pine	15k	WPC 9-5	2-U-0	37.7	2a	1	10/1/08	1-5	Slowly Eroding/ Undercut/ Vegetated	31.5	169	8.5	5.3	5.3	0.0	0.0	0.0	0.0	5.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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APPENDIX C - LOWER CLARK FORK TRIBUTARIES STRATIFICATION TABLES

Stratification Results

GNIS Name	Reach ID	primary eco	Gradient	Stream order	confinement	LB anthro influence	LB riparian vegetation	LB rip health	RB anthro influence	RB riparian veg	RB ripar health	length ft
Bull River	BULL 1-1	15q	2% to <4%	3	unconfined	no	mature coniferous	good	no	mature deciduous	good	789
Bull River	BULL 2-1	15q	<2%	3	unconfined	no	mature coniferous	good	no	mature deciduous	good	914
Bull River	BULL 3-1	15q	<2%	3	unconfined	no	mature coniferous	good	no	mature deciduous	good	2574
Bull River	BULL 3-2	15q	<2%	3	unconfined	yes	shrubs	fair	yes	shrubs	fair	8998
Bull River	BULL 3-3	15q	<2%	3	unconfined	no	grass	good	yes	grass	fair	11562
Bull River	BULL 4-1	15q	<2%	3	unconfined	yes	grass	fair	yes	grass	fair	13640
Bull River	BULL 4-2	15q	<2%	3	unconfined	yes	mature coniferous	fair	yes	grass	fair	3870
Bull River	BULL 5-1	15q	<2%	3	unconfined	yes	shrubs	fair	yes	shrubs	fair	6025
Bull River	BULL 5-2	15q	<2%	3	unconfined	yes	shrubs	poor	no	shrubs	good	7406
Bull River	BULL 6-1	15q	<2%	3	unconfined	yes	grass	fair	yes	grass	good	2311
Bull River	BULL 6-2	15q	<2%	3	unconfined	yes	grass	poor	yes	grass	poor	3370
Bull River	BULL 7-1	15q	<2%	3	unconfined	yes	grass	fair	yes	grass	fair	22632
Bull River	BULL 8-1	15q	<2%	4	unconfined	no	shrubs	good	yes	shrubs	fair	16374
Bull River	BULL 8-2	15q	<2%	4	unconfined	yes	bare	poor	no	shrubs	good	3780
Bull River	BULL 8-3	15q	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	10838
Bull River	BULL 8-4	15q	<2%	4	unconfined	no	mature coniferous	good	yes	shrubs	fair	5384
Bull River	BULL 8-5	15q	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	4494
Bull River	BULL 8-6	15q	<2%	4	unconfined	yes	mature coniferous	fair	yes	mature coniferous	fair	9861
Dry Creek	DRY 1-1	15q	>10%	1	unconfined	yes	shrubs	fair	yes	shrubs	fair	1190
Dry Creek	DRY 2-1	15q	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	1345
Dry Creek	DRY 3-1	15q	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	2366
Dry Creek	DRY 4-1	15q	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	1595
Dry Creek	DRY 5-1	15q	4% to 10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	1110
Dry Creek	DRY 6-1	15q	>10%	1	confined	no	mature deciduous	good	no	mature deciduous	good	1458
Dry Creek	DRY 7-1	15q	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	826
Dry Creek	DRY 8-1	15q	4% to 10%	1	unconfined	yes	mature coniferous	fair	yes	mature coniferous	fair	1637
Dry Creek	DRY 9-1	15q	4% to 10%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	1236
Dry Creek	DRY 9-2	15q	4% to 10%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	2299
Dry Creek	DRY 9-3	15q	4% to 10%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	3785
Dry Creek	DRY 10-1	15q	2% to <4%	2	unconfined	yes	mature coniferous	good	no	mature coniferous	good	2771
East Fork Elk Creek	EFELK 1-1	15o	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	2308
East Fork Elk Creek	EFELK 2-1	15o	>10%	1	confined	yes	mature coniferous	fair	no	mature coniferous	good	3834
East Fork Elk Creek	EFELK 3-1	15o	>10%	2	confined	no	mature coniferous	good	no	mature coniferous	good	1445
East Fork Elk Creek	EFELK 4-1	15k	>10%	2	confined	yes	mature coniferous	fair	yes	mature coniferous	good	3634
East Fork Elk Creek	EFELK 5-1	15k	4%to 10%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	906
East Fork Elk Creek	EFELK 6-1	15k	>10%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	1218
East Fork Elk Creek	EFELK 7-1	15k	4%to 10%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	2358
East Fork Elk Creek	EFELK 7-2	15k	4%to 10%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	4426
East Fork Elk Creek	EFELK 8-1	15k	2% to <4%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	3501
East Fork Elk Creek	EFELK 8-2	15k	2% to <4%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	7136
East Fork Elk Creek	EFELK 9-1	15k	<2%	2	unconfined	yes	mature coniferous	fair	yes	mature coniferous	fair	5543
East Fork Elk Creek	EFELK 10-1	15k	<2%	3	unconfined	no	mature coniferous	good	yes	shrubs	fair	3167
East Fork Elk Creek	EFELK 10-2	15k	<2%	3	unconfined	yes	shrubs	fair	yes	shrubs	fair	4229
East Fork Elk Creek	EFELK 10-3	15k	<2%	3	unconfined	yes	bare	poor	yes	grass	poor	4191
East Fork Elk Creek	EFELK 11-1	15k	<2%	3	unconfined	yes	grass	fair	yes	grass	fair	2046
West Fork Elk Creek	WFELK 1-1	15o	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	5358

Stratification Results

GNIS Name	Reach ID	primary eco	Gradient	Stream order	confinement	LB anthro influence	LB riparian vegetation	LB rip health	RB anthro influence	RB riparian veg	RB ripar health	length ft
West Fork Elk Creek	WFELK 2-1	15o	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	966
West Fork Elk Creek	WFELK 3-1	15o	4% to 10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	1648
West Fork Elk Creek	WFELK 4-1	15o	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	719
West Fork Elk Creek	WFELK 5-1	15o	4% to 10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	1156
West Fork Elk Creek	WFELK 6-1	15o	4% to 10%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	2815
West Fork Elk Creek	WFELK 7-1	15o	2% to <4%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	5990
West Fork Elk Creek	WFELK 8-1	15o	<2%	2	unconfined	yes	mature coniferous	good	no	mature coniferous	good	4045
West Fork Elk Creek	WFELK 9-1	15o	<2%	3	unconfined	yes	mature deciduous	fair	yes	mature deciduous	fair	885
West Fork Elk Creek	WFELK 10-1	15k	<2%	3	unconfined	yes	bare	poor	yes	shrubs	fair	6940
Elk Creek	ELK 11-1	15k	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	1280
Elk Creek	ELK 11-2	15k	<2%	4	unconfined	yes	shrubs	fair	no	shrubs	good	6994
Elk Creek	ELK 11-3	15k	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	7737
Elk Creek	ELK 11-4	15k	<2%	4	unconfined	yes	grass	fair	yes	shrubs	fair	3148
Elk Creek	ELK 11-5	15k	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	14749
Elk Creek	ELK 11-6	15k	<2%	4	unconfined	yes	grass	poor	yes	shrubs	fair	2793
Elk Creek	ELK 11-7	15k	<2%	4	unconfined	yes	shrubs	fair	yes	shrubs	fair	5675
North Branch Marten Creek	NBMC 1-1	15h	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	1182
North Branch Marten Creek	NBMC 2-1	15o	>10%	1	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	1632
North Branch Marten Creek	NBMC 3-1	15o	>10%	1	confined	no	mature coniferous	good	yes	mature coniferous	fair	4451
North Branch Marten Creek	NBMC 4-1	15o	>10%	1	unconfined	yes	mature coniferous	fair	yes	mature coniferous	fair	767
North Branch Marten Creek	NBMC 4-2	15o	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	1078
North Branch Marten Creek	NBMC 5-1	15o	>10%	1	confined	yes	mature coniferous	fair	no	mature coniferous	good	1605
North Branch Marten Creek	NBMC 6-1	15o	>10%	2	confined	no	mature coniferous	good	no	mature coniferous	fair	652
North Branch Marten Creek	NBMC 7-1	15o	4% to 10%	2	confined	no	mature coniferous	good	yes	mature coniferous	fair	3465
North Branch Marten Creek	NBMC 7-2	15o	4% to 10%	2	confined	no	mature coniferous	good	yes	mature coniferous	fair	2858
North Branch Marten Creek	NBMC 8-1	15o	4% to 10%	2	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	2069
South Branch Marten Creek	SBMC 1-1	15o	>10%	1	confined	yes	mature coniferous	fair	no	mature coniferous	good	4862
South Branch Marten Creek	SBMC 2-1	15o	4% to 10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	1788
South Branch Marten Creek	SBMC 3-1	15o	4% to 10%	2	confined	yes	mature coniferous	fair	no	mature coniferous	good	5304
South Branch Marten Creek	SBMC 3-2	15o	4% to 10%	2	confined	yes	mature coniferous	fair	no	mature coniferous	good	1398
South Branch Marten Creek	SBMC 4-1	15o	4% to 10%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	1769
Marten Creek	MC 5-1	15o	4% to 10%	3	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	870
Marten Creek	MC 6-1	15o	2% to <4%	3	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	2446
Marten Creek	MC 6-2	15o	2% to <4%	3	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	8246
Marten Creek	MC 7-1	15k	2%to <4%	3	unconfined	yes	shrubs	fair	no	shrubs	good	2268
Marten Creek	MC 8-1	15k	<2%	3	unconfined	yes	shrubs	fair	no	mature coniferous	good	1905
Marten Creek	MC 9-1	15k	<2%	3	unconfined	yes	shrubs	fair	no	shrubs	good	3568
Marten Creek	MC 10-1	15k	<2%	3	unconfined	yes	shrubs	fair	no	mature coniferous	good	4094
Marten Creek	MC 10-2	15k	<2%	3	unconfined	yes	shrubs	fair	no	shrubs	good	11213
Marten Creek	MC 11-1	15k	<2%	3	unconfined	yes	shrubs	fair	no	shrubs	good	1166
Swamp Creek	SWP 1-1	15h	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	740
Swamp Creek	SWP 1-2	15h	>10%	1	confined	no	shrubs	good	no	bare	fair	751
Swamp Creek	SWP 2-1	15h	>10%	1	unconfined	no	shrubs	good	no	shrubs	good	604
Swamp Creek	SWP 2-2	15h	>10%	1	unconfined	no	grass	good	no	shrubs	good	832
Swamp Creek	SWP 2-3	15h	>10%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	598
Swamp Creek	SWP 3-1	15h	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	324
Swamp Creek	SWP 4-1	15q	>10%	1	confined	no	shrubs	good	no	shrubs	good	394

Stratification Results

GNIS Name	Reach ID	primary eco	Gradient	Stream order	confinement	LB anthro influence	LB riparian vegetation	LB rip health	RB anthro influence	RB riparian veg	RB ripar health	length ft
Swamp Creek	SWP 5-1	15q	>10%	1	unconfined	no	shrubs	good	no	shrubs	good	616
Swamp Creek	SWP 6-1	15q	4% to 10%	1	unconfined	yes	mature coniferous	good	no	mature coniferous	good	1192
Swamp Creek	SWP 7-1	15q	2% to <4%	1	unconfined	no	shrubs	good	no	shrubs	good	1071
Swamp Creek	SWP 7-2	15q	2% to <4%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	447
Swamp Creek	SWP 7-3	15q	2% to <4%	1	unconfined	no	shrubs	good	no	shrubs	good	805
Swamp Creek	SWP 7-4	15q	2% to <4%	1	unconfined	no	mature coniferous	good	no	mature coniferous	good	769
Swamp Creek	SWP 8-1	15q	4% to 10%	1	unconfined	no	forest	good	no	mature coniferous	good	847
Swamp Creek	SWP 9-1	15q	4% to 10%	1	confined	no	forest	good	no	mature coniferous	good	545
Swamp Creek	SWP 10-1	15q	>10%	1	confined	no	forest	good	no	mature coniferous	good	1348
Swamp Creek	SWP 11-1	15q	4% to 10%	1	confined	no	forest	good	no	mature coniferous	good	1628
Swamp Creek	SWP 12-1	15q	4% to 10%	1	unconfined	no	forest	good	no	mature coniferous	good	6417
Swamp Creek	SWP 13-1	15q	2% to <4%	1	unconfined	no	forest	good	no	mature coniferous	good	2075
Swamp Creek	SWP 14-1	15q	2% to <4%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	1011
Swamp Creek	SWP 14-2	15q	2% to <4%	2	unconfined	no	mature coniferous	good	no	shrubs	good	2027
Swamp Creek	SWP 15-1	15q	2% to <4%	2	confined	no	mature coniferous	good	no	shrubs	good	1252
Swamp Creek	SWP 16-1	15q	2% to <4%	2	unconfined	no	mature coniferous	good	no	shrubs	good	1052
Swamp Creek	SWP 17-1	15q	4% to 10%	2	unconfined	no	mature coniferous	good	no	shrubs	good	1736
Swamp Creek	SWP 18-1	15q	2% to <4%	2	unconfined	no	mature coniferous	good	no	shrubs	good	7732
Swamp Creek	SWP 18-2	15q	2% to <4%	2	unconfined	no	mature deciduous	good	no	mature deciduous	good	5498
Swamp Creek	SWP 18-3	15q	2% to <4%	2	unconfined	no	shrubs	good	yes	shrubs	fair	5709
Swamp Creek	SWP 19-1	15q	<2%	2	unconfined	no	shrubs	good	yes	shrubs	fair	570
Swamp Creek	SWP 19-2	15q	<2%	2	unconfined	no	shrubs	good	no	shrubs	good	411
Swamp Creek	SWP 20-1	15q	<2%	3	unconfined	no	shrubs	good	no	shrubs	good	1746
Swamp Creek	SWP 21-1	15k	<2%	3	unconfined	yes	shrubs	fair	yes	shrubs	fair	4056
Swamp Creek	SWP 22-1	15q	<2%	3	unconfined	yes	grass	poor	yes	grass	poor	3583
Swamp Creek	SWP 21-2	15k	<2%	3	unconfined	yes	shrubs	fair	yes	grass	fair	2693
Swamp Creek	SWP 22-2	15q	<2%	3	unconfined	yes	shrubs	fair	yes	bare	poor	1055
Swamp Creek	SWP 22-3	15q	<2%	3	unconfined	yes	shrubs	fair	yes	shrubs	fair	9576
White Pine Creek	WHP 1-1	15o	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	1727
White Pine Creek	WHP 2-1	15k	>10%	1	confined	no	mature coniferous	good	no	mature coniferous	good	4666
White Pine Creek	WHP 3-1	15k	>10%	1	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	411
White Pine Creek	WHP 4-1	15k	4%to 10%	1	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	1886
White Pine Creek	WHP 4-2	15k	4%to 10%	1	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	4983
White Pine Creek	WHP 5-1	15k	2% to <4%	1	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	2438
White Pine Creek	WHP 6-1	15k	2% to <4%	1	confined	no	mature coniferous	good	yes	mature coniferous	fair	6246
White Pine Creek	WHP 7-1	15k	2% to <4%	1	unconfined	no	mature coniferous	good	yes	mature coniferous	fair	7064
White Pine Creek	WHP 8-1	15k	2% to <4%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	2239
White Pine Creek	WHP 8-2	15k	2% to <4%	2	unconfined	yes	bare	poor	no	mature coniferous	good	2524
White Pine Creek	WHP 8-3	15k	2% to <4%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	3704
White Pine Creek	WHP 8-4	15k	2% to <4%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	3815
White Pine Creek	WHP 8-5	15k	2% to <4%	2	unconfined	no	mature coniferous	good	no	mature coniferous	good	2350
White Pine Creek	WHP 9-1	15k	<2%	2	unconfined	yes	mature coniferous	fair	no	mature coniferous	good	1936
White Pine Creek	WHP 9-2	15k	<2%	2	unconfined	yes	shrubs	fair	no	shrubs	good	10360
White Pine Creek	WHP 9-3	15k	<2%	2	unconfined	yes	grass	poor	yes	grass	poor	4103
White Pine Creek	WHP 9-4	15k	<2%	2	unconfined	yes	shrubs	fair	yes	mature coniferous	fair	2137
White Pine Creek	WHP 9-5	15k	<2%	2	unconfined	yes	grass	fair	no	shrubs	good	2704

APPENDIX D - REFERENCE CONDITIONS AND TARGET VALUE RATIONALE

D.1 REFERENCE CONDITIONS AND DATA SOURCES

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 water body 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 water body's greatest potential for water quality given historic land use activities.

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.

Also, Montana WQS do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when nutrients, flow, or habitat modifications are present.

Water bodies 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 water body to reference water body 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 water body to baseline data from minimally impaired water bodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the water body in the past.

- Comparing conditions in a water body to conditions in another portion of the same water body, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc., that were conducted on similar water bodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the water body's fisheries health or 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 reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

Two main sources of data served as information for "reference conditions" in the LCF TPA. Target values for the parameters of interest were based on unpublished data from USFS PIBO data collected throughout the Kootenai and Lolo National Forests, and from data collected during the 2008 DEQ Lower Clark Fork sediment/habitat field study.

United States Forest Service Pacfish/Infish Biological Opinion (PIBO) data (2009) was reviewed for assistance in developing target values for width to depth ratios, percent fines less than 2mm and 6mm, pool frequency, and large woody debris frequency. PIBO data was specifically selected to include data from throughout the Cabinet and Plains-Thompson Falls Forest Districts, within the Kootenai and Lolo National Forests – both of which are partially within the Lower Clark Fork TPA.

2008 DEQ field data was used for the development of all parameter values. Data from the DEQ field effort was collected on listed and non-listed streams throughout the Lower Clark Fork TPA.

2008 DEQ data was categorized by the reach results based on the stream stratification procedure. No true "reference" reaches were identified through the stream stratification procedure; however, in the sampling analysis design for the 2008 field data study, sites were chosen to represent the variability among reach type categories and stratification parameters. Although few if any of the reaches represent full application of all reasonable land, soil, and water conservation practices, some reaches were sampled that reflected some of the healthiest reaches in the study area where negative impacts from land use activities were most limited.

D.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 D-1 is an example boxplot type 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 (EPA 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 (DEQ 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.

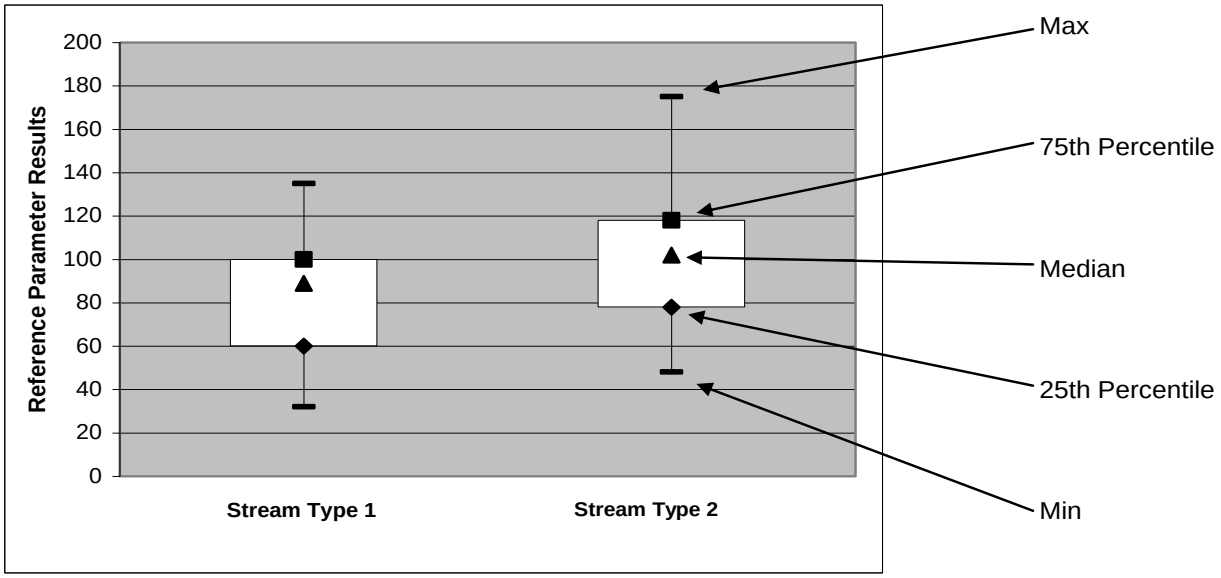


Figure D-1. Boxplot Example for Reference Data.

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 water bodies 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 water bodies 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 D-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, cold water 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 (DEQ 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 (EPA 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 25^{th} or 75^{th} percentiles as potential target values, but you would use the 25^{th} and 75^{th} 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 D-2** is an example statistical distribution where higher values represent better water quality. In **Figure D-2**, the median and 25^{th} percentiles represent potential target values versus the median and 75^{th} percentiles discussed above for regional reference distribution. Whether you use the median, the 25^{th} 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 also 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.

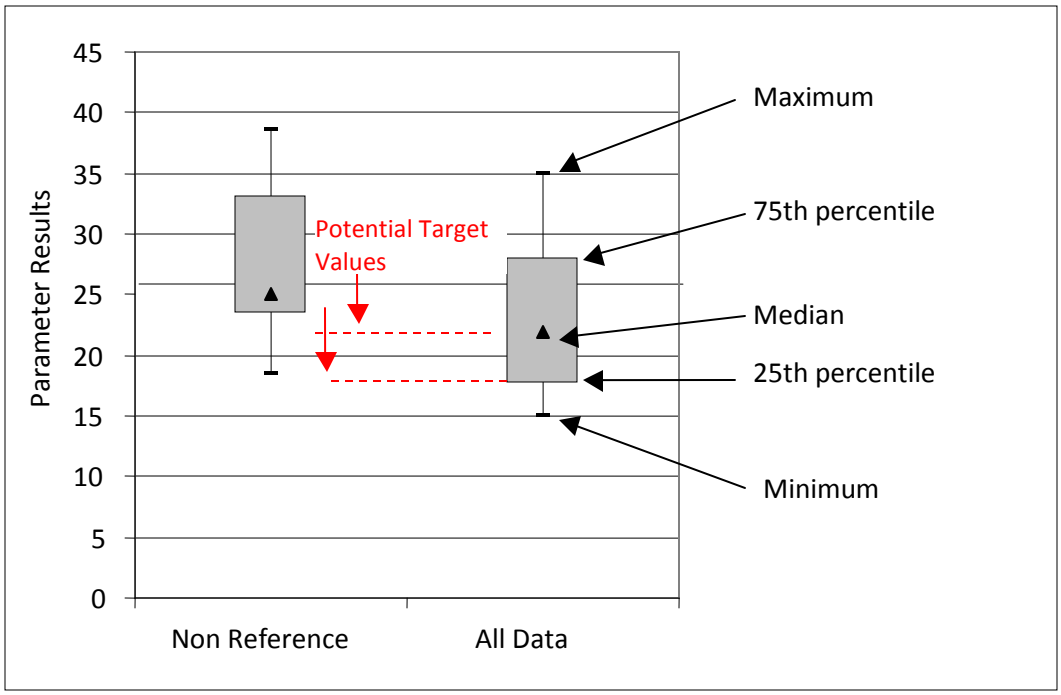


Figure D-2. Boxplot example for the use of all data to set targets.

D.3 Statistical Application and Target Development in the Lower Clark Fork

Target values are often presented for a range of values based on stream size, parent geology, or other significant factors that influence stream function and response. For instance, depending on the setting, sediment and habitat conditions in a 5th order stream may vary considerably from those in a 2nd order stream and therefore assessing the respective condition of each against the same target values would be inappropriate for some target values. In the Lower Clark Fork TPA, (with the exception of the Bull River) given the similar stream sizes, geographic setting, and response to influencing factors in all the streams assessed, as well as similarity in geographic setting to streams used within the PIBO comparison, data was sorted and analyzed based on stream gradient and level IV ecoregion. Bull River data was not included in the target setting data analysis due to the significant difference in stream size and character from the rest of the reaches investigated during the 2008 field session, and therefore would skew statistics. Applicable target values specific to the Bull River are discussed below in **Section D.4**.

In general, targets were developed for two categories for the purposes of this TMDL; those targets that are applicable to high gradient stream segments, also referred to as "transport reaches" (streams with a slope greater than 2%), and targets that are applicable to low gradient stream segments, or depositional reaches (slope less than 2%). Although USFS and DEQ employed two somewhat different methodologies for classifying the reaches and grouping the corresponding data, the methods used to collect data, the criteria for the reach classifications and the relationship to slope allow for some comparison. For additional applicability across methods and stream understanding, the two stream categories identified for this target setting can be described further: Rosgen A, B, and G reaches are classified with slopes >2% and thus qualify as high gradient reaches; Rosgen C and F reaches have slopes <2%, and apply to

low gradient reaches. Rosgen E reaches, which are also characterized by slopes <2%, may not be comparable however due to the inherently higher fines and sediment storage that is typically associated with these reach types. The exception to this approach was used in the development of the Residual Pool Depth targets which were based on bankfull width rather than gradient, and in the development of Bull River targets which, due to a smaller local data set and different character from the other Lower Clark Fork tributaries investigated warranted exclusion from the water quality targets presented here.

As described above, the use of median and percentiles in statistical analysis is often employed when data, such as water quality data, tend to have a non-normal distribution. Also, limited amounts of data can sometimes lead to skewed results if using normal distribution statistics. For these reasons, it is more appropriate to use non-normal or non-parametric statistics for setting reference conditions and determining target values for most parameters.

If parameters are used where lower numbers represent better water quality conditions, then typically the 75th percentile of the reference data set is often the reference value used as a potential target value because values greater than the 75th percentile are beyond the range of expected variability. If the opposite were true, then the 25th percentile would apply. Where there is less confidence in the data to represent "reference" conditions, the 50th percentile or median value can be used, such as when a total data set incorporates both reference and non-reference conditions.

Since no true "reference sites" were identified when developing target values, generally the median (50th percentile) of the total population of the DEQ and USFS data sets were reviewed and a target value was determined based on a comparison between the data sets, best professional judgment, and relation to commonly accepted literature values. For comparison, the 25th or 75th percentile of the total population was also included (dependent on which percentile represented "best" conditions). Including this number provides some insight into what may be the most desirable of the values that may be achievable. Twenty two sites were assessed during the 2008 DEQ field study, 16 sites qualified as "Low Gradient" or "depositional" reaches, and 6 sites qualified as "High Gradient" or "transitional" reaches. The PIBO data set provided an additional 31 low gradient sites, and 15 high gradient sites.

The use of a non-parametric statistical distribution for interpreting narrative water quality standards or developing numeric criteria is consistent with EPA guidance for determining 'water quality' criteria (EPA, 2000). Therefore, the selection of the applicable statistics from a data set is consistent with ongoing MDEQ and EPA guidance development for interpreting narrative water quality standards.

Information and rationale used to derive target values follows below. Target parameter description and rationale for inclusion is presented in **Section 5.4**.

D.3.1 WIDTH DEPTH RATIO

Table D-1. Width Depth Ratio

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	19.0	24.2
Median – USFS PIBO all reaches	18.9	24.9
25th percentile – DEQ all reaches	13.5	19.1
25th percentile – USFS PIBO all reaches	16.7	20.3
Target Value	**≤20**	**≤25**

Delineative criteria based on Rosgen stream type classification for width to depth ratios gives guidance of <12 for A and G stream types, and >12 for B and C stream types. The high gradient category incorporates A, B and G Rosgen stream types, however the data set does not include any reaches greater than 4% as reaches with such a steep gradient are generally located in headwater areas where human impacts are limited, and field sampling is impractical. Therefore, the targets for high gradient reaches are more focused on B reaches, but incorporate A reaches. Based on analysis of the data, width/depth ratios of <20 under most circumstances should represent stable channel conditions for high gradient streams.

Similarly, the low gradient reach target is based on the results of C channel investigations. However, the Bull River and other streams occasionally exhibit E channel characteristics, which despite having low gradients, have a width/depth criteria of <12. For those instances where E channels occur, the width/depth value should be consistent with the Rosgen reach type criteria of <12.

D.3.2 ENTRENCHMENT

Table D-2. Entrenchment

	High Gradient (>2%) ***Rosgen B***	**Low Gradient (<2%)** ***Rosgen C,E***
Median – DEQ all reaches	3.0	5.7
75th percentile – DEQ all reaches	4.3	7.2
Target Value	**>1.4-<2.2**	**>2.2**

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 Lower Clark Fork as well. The most commonly encountered high gradient reaches assessed through the DEQ field effort were Rosgen B reaches and therefore the B reach entrenchment target is presented above. In general, A stream types (gradients 4-10%) often do not occur in places where anthropogenic influence has much immediate impact on entrenchment values and therefore target comparison is most relevant to B reach types in high gradient systems. Entrenchment values >2.2 are described by Rosgen as slightly entrenched to non-entrenchment as the values increase. A target value based on Rosgen delineative criteria of >2.2 is thereby assigned for low gradient reaches, however the upper range of values should be consistent with the upper range from the data set.

D.3.3 PEBBLE COUNT - <6MM

Table D-3. Pebble Count - <6mm

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	5	10
Median – USFS PIBO all reaches	8	9
25th percentile – DEQ all reaches	4	8
25th percentile – USFS PIBO all reaches	3	3
Target Value	**<5**	**<10**

High gradient reaches are also defined within this document as "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. Consequently, based on the values found in the DEQ and USFS PIBO data, the values determined to be both representative of 'good' conditions under most circumstances in the Lower Clark Fork and that are protective of aquatic life and cold water fisheries are <5% for high gradient reaches, and <10% for low gradient reaches have been chosen.

It should be noted that a distinctive difference in the pebble count data between the DEQ dataset and the USFS data set exists and that the values from the two agencies presented here are only for broad comparisons, and to help with the decision making process when developing the target values. In the case of the DEQ dataset, pebble counts were conducted at riffles, using the Wolman pebble count method which randomly and systematically measures approximately 100 substrate particles across the channel. In the case of the USFS PIBO data, the available percent surface fines data were measured at pool tails, using a grid method in which particles less than 2mm and 6mm are observed and recorded if they occur beneath an intersection in the grid. The number of occurrences are then divided by the number of intersections observed (50) to derive a percent. (Percent fines in pool tails, using the grid method, was also conducted by DEQ during the 2008 field assessment, however, pool fines data was sporadic and deemed insufficient for inclusion in the analysis and comparison for these targets.) Despite the differences between the DEQ and PIBO percent fines datasets, both measures are essentially looking at the accumulation of fine sediment particles in areas of the stream most likely to be used by cold water fish for spawning. The higher the surface fines values, the greater the impact on spawning success. In the case of the Lower Clark Fork, the target values were derived mainly from the results of the DEQ riffle pebble count data, and therefore should be applied to the results from pebble counts in riffles, however the PIBO pool grid toss data is provided to allow a cursory comparison with the overall sediment conditions witnessed in Lower Clark Fork streams.

It should also be noted that this target does not apply to E channels, which typically exhibit much higher natural values of percent surface fines. Not enough data was collected specific to E channels through this study to develop a TPA specific target, therefore, percent fines in E channel reaches should be evaluated on a case by case basis.

D.3.4 PEBBLE COUNT - <2MM

Table D-4. Pebble Count - <2mm

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	2	7
Median – USFS PIBO all reaches	4	4
25th percentile – DEQ all reaches	1	5
25th percentile – USFS PIBO all reaches	0	1
Target Value	**<5**	**<5**

In this case, a value of <5% was determined to be an appropriate target value for all tributary streams based on the results from the DEQ and PIBO data sets, and the understanding that <5% is protective for fishery and aquatic life beneficial uses.

As with the pebble count target for percent fines less than 6mm, it should also be noted that this target does not apply to E channels, which typically exhibit much higher natural values of percent surface fines. Not enough data was collected specific to E channels through this study to develop a TPA specific target, therefore, percent fines in E channel reaches should be evaluated on a case by case basis.

D.3.5 RESIDUAL POOL DEPTH

Table D-5. Residual Pool Depth

	Bankfull Width 20-29 feet	Bankfull Width 30-39 feet	Bankfull Widths 40-49
Median – DEQ all reaches	1.1	1.5	1.7
Median – PIBO	1.0	1.6	-
75th percentile – DEQ all reaches	1.3	1.7	1.8
75th percentile - PIBO	1.2	1.7	-
Target Value	**≥1.2**	**≥1.6**	**≥1.7**

A slightly different approach was taken when developing target values for residual pool depth. In this case, because pool depths are often more a function of stream size and volume as opposed to simply using stream gradient, it was deemed appropriate to segregate sampled reaches by bankfull width, which provides an indication of general stream dimensions and power that affects pool size and quality. Three categories were broken out based on the sampled reaches; bankfull widths between 20-30', bankfull widths between 31-39', and bankfull widths 40-49'. Bankfull widths greater than 50', generally speaking, are larger than most of the tributary streams represented in the Lower Clark Fork TPA, the exception being the Bull River, and therefore would require targets for larger size streams, such as the Bull River targets as discussed in **Section 5.4.3.1**. The Bull River data was not included in this analysis – each of the three Bull River reaches had bankfull widths greater than 60 feet. In addition, of the USFS PIBO data sets, very limited data was available specific to residual pool depths and therefore was not included in the analysis here.

Target values for the bankfull width categories are presented in the above table and were determined based on review of the median and 75th percentiles of the two data sets for each bankfull width category. No PIBO data was available for Bankfull Widths greater than 39 feet. The target values are assumed to be representative of quality residual pool depths that would be found under desired conditions for most Lower Clark Fork tributaries.

D.3.6 POOL FREQUENCY (PER 1000')

Table D-6. Pool Frequency (per 1000')

	High Gradient (>2%) *Rosgen A, B, G*	Low Gradient (<2%) *Rosgen C, F*
Median – DEQ all reaches	8	9
Median – USFS PIBO all reaches	5	12
75th percentile – DEQ all reaches	14	11
75th percentile – USFS PIBO all reaches	13	17
Target Value	**>9**	**>9**

In some environments, pool frequency may vary based on gradient, geology, and other environmental factors affecting the stream (riparian health and large woody debris). Often, high gradient reaches are characterized by more numerous albeit smaller and shallower pools, than low gradient reaches. Based

on the data for the Lower Clark Fork tributaries reviewed here, not much discernable difference in pool frequency between high and low gradient reaches is apparent. The median value of 9 for low gradient reaches also matches the pool frequency target for the nearby Prospect Creek TPA, and therefore a minimum of 9 pools per 1000' (47 pools per mile) is targeted for the Lower Clark Fork TPA.

D.3.7 GREENLINE – PERCENT SHRUB

Table D-7. Greenline – Percent Shrub

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	91	58
75th percentile – DEQ all reaches	93	72
Target Value	**>90**	**>60**

Riparian green line is not used as a true "target" for analysis in the Lower Clark Fork; however it is reviewed as supplemental information because of its relation to bank stability and therefore potential sediment production and an overall gage of stream health. Shrub cover in particular provides stronger, more stable stream side woody vegetation, and it often provides an indicator of potential bank stability and temperature variability. Although riparian health is not dependent on the slope of the terrain in many cases, data from the 2008 field study do suggest some differentiation between riparian conditions in high and low gradient reaches.

The statistics for riparian greenline are presented here to demonstrate the range of values that occur in the sites sampled as part of the 2008 field study. In this case, half of the high gradient reaches sampled had over 90% of their banks established with shrub-class vegetation. Therefore, a suggested target of >90% is presented for high gradient reaches. As for low gradient reaches, half of the reaches sampled had 58% or greater shrub presence, and one quarter of the low gradient reaches investigated had 72% or better. As a result, >60% shrub cover is conservatively suggested for low gradient reaches.

D.3.8 GREENLINE – PERCENT BARE GROUND

Table D-8. Percent Bare Ground

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	0	0
25th percentile – DEQ all reaches	0	0
Target Value	**0%**	**0%**

Riparian green line is not used as a true "target" for analysis in the Lower Clark Fork; however it is reviewed as supplemental information because of its relation to potential sediment production and overall gage of stream health. Bare ground along the riparian is the most unstable and most indicative display of sediment sources. Similar to the percent shrub analysis, the statistics for percent bare ground are only used as a relative gage by which to select an appropriate value to achieve. In this case, lower percentages of percent bare ground are the expected and desired condition. Based on a review of the available information, the Lower Clark Fork TPA would not expect to see any bare ground under most normal natural conditions. As such, the target for bare ground in conjunction with anthropogenic activities is 0%, however, it is acknowledged that some natural conditions (although not witnessed in

this data) may result in a small percentage of bare ground near the bank and therefore, this target is not absolute and will allow for some variance under specific natural conditions.

D.3.9 LARGE WOODY DEBRIS

Table D-9. Large Woody Debris (per 1000')

	High Gradient (>2%) ***Rosgen A, B, G***	**Low Gradient (<2%)** ***Rosgen C, F***
Median – DEQ all reaches	34	37
Median – USFS PIBO all reaches	47	46
75th percentile – DEQ all reaches	96	56
75th percentile – USFS PIBO all reaches	86	67
Target Value	**>40**	**>40**

Large woody debris is not used as a true "target" for analysis in the Lower Clark Fork; however it is reviewed as supplemental information because of its relation to riparian condition and sediment production, its affect on pool formation and habitat creation for both fish and macroinvertebrates, and its overall gage of stream health.

The Lower Clark Fork TPA is dominated by forest throughout its landscape and prior to agricultural development in some of the valleys, and timber harvest along the banks, the Lower Clark Fork tributaries likely were bordered by lush and dense riparian areas for nearly their entire lengths. The high counts of large woody debris evident in the data suggest this as well. Based on the median values, a minimum of 40 large woody debris pieces per 1000' is recommended as a guideline minimum value for this area.

D.4 BULL RIVER TARGETS

The size and character of the mainstem Bull River varies considerably from the majority of the tributaries reviewed during the 2008 field effort. As a result, although three Bull River sites were investigated, the data from these sites was not deemed sufficient enough to develop targets to represent the entire Bull River watershed. Additionally, the data from these three sites was not included in the pool of data used to develop targets for the Lower Clark Fork tributaries, for concern that it did not represent the commonly occurring streams in the watershed, and would skew the results. Because of this, data from other TMDLs, developed for watersheds in geographic close proximity (and therefore sharing similar geology and climate characteristics) and for streams of a more similar size to the Bull River were relied upon for target setting. Sediment targets from the St. Regis River, Prospect Creek, and Yaak TPAs were reviewed, and targets were determined using these values and best professional judgment.

<u>Yaak River Sediment Related Targets</u>

- Width/Depth Ratio = within the expected range for the appropriate Rosgen stream type
- Entrenchment Ratio = within the expected range for the appropriate Rosgen stream type
- Percent Surface Fines <6mm (riffle) = <20%
- Percent Surface Fines <2mm (riffle) = <20%

St. Regis River Sediment Related Targets

- Width/Depth Ratio = ≤30
- Percent Surface Fines <2mm (riffle) = <20%
- Percent Surface Fines <6mm (pool tail outs); using grid toss method = ≤8%
- Pools/Mile (C stream types >20' and <45' wide) = ≥16
- Large Woody Debris (B/C Stream types >35' wide) = ≥104

Prospect Creek Sediment Related Targets

- Width/Depth Ratio = <30
- Percent Surface Fines <6mm (riffle); pebble count = <15%
- Percent Surface Fines <6mm (pool tail/riffles); using grid toss or equivalent = <10%
- Pools/Mile = >26

As a result of the review of the above targets, sediment targets for the Bull River were selected and are presented in **Table D-10** below. In addition, most of the stream types described in the Yaak, St. Regis, and Prospect TPAs deal with B and C stream types, however there are significant sections of the Bull River that are classified as an E stream type. E stream types are typically more sinuous, deeper, and often demonstrate higher fines accumulations. In the Bull River, some of these E stream type reaches are also characterized by monocultures of reed canary grass, and extensive bank erosion. Although, the E reaches in the Bull River may very well show naturally higher fines, to remain protective of bull trout and westslope cutthroat trout the values for percent fines presented here will be set as the target until further assessment and evaluation of the Bull River system can be conducted to refine these targets, and management in the Bull River watershed is improved to reduce bank erosion input.

Table D-10. Lower Clark Fork TPA Sediment and Habitat Targets; Bull River

Sediment and Habitat Water Quality Target			
Morphology			
Width/Depth Ratio	Within expected values for appropriate Rosgen stream type; (Width/Depth guidelines: C types <30, B types <25, E < 12)		
Entrenchment			
Substrate Composition			
Pebble Count, % <2mm	≤20		
Pebble Count, % <6mm	≤20		
Pool Habitat			
Pool Frequency (per 1000')	>4		
Residual Pool Depth	**Bankfull Width 30-39 feet**	**Bankfull Width 40-49 feet**	**Bankfull Width >50 feet**
	≥1.6	≥1.7	≥1.9

APPENDIX E - TOTAL MAXIMUM DAILY LOADS

E.1 SEDIMENT

E.1.1 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.

E.1.2 Approach

In order to determine a daily load, the means of daily mean values for suspended sediment discharge in tons per day were reviewed from USGS gage stations in northwest Montana within reasonable proximity to the Lower Clark Fork tributaries. The USGS station on the Fisher River near Libby (12302055) was selected to represent the daily variability in sediment loading in the Lower Clark Fork tributaries due to its relative proximity to the Lower Clark Fork TPA, and therefore similar climate; its similarity in flow regime to the Bull River; and the fact that it had a period of record for annual total suspended sediment (most USGS stations in the region did not have daily sediment data). Although there is some variability in size between the Bull River (represented by the Fisher River data) and other tributaries of interest in the watershed, the true size of the streams is of less concern in this case because it is the relationship between sediment load (a function of sediment concentration and flow) and the day of the year that is the primary focus for this analysis. It is assumed that the hydrologic properties and rate of loading on a given day is similar throughout the watershed, regardless of the stream, and therefore is appropriate to use for these purposes.

The mean of daily mean values for suspended sediment discharge, in tons per day, was calculated based on approximately 8 years of record (October 1, 1967 – January 31, 1976) (**Table E-1**). This period of record is the only period of record with available daily suspended sediment data. The mean annual suspended sediment load for USGS gage 12302055, based on a summation of the mean of daily mean values, is 76,399 tons per year. Although the suspended sediment load is a portion of the total load from the source assessment, it provides an approximation of the relationship between sediment and flow in the Lower Clark Fork tributaries. Using the mean of daily mean sediment loads, a daily percentage relative to the mean annual suspended sediment load was calculated for each day (**Table E-2**). **Figure E-1** visually represents the average daily percentage of the total yearly sediment load for each day of the calendar year.

To conserve resources, this appendix only provides the base data from the USGS stream gage, and the daily percentages of the total annual load. For specific streams, all daily TMDLs may be derived by using the daily percentages in **Table E-2** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.6**. For instance, the total allowable annual sediment load for Marten Creek is

3689.2 tons. To determine the TMDL for January 1, this value is multiplied by 0.01% which provides a daily load for January 1st for Marten Creek of 36.9 tons. 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 5.6** to the daily load.

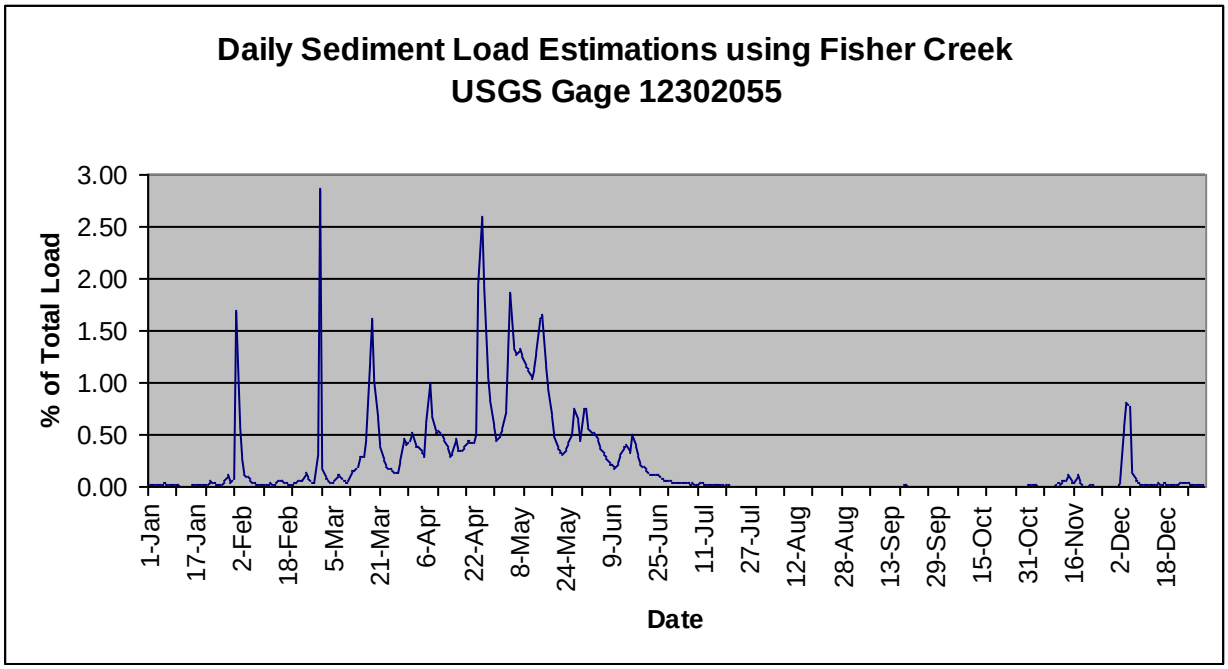


Figure E-1. Average Percentage of Total Daily Sediment Loading Throughout the Calendar Year.

The percent of total daily sediment loading from the Fisher Creek near Libby USGS gage station information in **Figure E-1** illustrates the fluctuating nature of sediment loads, driven by climate and precipitation, in many western Montana streams. In general, it appears that elevated sediment loading is linked to spring runoff, with occasional sporadic elevated loads, probably as the result of individual runoff events, mostly in winter and early spring, potentially as a result of wet spring snows with rapid melting or rain-on-snow events. (Sediment load records during January of 1974 were removed from the average calculations because these values corresponded to an extreme flood event that was not deemed representative of typical conditions in the Lower Clark Fork watershed.)

Table E-1. USGS Stream Gage 12302055 (Fisher Creek @ near Libby) - Mean of daily mean suspended sediment values for each day of record in tons/day (Calculation Period 1967-10-01 -> 1976-01-31)

Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	12.0	561.9	164.0	520.0	490.3	546.5	45.0	3.2	2.4	1.1	15.0	3.8
2	16.1	267.2	74.4	385.2	545.0	492.5	34.0	3.8	1.5	1.5	15.6	50.7
3	21.9	106.2	64.0	378.3	712.6	506.5	38.2	3.4	2.1	1.4	9.7	570.5
4	24.0	99.2	38.0	322.8	1288.8	429.8	32.3	2.8	1.6	4.8	3.1	799.0
5	20.5	56.7	52.9	278.1	1832.8	358.2	29.1	2.4	1.6	5.0	5.2	755.5
6	28.8	36.9	123.1	602.9	1314.8	305.5	26.7	2.2	1.6	1.7	3.9	138.2
7	28.2	27.3	86.9	984.1	1258.0	257.5	28.8	2.8	1.4	2.0	2.8	51.4
8	10.8	26.4	55.0	659.3	1314.3	213.6	23.3	2.9	1.6	1.7	2.0	34.6
9	10.9	27.1	42.7	521.0	1232.8	206.1	19.4	3.9	1.5	1.9	1.2	28.2
10	11.4	22.3	61.0	532.5	1131.1	175.9	35.1	2.1	1.8	1.7	36.6	22.2
11	13.1	18.5	147.0	495.9	1098.3	218.2	22.8	1.9	2.2	2.2	26.4	18.7
12	5.5	30.3	147.6	440.5	1031.3	306.2	15.9	1.9	3.0	3.9	52.1	13.0
13	5.6	27.0	181.0	364.4	1128.1	383.8	13.5	2.4	2.8	4.2	55.9	21.1
14	6.1	35.9	283.0	293.1	1274.6	392.5	13.4	3.4	2.0	3.1	115.1	21.1
15	6.6	59.8	280.8	317.1	1592.0	326.9	11.3	2.7	1.3	4.2	40.7	32.5
16	12.7	50.9	446.2	457.1	1639.4	491.5	9.6	2.7	1.2	2.9	38.3	27.6
17	23.8	34.0	1188.8	348.0	1143.6	377.1	9.7	2.3	1.6	2.2	112.4	29.3
18	19.5	25.4	1584.1	338.6	930.1	275.6	8.0	2.1	14.2	1.4	35.2	20.0
19	20.3	27.6	1004.8	378.5	664.6	216.7	9.7	2.0	18.1	1.8	6.0	18.6
20	18.0	46.8	644.4	442.4	464.8	186.9	8.3	1.7	3.2	2.2	6.6	15.2
21	24.8	45.7	380.6	417.4	355.3	142.5	7.8	2.0	2.3	2.1	6.3	10.6
22	63.6	65.7	247.7	408.5	323.5	121.9	5.9	2.0	3.1	1.8	10.5	20.9
23	31.1	61.9	198.9	518.4	306.1	110.4	5.9	1.8	2.5	2.9	8.3	31.9
24	22.8	141.0	172.3	1919.9	367.9	111.7	4.8	1.9	3.3	1.8	4.7	33.4
25	19.3	82.6	147.9	2556.7	410.5	108.3	4.2	2.1	2.3	2.1	3.6	31.7
26	16.5	41.5	124.6	1895.3	519.8	82.9	4.1	2.2	2.5	4.3	3.8	18.9
27	55.5	43.5	128.3	1043.4	743.6	65.7	3.7	2.2	2.0	4.0	4.7	17.9
28	108.1	328.0	241.6	821.0	621.1	59.0	5.1	1.6	1.4	5.8	7.0	13.5
29	34.8	2816.5	464.5	567.8	440.3	52.9	2.5	1.6	1.4	6.8	4.5	15.0
30	73.8		389.2	442.0	730.0	47.1	3.1	2.1	0.9	4.4	3.0	15.0
31	1672.8		435.8		745.0		3.8	2.0		9.8		11.2

Table E-2. USGS Stream Gage 12302055 (Fisher Creek near Libby) - Percent of Mean Annual Suspended Sediment Load Based on Mean of Daily Mean Suspended Sediment Values for each Day of Record (Calculation Period 1967-10-01 -> 1976-01-31)

Day of Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.01	0.57	0.17	0.53	0.50	0.55	0.05	0.00	0.00	0.00	0.02	0.00
2	0.02	0.27	0.08	0.39	0.55	0.50	0.03	0.00	0.00	0.00	0.02	0.05
3	0.02	0.11	0.06	0.38	0.72	0.51	0.04	0.00	0.00	0.00	0.01	0.58
4	0.02	0.10	0.04	0.33	1.31	0.44	0.03	0.00	0.00	0.00	0.00	0.81
5	0.02	0.06	0.05	0.28	1.86	0.36	0.03	0.00	0.00	0.01	0.01	0.77
6	0.03	0.04	0.12	0.61	1.33	0.31	0.03	0.00	0.00	0.00	0.00	0.14
7	0.03	0.03	0.09	1.00	1.28	0.26	0.03	0.00	0.00	0.00	0.00	0.05
8	0.01	0.03	0.06	0.67	1.33	0.22	0.02	0.00	0.00	0.00	0.00	0.04
9	0.01	0.03	0.04	0.53	1.25	0.21	0.02	0.00	0.00	0.00	0.00	0.03
10	0.01	0.02	0.06	0.54	1.15	0.18	0.04	0.00	0.00	0.00	0.04	0.02
11	0.01	0.02	0.15	0.50	1.11	0.22	0.02	0.00	0.00	0.00	0.03	0.02
12	0.01	0.03	0.15	0.45	1.05	0.31	0.02	0.00	0.00	0.00	0.05	0.01
13	0.01	0.03	0.18	0.37	1.14	0.39	0.01	0.00	0.00	0.00	0.06	0.02
14	0.01	0.04	0.29	0.30	1.29	0.40	0.01	0.00	0.00	0.00	0.12	0.02
15	0.01	0.06	0.28	0.32	1.61	0.33	0.01	0.00	0.00	0.00	0.04	0.03
16	0.01	0.05	0.45	0.46	1.66	0.50	0.01	0.00	0.00	0.00	0.04	0.03
17	0.02	0.03	1.21	0.35	1.16	0.38	0.01	0.00	0.00	0.00	0.11	0.03
18	0.02	0.03	1.61	0.34	0.94	0.28	0.01	0.00	0.01	0.00	0.04	0.02
19	0.02	0.03	1.02	0.38	0.67	0.22	0.01	0.00	0.02	0.00	0.01	0.02
20	0.02	0.05	0.65	0.45	0.47	0.19	0.01	0.00	0.00	0.00	0.01	0.02
21	0.03	0.05	0.39	0.42	0.36	0.14	0.01	0.00	0.00	0.00	0.01	0.01
22	0.06	0.07	0.25	0.41	0.33	0.12	0.01	0.00	0.00	0.00	0.01	0.02
23	0.03	0.06	0.20	0.53	0.31	0.11	0.01	0.00	0.00	0.00	0.01	0.03
24	0.02	0.14	0.17	1.95	0.37	0.11	0.00	0.00	0.00	0.00	0.00	0.03
25	0.02	0.08	0.15	2.59	0.42	0.11	0.00	0.00	0.00	0.00	0.00	0.03
26	0.02	0.04	0.13	1.92	0.53	0.08	0.00	0.00	0.00	0.00	0.00	0.02
27	0.06	0.04	0.13	1.06	0.75	0.07	0.00	0.00	0.00	0.00	0.00	0.02
28	0.11	0.33	0.25	0.83	0.63	0.06	0.01	0.00	0.00	0.01	0.01	0.01
29	0.04	2.86	0.47	0.58	0.45	0.05	0.00	0.00	0.00	0.01	0.00	0.02
30	0.07		0.39	0.45	0.74	0.05	0.00	0.00	0.00	0.00	0.00	0.02
31	1.70		0.44		0.76		0.00	0.00		0.01		0.01

ATTACHMENT 1 - ROAD SEDIMENT ASSESSMENT & MODELING

ROAD SEDIMENT ASSESSMENT & MODELING LOWER CLARK FORK RIVER TPA

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1.0 INTRODUCTION

This report presents a sediment and culvert assessment of the unpaved road network within six watersheds of the Lower Clark Fork River TMDL Planning Area (TPA). This assessment was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. Roads located near stream channels can impact stream function through degradation of riparian vegetation, channel encroachment, and sediment loading. The degree of impact is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of Best Management Practices (BMPs). Through a combination of GIS analysis, field assessment, and computer modeling, estimated sediment loads were developed for unpaved road crossings and parallel segments. Existing road conditions were modeled and future road conditions were estimated after the application of sediment reducing Best Management Practices (BMPs). Existing culverts were also assessed for fish passage.

The 2008 303(d) List includes the following stream segments for sediment / siltation impairment: Bull River, Dry Creek, Marten Creek and White Pine Creek. Elk Creek, which had a TMDL completed in 1997, and Swamp Creek were also included in analysis for this report. **Table A-1** includes a summary of sediment impaired stream segments.

2.0 DATA COLLECTION

The Lower Clark Fork Unpaved Road Sediment assessment consisted of three primary tasks: 1.) GIS Layer development and summary statistics, 2.) field assessment and sediment modeling, and 3.) sediment load calculations and load reduction allocations for sediment listed watersheds. Additional information on assessment techniques is available in prior reporting for this project: *Task 1. Road GIS Layers and Summary Statistics* (MDEQ 2009), and *Task 2. Sampling and Analysis Plan* (MDEQ 2009).

2.1 Spatial Analysis

Using road layers provided by the Kootenai National Forest (KNF), crossings and parallel segments in the road network were identified and classified relative to 6th code subwatershed (with the separation of Dry Creek from Upper Bull River), land ownership, soil erosion hazard class and road type (**Tables A-2a through A-2d**). A random subset of 50 unpaved crossing sites was generated for field assessment based on the proportion of total crossings within each watershed and by land ownership. Some sites were relocated prior to the field effort to focus on road crossings accessible by vehicle. The goal of the field effort was to characterize at least 40 road crossings and up to 10 parallel segments.

Parallel road segments were identified as areas where roads encroach upon the stream channel, and total road lengths within 100-foot stream buffer zones were generated. There is a total of 23.65 miles of unpaved parallel road segments within 100 feet of stream channels.

2.2 Field Data Collection

A total of 43 unpaved crossings and 19 parallel segments were evaluated in the field (**Figures 2, 3, 4, and 5, Attachment B, D, and E**). The following crossings were evaluated in each watershed: two crossings in Swamp Creek, one crossing in Dry Creek, seven crossings in White Pine Creek, ten crossings in Marten Creek, eleven crossings in Elk Creek and twelve crossings in the Bull River watershed.

In the field, parallel segments were selected based on best professional judgment while traveling roads on which specific crossings were selected for evaluation. When a parallel reach was encountered, the reach was divided into smaller segments and assessed at pre-selected intervals to eliminate sample bias. Parallel segments were evaluated in the Marten Creek, White Pine Creek and Elk Creek watersheds.

2.3 Sediment Assessment Methodology

The road sediment assessment was conducted using the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length). In addition, supplemental data was collected on vegetation condition of the buffer, evidence of erosion from the road system, and potential for fish passage failure.

The six watersheds encompass a wide range of annual precipitation: Precipitation quantity ranges from 26 to 100 inches per year with an average value of 47.5 inches and a median value of 46 inches. The sites assessed in the field ranged in elevation from 2340 feet to 5108 feet. The weather stations within the TMDL planning area are Trout Creek 2 W, Montana (248379, 30.32 inches annual precipitation; 2490 feet elevation) and Trout Creek Ranger Stn, Montana, (248380, 28.54 inches annual precipitation; 2360 feet elevation). Due to the lack of representative long-term precipitation stations in the Lower Clark Fork TPA, one station from outside the geographic area was selected to model the higher elevation sites (>3,500 feet). The selected station, Burke 2 ENE, Idaho (101272), contained similar climate and elevation conditions as those encountered in the Lower Clark Fork (48.9 inches annual precipitation; 4090 feet elevation). The Troy 18N, Montana (248395) station was used to model the lower elevation sites below 3,500 feet in elevation (35.60 inches annual precipitation; 2720 feet elevation). The Troy 18N site was chosen over the Trout Creek stations because the increased elevation better represented the sites assessed in the field (elevations are listed in **Attachment D**). Thirty year simulations were run for each unpaved road crossing segment since the quantity of precipitation exceeded 500 millimeters (19.69 inches) for all listed watersheds.

Some road conditions encountered in the field are not accurately represented in the WEPP:Road design options; as a result, some adjustments were made to the model to more appropriately

represent these types of roads. **Attachment C** contains a description of model or site condition adjustments, as recommended by the model author or by best professional judgment. **Attachment C** includes a table with specific adjustments per site name and custom climate parameters.

2.4 Field Adjustments

Field conditions required that a number of sites be moved to different locations due to lack of access (landowner permission, road condition, or accessibility by vehicle). In the Task 2. Sampling and Analysis Plan, fifty stream crossing field sites were identified with the intent that at least forty stream crossings and up to ten parallel sites would be assessed in the field. The resulting forty-three (43) assessment sites were selected in the field as shown on **Table A-3** and on **Figures 2 through 5**.

2.5 Mean Sediment Loads from Field Assessed Sites – Stream Crossings

Field assessment data and WEPP:Road modeling results were used to develop sediment loads based on various watershed criteria. A standard statistical breakdown of loads from the unpaved road network across all six watersheds was generated for each ownership class using the applicable dataset of field assessed crossing sites. Mean load and contributing length, median load, maximum and minimum loads, and 25th and 75th percentile loads were calculated for unpaved road crossings within each watershed and ownership type that was the basis of the field assessment. A statistical summary of sediment loads for field assessed sites are included in **Table 2-1**.

Table 2-1. Sediment Load Summary for Field Assessed Crossings by Ownership

Statistical Parameter	Federal	Federal (USFS Roadless Area)	State	Private	Sum
Total Number of Crossings	293	7	5	80	385
Number of Sites (n)	39	0	1	3	43
Mean Contributing Length (ft)	274.4	N/A	121.0	419.3	
Mean Load (tons/year)	0.14	N/A	0.02	0.23	
Median Load (tons/year)	0.02	N/A	0.02	0.15	
Maximum Load (tons/year)	1.49	N/A	0.02	0.49	
Minimum Load (tons/year)	0.00	N/A	0.02	0.04	
25th Percentile (tons/year)	0.01	N/A	0.02	0.10	
75th Percentile (tons/year)	0.10	N/A	0.02	0.32	

The sediment load summaries from ownership categories with greater than one site (Federal and Private) show significant differences between minimum and maximum load values, as well as

between mean and median values. These data suggest that a small number of high sediment load crossing sites impact the average values.

For the purposes of estimating the sediment load from each road crossing in the Lower Clark Fork TPA, the average of all field sites by ownership category assumes that the random subset of crossings assessed as part of this study is representative of the road crossing conditions in each of the six watersheds. Due to accessibility issues, unpaved privately-owned road crossings were not assessed in the Bull River and White Pine Creek watersheds, and a privately-owned crossing was not randomly chosen in the Sampling and Analysis Plan for the Marten Creek watershed. The average result from stream crossings on privately owned land in the Swamp Creek and Elk Creek watersheds was used to represent the sediment load on private land.

The single crossing evaluated in Dry Creek contributed the most significant sediment load (1.49 tons/year) of the assessed sites due to its road length (700 feet) and high road gradient (15%). The method of averaging all federally-owned sites assumes that the fifteen crossings in Dry Creek are not contributing sediment at the same magnitude as the single assessed site. Additional investigation may be warranted in this watershed since the sediment load from the single crossing is much greater than the average annual sediment load. Craig Neesvig, District Hydrogeologist for the Cabinet Ranger District, stated that an assessment of the Federal roads is currently underway by the Watershed Council in the Dry Creek watershed. Mr. Neesvig attributed the sediment listing in Dry Creek due to its flashy nature and due to logging of large diameter cedar trees.

The random selection of sites as described in *Task 2. Sampling and Analysis Plan* (MDEQ 2009) did not select any of the Federal – Roadless crossings. Although the Roadless designation and remoteness would intuit a smaller average sediment load, site evaluation was not performed to support this theory. Without available data, the average sediment loads for Federal sites will be used for the seven crossings in the Federal – USFS Roadless Areas.

Mean sediment loads were also calculated and classified based on Kooteni National Forest (KNF) road classification and are compared to results from the Yakk River TPA. Road classifications are numerically categorized (1 – Impassable to Motorized Vehicles, 2 – Restricted / Legally Gated Admin Use, 3 – Barriered / Legally No Admin Use, and 4 – Open During Bear Season). The Yaak River TPA Unpaved Road Assessment has many similarities to this report: the field-assessment focused on listed watersheds only, the WEPP:Road model with the same climate stations was utilized, and both sites are located in the KNF. The similar order of magnitude of WEPP:Road results from the Class 2 and 4 roads suggests that the unpaved road condition may have been accurately characterized with a limited number of samples. Results are shown in **Table 2-2**.

Table 2-2. Mean Sediment Loads by KNF Road Classification

KNF Road Classification (IGBC) Lower Clark Fork River TPA	Number of Sites Assessed	Mean Contributing Length (ft)	Mean Sediment Load (tons/yr)
1 – Impassible to Motorized Vehicles	0	N/A	N/A
2 – Restricted/Legally Gated Admin Use	8	180	0.01
3 – Barriered/Legally No Admin Use	0	N/A	N/A
4 – Open During Bear Season	35	304	0.15
KNF Road Classification (IGBC) Yaak River TPA	**Number of Sites Assessed**	**Mean Contributing Length (ft)**	**Mean Sediment Load (tons/yr)**
1 – Impassible to Motorized Vehicles	4	170	0.001
2 – Restricted/Legally Gated Admin Use	15	268	0.06
3 – Barriered/Legally No Admin Use	10	207	0.11
4 – Open During Bear Season	18	451	0.60

2.6 Mean Sediment Loads from Field Assessed Sites – Parallel Segments

Mean sediment loads were calculated for parallel road segments in White Pine Creek watershed, Marten Creek watershed and Elk Creek watershed. Only two segments in Marten Creek were assessed on privately-owned land (MC-PP-05 and MC-PP-05). There was no observable or modeled difference between the private and Federal segments as shown in **Attachment D**. The parallel segments in Elk Creek were measured every 550 feet. It was noted that BMPs were in place every 300 to 400 feet along the road. Thus the average sediment load may be best characterized with the road length decreased to 400 feet (**Attachment E**) rather than at the road length of 550 feet as listed on the field worksheet. A summary of modeling results from field assessed sites is located in **Attachments D and E** and **Table 2-3**.

Table 2-3. Sediment Load Summary from Unpaved Field Assessed Parallel Sites

Statistical Parameter	White Pine Creek	Marten Creek	Elk Creek
Number of Segments (n)	5	6	8
Mean Contributing Length (ft)	573.3	843.5	300.9[A]
Mean Road Gradient (%)	6.8	2.3	7.1
Mean Buffer Length (ft)	103.7	110.8	28.2
Mean Buffer Gradient (%)[B]	0.7	0.9	29.3
Mean Load (tons/year/mile)	0.095	0.002	2.10
Median Load (tons/year/mile)	0.00	0.00	2.44
Maximum Load (tons/mile/ year)	0.414	0.010	3.85
Minimum Load (tons/year/mile)	0.00	0.00	0.00

[A]Road Lengths for ELF-FS-06 (4 segments) were decreased to 400 feet due to existing BMPs.

[B]A minimum value of 0.3 % was used for buffer gradients that could not be measured in the field.

These results indicate that sediment load per mile per year is dependent on road length and gradient and the buffer length and gradient. The sediment load did not appear to be dependent on ownership management of the parallel segments based on the Marten Creek segments.

2.7 Paved Parallel Roads

As shown in **Figure 6**, few of the parallel roads are paved. Winter maintenance of the roads is divided between county and state responsibility. The Sanders County Road Department, District 3 applies traction sand to the paved, graveled and native surfaced roads near Trout Creek, Noxon and Heron (Elk Creek Watershed) due to regular use and steep gradients of the roads. The traction sand, of glacier deposit origin, is taken from the White Pine Creek or Elk Creek watershed; the coarser material is used on gravel roads in the summer. The quantity of sand applied to the roads was estimated as 10 cubic yards for 85 lane miles (42.5 road miles, **0.28 tons/mile**). The Sanders County Road Department usually plows and re-applies traction sand every day (depending on snowfall) for four to five months in the winter. This would equate to **28 tons/mile/year** assuming a five day workweek, for five months. The Noxon Section, Montana Department of Transportation (MDT) estimates that 10 cubic yards of sand was applied to 15 miles of road along the Bull River (**0.83 tons/mile**); however MDT has discontinued the use of sand in favor of using salt. Conversions were calculated with an assumed bulk density of 1.25 tons per cubic yard.

The Blackfoot Headwaters TPA Unpaved Road assessment assumed a delivery rate of 5% for roads within 100 feet and 10% for roads within 200 feet of surface water. Per the report, a comparison with a study in Vail Pass, Colorado suggested that as much as 30% of traction sand was

delivered to the nearby surface water. Per **Figure 6**, discussions with the State and County Road Departments, and the Vail Pass, Colorado study, traction sand may be delivered to surface waters within the Elk River watershed.

3.0 UNPAVED ROAD NETWORK LOAD ANALYSIS-

The annual mean sediment loads from field assessed sites for unpaved road crossings and parallel segments were extrapolated to the six specific watersheds: Bull River, Dry Creek, Elk Creek, Marten Creek, White Pine Creek and Swamp Creek. Results indicate that the greatest sediment is produced from Federally-owned roads due to the sheer quantity of Federal roads; however the sediment load per crossing was greater on private land.

Sediment load results were also compared to the USDA NRCS Soil Hazard Classification and the results from this study did not appear to correlate with hazard class, which is likely due to the greater sensitivity of the WEPP:road model to road length for specific high-load crossings in the Lower Clark Fork TPA rather than to the variables of the USDA NRCS rating system (soil erosion factor K, slope, and content of rock fragments).

A fish passage evaluation was completed for field-assessed culverts using the criteria listed in Table 1 of the document *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska* (USFS, September 27, 2002). Few culverts passed the fish passage evaluation due to steep culvert gradients and minimal constriction ratios.

3.1 Sediment Load from Road Crossings - Extrapolation to Watershed Scale

The road network was classified by major landowner within each watershed, as various entities and administrative controls direct operation and maintenance of the road network. Three major landowner classifications were developed: Federal lands, State of Montana, and private landowners. Mean sediment loads from field assessed sites were used to extrapolate existing loads for each ownership class in each listed watershed. Extrapolation of these results to the remainder of road crossings assumes that the random subset of crossings assessed as part of this study is representative of the each of the six watersheds.

The total extrapolated annual sediment load for each listed watershed from Unpaved Road Crossing is shown in **Table 3-1**. Detailed sediment loads for road crossings classified by ownership within each subwatershed are included in **Table A-4**.

Table 3-1. Extrapolated Sediment Load Summary from Unpaved Road Crossings – Existing Conditions

Sub Watershed	Total Number of Crossings	Total Number of Assessed Crossings	Total Sediment Load (t/y)
Bull River	111	12	16.65
Dry Creek	17	1	2.38
Elk Creek	98	11	17.86
Marten Creek	82	10	11.66
Swamp Creek	15	1	2.91
White Pine Creek	62	7	9.04

Road crossing extrapolation results showed that the Elk Creek (17.86 tons/year) and the Bull River (16.65 tons/year) contained the two highest sediment loads from unpaved road crossings. In the six watersheds, the majority of sediment load is generated from crossings on Federal land (42.0 tons/year, 300 crossings), followed by private land (18.4 tons/year, 80 crossings), and State land (0.1 tons/year, 5 crossings).

3.2 Sediment Load from Parallel Segments - Extrapolation to Watershed Scale

Mean sediment loads per mile per year were calculated for parallel road segments in White Pine Creek watershed, Marten Creek watershed and Elk Creek watershed as stated in **Section 2.6**. The annual sediment load from each parallel segment was normalized to a per mile sediment load (**Table 2-3**); the normalized results were averaged to represent the six watersheds (**Table 3-2**). Extrapolation of these results to the remainder of parallel segments assumes that the random subset of parallel segments assessed as part of this study is representative of the larger watershed. The results in **Section 2.6** show the dependence of the sediment load on road and buffer characteristics.

Table 3-2. Sediment Load Extrapolation From Unpaved Parallel Segments by HUC/303(d) Subwatershed – Existing Conditions

Watershed	Unpaved Roads w/in 100 ft of Stream (Mi)	Average Sediment Load per mile (t/y/mile)	Total Sediment Load (t/y)
Elk Creek[A]	6.78	0.843	5.72
Marten Creek	4.91	0.843	4.14
White Pine Creek	4.12	0.843	3.47
Bull River (without Dry Creek)	6.06	0.843	5.11
Dry Creek	0.79	0.843	0.67
Swamp Creek	0.99	0.843	0.83

[A]Elk Creek parallel segments had existing BMPs every 300 to 400 feet. The modeled results from WEPP: Road with the contributing length reduced to every 400 feet were utilized in the report and in this table.

3.3 Sediment Load from Road Crossings – USDA / NRCS Soil Hazard Classification

Soil types were downloaded from USDA – NRCS Soil Web Survey as a possible tool to predict where problem culverts may occur. Within the Soil Data Mart tool provided from USDA-NRCS, there is a Hazard of Erosion and Suitability for Roads on Forestland category from which the hazard of erosion on roads and trails is detailed for each soil type. The soils in the Lower Clark Fork TPA include a range of slight, moderate, and severe hazard classifications and the rating system is based on the soil erosion factor K, slope, and content of rock fragments of each soil component. Many of the road crossings were assessed on the same soil unit (e.g. four crossings were assessed on USDA NRCS soil map unit 112, severe hazard classification, Eutric Glossoboralfs, lacustrine terraces).

WEPP:Road sediment load results were compared to the specific soil identified in the USDA NRC soil survey. The average annual sediment load results were highest in the slight and moderate Soil Hazard Classifications. The results were compared to the WEPP:Roads input for traffic level, gravel surface addition, fillslope gradient, rock content, road length (**Figure 7**) and road gradient. Road gradient and rock fragment (of the native road surface) varied within a single soil type. The results from this study did not appear to correlate with hazard class, which is likely due to the greater sensitivity of the WEPP:road model to road length for the specific high-load crossings in the Lower Clark Fork TPA rather than to road gradient or to rock content per the USDA NRCS rating system.

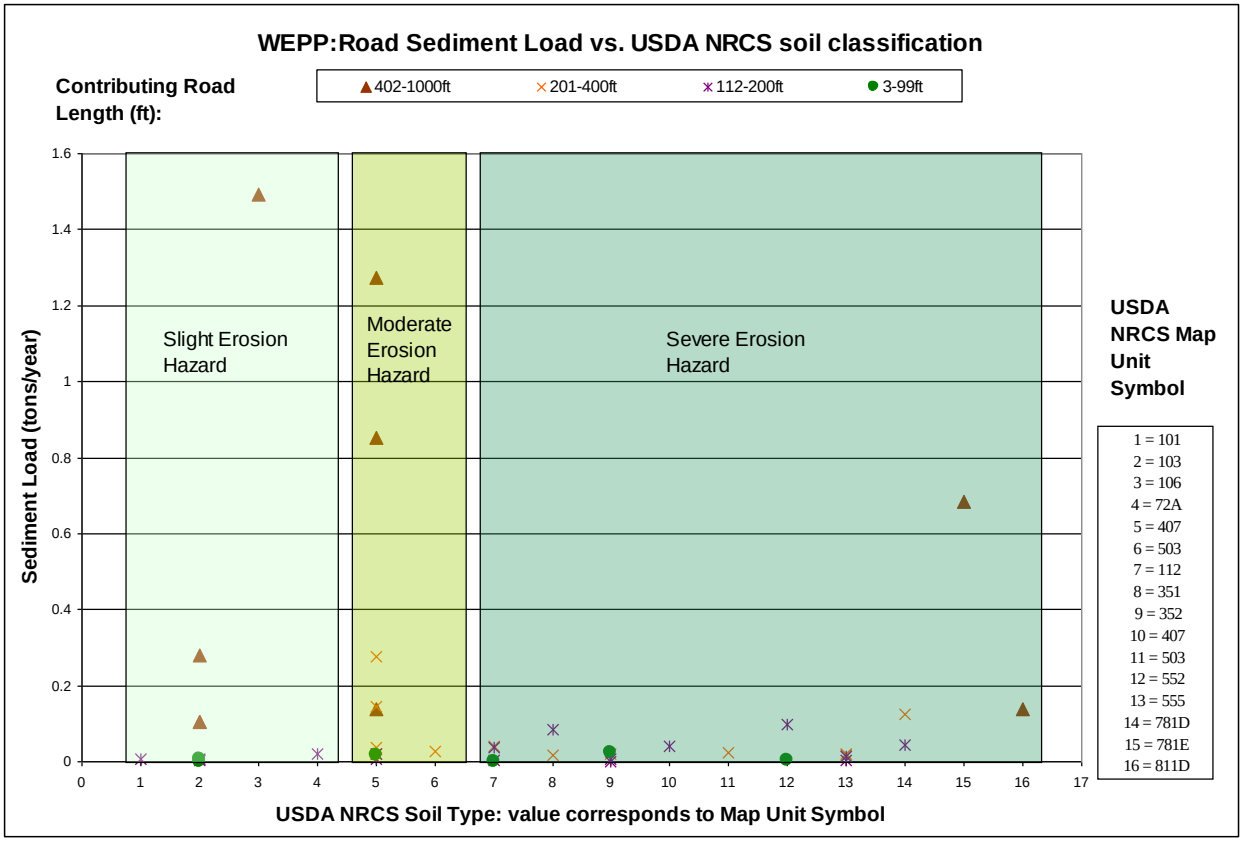


Figure 7. WEPP:Road Sediment Results for each USDA NRCS Soil Unit

3.4 Culvert Assessment – Fish Passage

Culverts were analyzed for their ability to allow for fish passage. Of the 43 field assessed road crossing sites, field sites with bridges, along with any sites where any of the required screening data could not be accurately collected were removed from the dataset. After removing these sites from the dataset, thirty five (35) culverts were determined to be suitable for fish passage assessment.

Measurements were collected at each field assessed crossing site, and these values were used to determine if culverts represented fish passage barriers at various flow conditions. The fish passage evaluation was completed using the criteria listed in Table 1 of the document *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska* (USFS, September 27, 2002). The analysis uses site-specific information to classify culverts as green (passing all life stages of salmonids), red (partial or total barrier to salmonids), or grey (needs additional analysis). Indicators used in the classification are the ratio of the culvert width to bankfull width (constriction ratio), culvert slope, and outlet drop, with large (>48-inches) and small (<48-inches) culvert groups evaluated differently. Failure of any one of the three indicators results in a red classification. Using the Alaska fish passage analysis, 33 of 35 culverts (94%) were classified as partial or total fish barriers, and 2 of 35 (6%) were classified as needing additional evaluation. None of the field assessed culverts were classified as

capable of passing fish at all flows and life stages (**Table 3-3**). The predominant cause for preventing fish passage was steep gradient across the culvert and minimal constriction ratios.

Table 3-3. Fish Passage Analysis for Selected Culverts Using Alaska Region Criteria

Culvert Classification or Indicator	Definition of Indicator	Number of Culverts	Percentage of Total Culverts Assessed (n = 35)
Green	High certainty of meeting juvenile fish passage at all flows	0	0%
Grey	Additional and more detailed analysis is required to determine juvenile fish passage ability	2	6%
Red	High certainty of not providing juvenile fish passage at all desired stream flows	33	94%

The eight crossings that could not be assessed for fish passage were due to the lack of a culvert (4 crossings: cattle guard, bridge, concrete pads, overland flow), bankfull width was not defined on a vegetated drainage swale (1 culvert) and the perch height of the culvert outlet was not recorded (3 culverts) due to the inability to see the outlet (steep gradients from 12 – 26%). The Montana Fish Wildlife & Parks (MFWP), GIS Layer *Fish Species Distribution – Streams* indicates that fish are present at only seven of the 43 stream crossing sites. GIS Metadata was updated 1999 – 2009 and notes that the absence of species on the GIS layer is not evidence of absence of fish in a stream. One of the seven crossings was not assessed for fish passage due to the presence of concrete pads; discussion of the remaining six sites are highlighted in a brown color in the comments section of **Table A-5.** Only 19 of the 35 culverts had visual stream flow during the visit. The flow was visually estimated and ranged from 0.2 cfs to 6 cfs. In addition to the six actively flowing and fish-bearing streams identified by MFWP, the 13 road crossings with active water flow are highlighted in yellow in the comments column in **Table A-5.**

4.0 APPLICATION OF BEST MANAGEMENT PRACTICES

Sediment impacts are widespread throughout the Lower Clark Fork River TMDL Planning Area, and sediment loading from the unpaved road network is one of several sources within the watershed. Application of Best Management Practices (BMPs) on the unpaved road network will result in a decrease in sediment loading to streams. BMP sediment reduction was evaluated based on a reduction in contributing road length.

The selected scenario for estimating sediment load reductions was calculated by assuming a uniform reduction in contributing road length to 200-feet for each unpaved crossing. Due to the extent of the unpaved road network and the resulting inability to assess it in its entirety, generalized assumptions are necessary for modeling the effects of BMPs. Restoration efforts would need to consider site-specific BMPs that, on average, would likely be represented by the modeling assumptions. Other management issues that will impact BMP scenarios are the ability to perform restoration work within the different land ownership categories.

4.1 Contributing Road Length Reduction Scenario

A contributing road length reduction scenario for road crossings was selected assuming a total road length reduction to 200 feet (100-feet on each road for a crossing with two contributing roads). On crossing locations in excess of this length reduction scenario, road lengths were reduced to the corresponding post-BMP scenario of 200-feet. No changes were made to crossing locations where the contributing road length was less than the 200-foot BMP reduction scenario. The 200-foot BMP scenario was evaluated using the WEPP:Road model, so potential sediment load reductions could be estimated. The results are shown in **Attachment E**. Average annual reduced mean sediment loads were then extrapolated to the entire watershed in the same manner in which the existing sediment loads were calculated. Estimated summary load reductions by watershed are show in **Table 4-1**. Detailed calculations are shown in **Table A-6.**

Table 4-1. Extrapolated Sediment Load Summary from Unpaved Road Crossings – Road Length Reduction

Watershed	Total Number of Sites	Existing Conditions - Total Sediment Load (t/y)	BMP Conditions - Total Sediment Load (t/y)	Load Reduction %
Bull River	111	16.65	4.91	71%
Dry Creek	17	2.38	0.68	71%
Elk Creek	98	17.86	5.30	70%
Marten Creek	82	11.66	3.34	71%
Swamp Creek	15	2.91	0.87	70%
White Pine Creek	62	9.04	2.60	71%

Total sediment load from road crossings would be approximately 70%, assuming all sites were fully BMP'd.

Parallel segments were modeled with a road length reduction to 400 feet (**Attachment E**). The presence of BMPs was noted in the Elk Creek watershed and WEPP:Road results from Attachment D were utilized for watershed extrapolation in **Table 3-2**. Further extrapolation is possible through a uniform road length reduction of Marten Creek (0.003 tons/mile/year) and White Pine Creek (0.072 tons/mile/year) segments. This would result in an average normalized sediment yield of 0.797 tons/year/mile across all parallel segments assessed in the field with contributing road lengths less than 400 feet.

4.2 Assessment of Existing BMPs

As an alternative to or in combination with reductions in contributing road length, other potential BMPs are available that would reduce sediment loading from the unpaved road network. Road sediment reduction strategies such as 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 are all BMPs that would lead to reduced sediment loading from the road network.

The presence of BMPs was noted for each of the field-assessed stream crossing sites. Of the 43 sites, 25 had at least one of the following: graveled surface, water bar, culvert drain, or drive through dip. Sample sizes for each category are included in the legend on the graph. Results are shown in **Figure 8**.

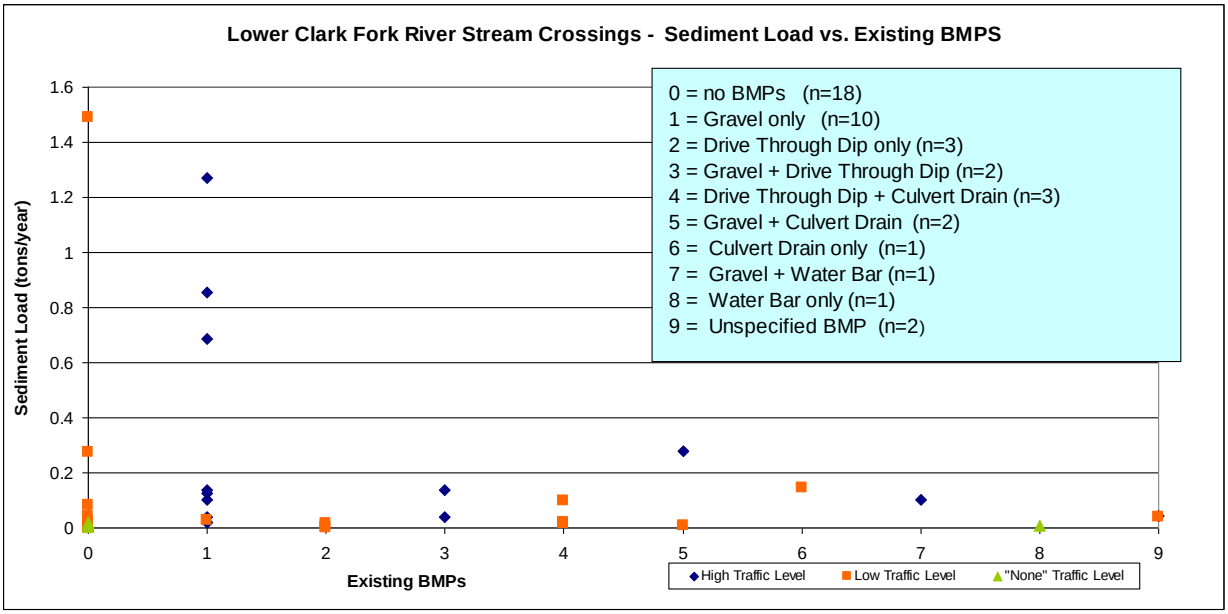


Figure 8. WEPP:Road Sediment Results for each BMP Category

The sediment yield for each crossing was impacted by the road surface (gravel or native) and the traffic level (high, low or none) in the WEPP model. Conclusions from Figure 8 are preliminary due to the small sample sizes; however it appears that the minimized traffic reduces sediment yield regardless of the presence of BMPs (with the exception of the Dry Creek crossing which had a significant road length (700 feet) and road gradient (15%). The presence of gravel did not appear to decrease sediment yield; however this may be due more to traffic level than to the presence of gravel, as noted in the comparison of the following categories: 0&1, 2&3, and 5&6. Drive-through dips, culvert drains and water bars appeared to be equally effective for the Lower Clark Fork River assessed crossings. WEPP software does not allow for specific modeling of BMPs and the results may not completely indicate effectiveness.

5.0 QUALITY ASSURANCE / QUALITY CONTROL RESULTS

5.1 Representativeness

Representativeness refers to the extent to which measurements represent an environmental condition in time and space. Spatial representation was achieved through the Lower Clark Fork Roads field assessment. Fifty sites were randomly selected through GIS based on watershed and ownership categories with the intent that at least forty sites would be assessed. A total of 43 road crossings were assessed in the field. Spatial representation is shown in **Table A-3**. Adequate coverage of Federal and State ownership was achieved in the six watersheds. Only three crossings were assessed on privately owned land out of a total of 80 crossings. The average sediment yield for crossings on private land may warrant additional research.

All forty-three field sites were located on Kootenai National Forest Road Classes: 2 – Restricted / Legally Gated Admin Use, and 4 – Open During Bear Season. Class 1 and 3 roads were not assessed with this report.

The single crossing evaluated in Dry Creek contributed the most significant sediment load (1.49 tons/year) of the assessed sites due to the road length (700 feet) and high road gradient (15%). Additional investigation may be warranted in this watershed since the annual sediment load is much greater than the average annual sediment load on Federal property.

Temporal variations were not accounted for in this study, as the field data collected at road crossing locations does not change during the year.

5.2 Comparability

Comparability is the applicability of the project's data to the WEPP:Road model input data. The WEPP:Road model includes a high and low data value for each input parameter. Field data was compared to the model input range and those sites with data outside these ranges were flagged for additional evaluation through the review of photographs, field comments, personal communication and other field data. No sites were determined to be unacceptable for use in the model. A review of comparability of field data is shown in **Table A-7**.

5.3 Completeness

Completeness is a measure of the amount of data prescribed for assessment activities and the usable data actually collected, expressed as a percentage.

Completeness as % = (No. Valid Data Points or Samples / Total # Data Points or Samples) x 100

The overall project goal is 90% completeness. A total of 43 sites were assessed in the field. As documented in **Table A-7**, and **Attachment C,** all sites were deemed valid through data adjustments based on comments, phone conversations with the field crew and through analysis of photographs for input into the WEPP:Road model. This equates to a completeness of 100%.

6.0 REFERENCES

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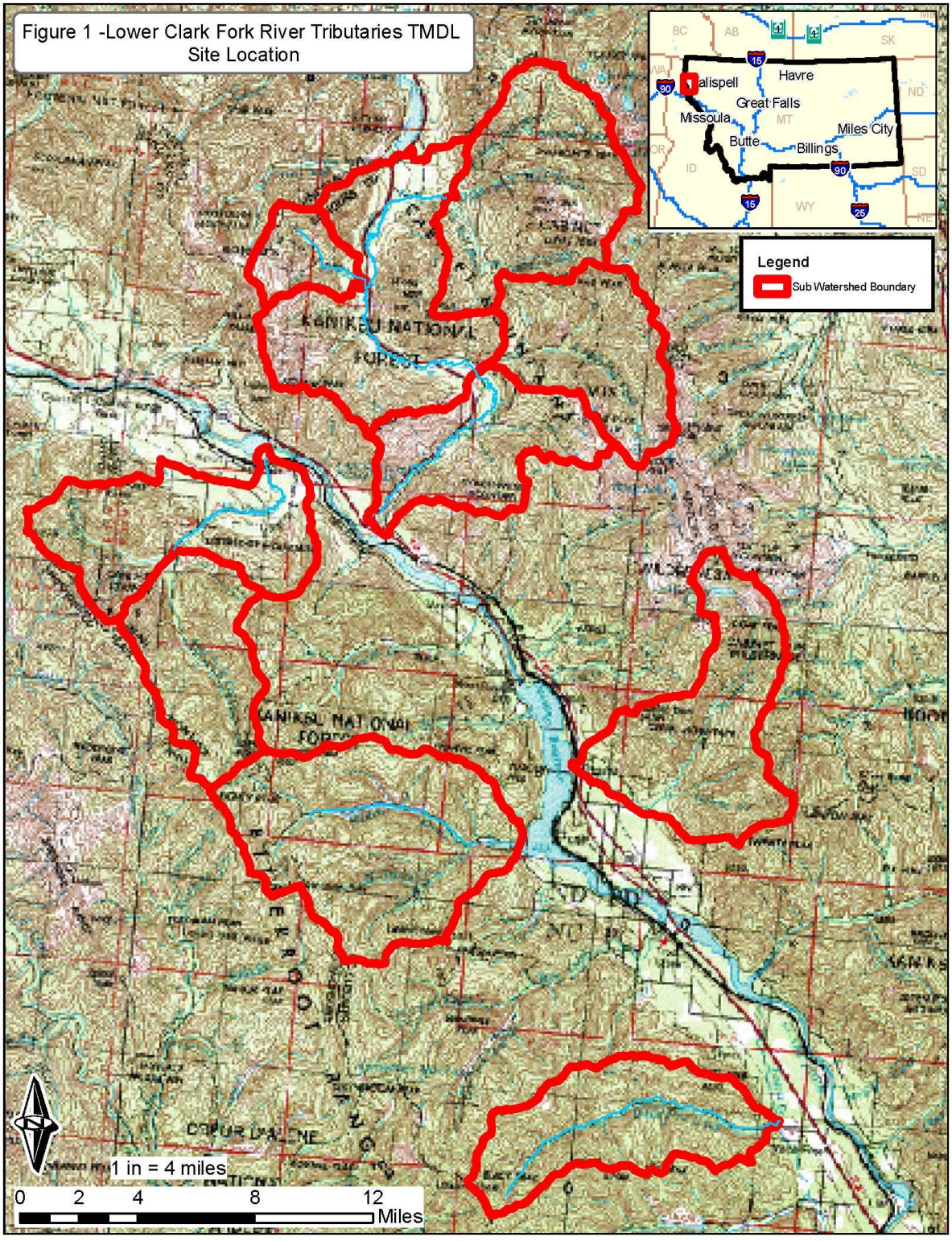
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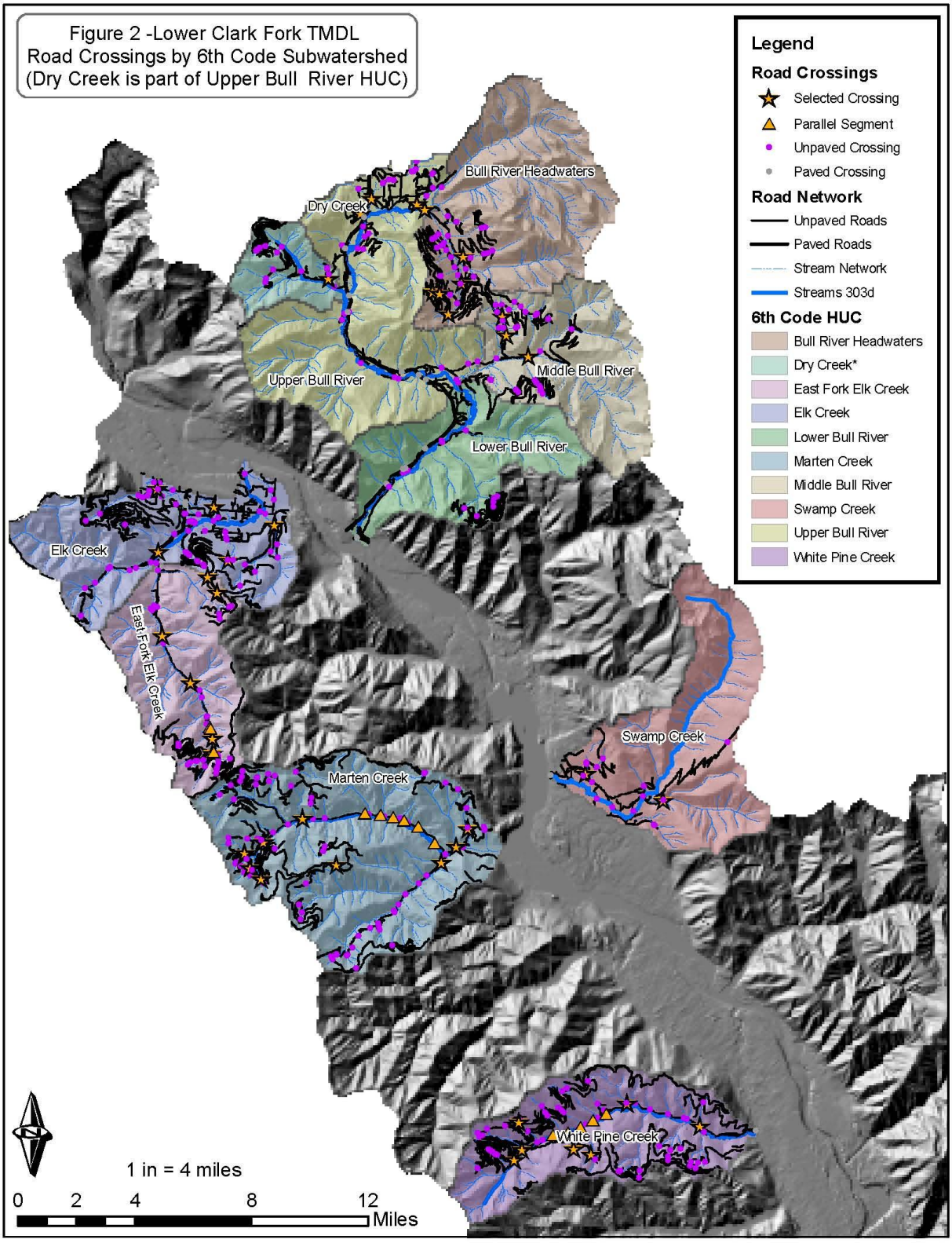
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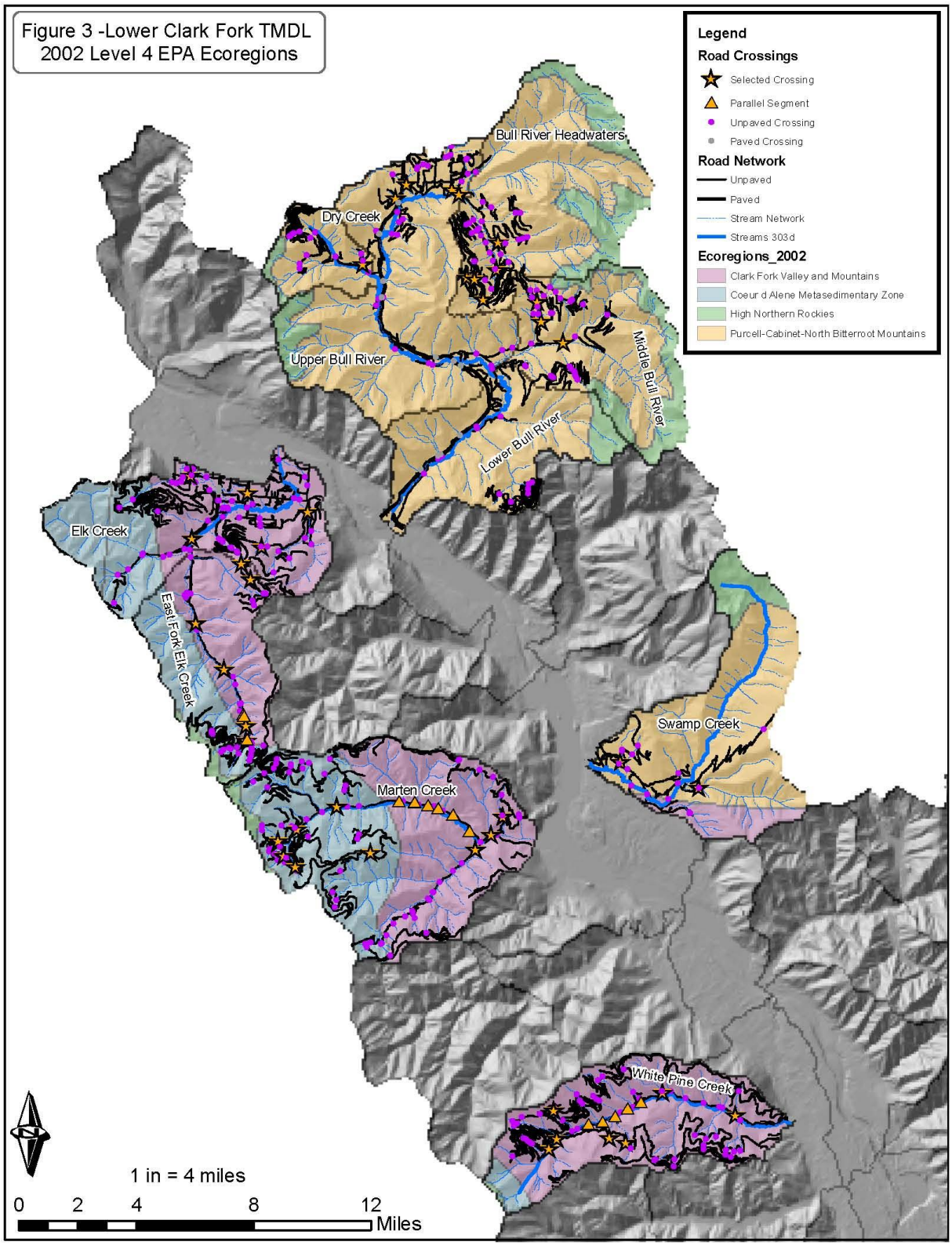
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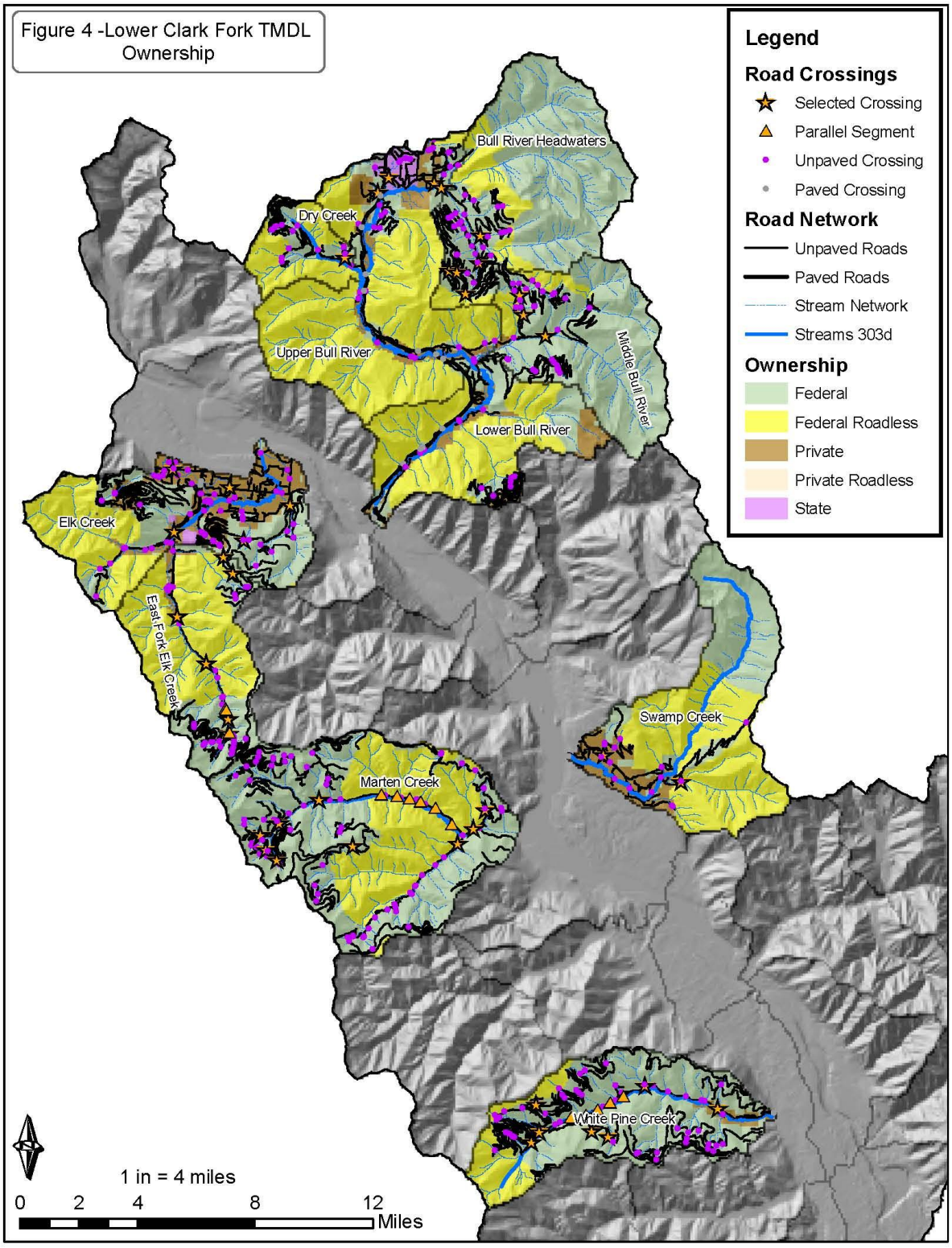
Traction Sand Material Safety Data Sheet, 2006, http://lanemt.com/msds.htm, last assessed March, 11, 2009.

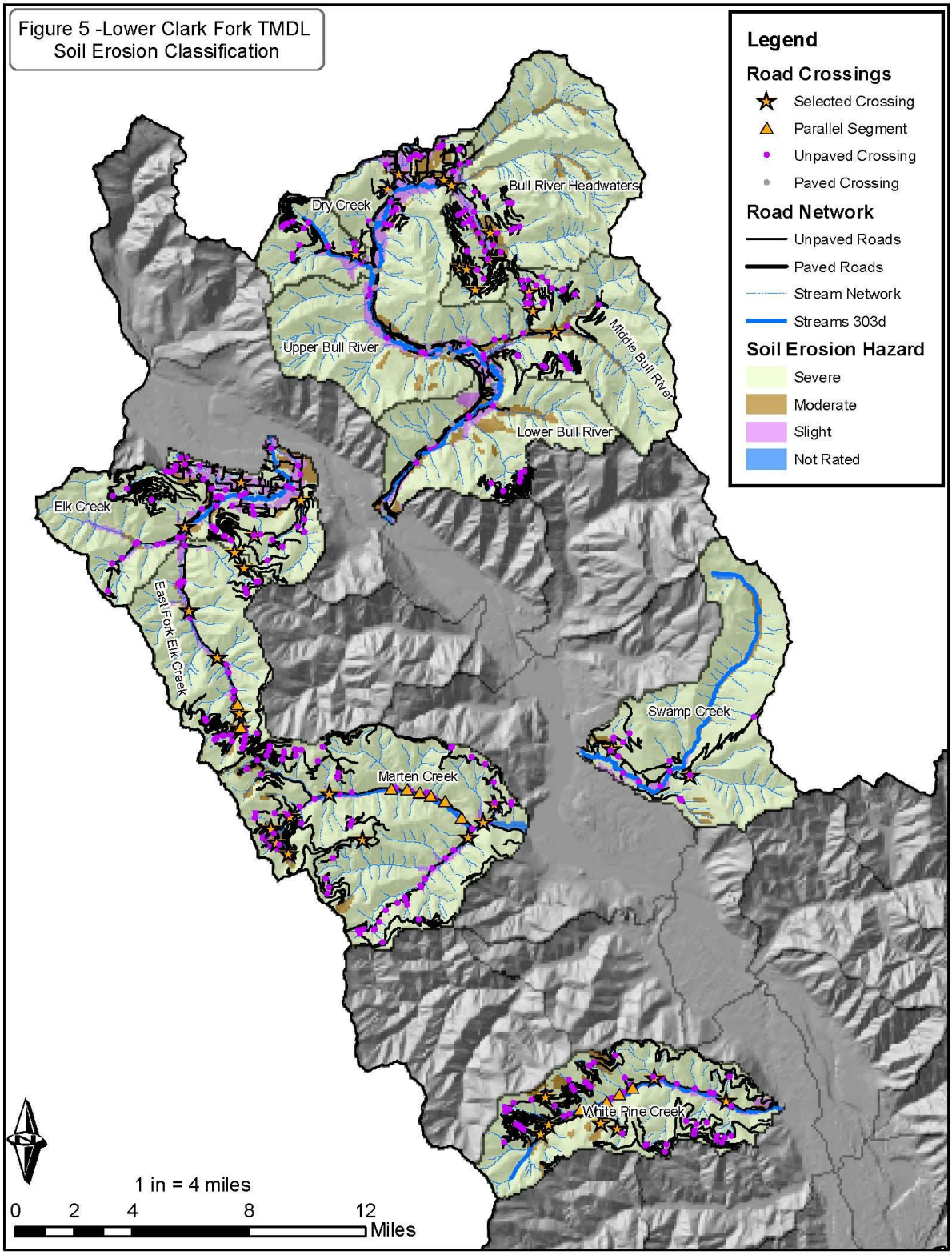
FIGURES

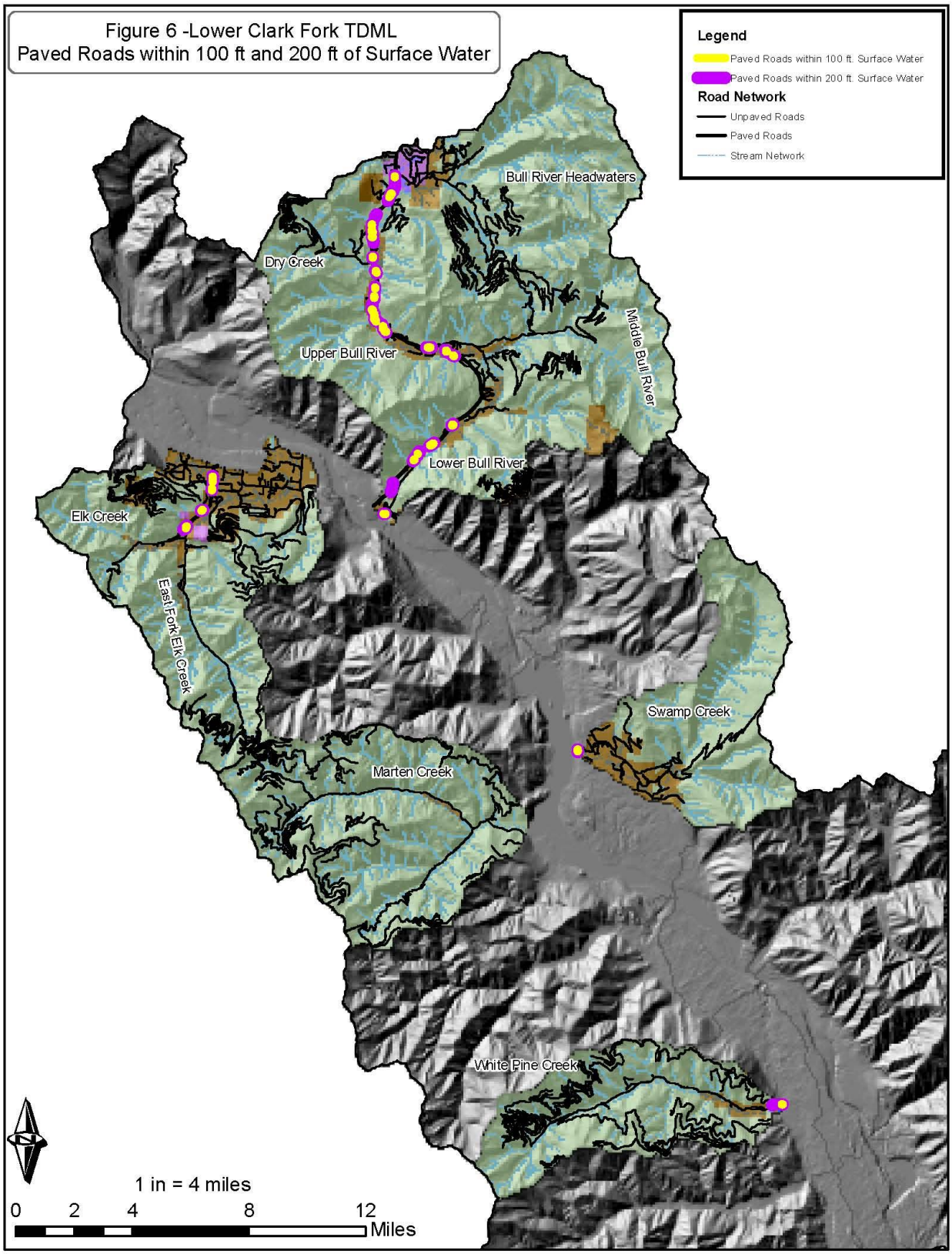

Figure 1 -Lower Clark Fork River Tributaries TMDL Site Location
Havre
Great Falls
Missoula
Butte
Billings
Miles City
Legend
Sub Watershed Boundary
1 in = 4 miles
0 2 4 8 12
Miles


Figure 2 -Lower Clark Fork TMDL
Road Crossings by 6th Code Subwatershed
(Dry Creek is part of Upper Bull River HUC)
Legend
Road Crossings
Selected Crossing
Parallel Segment
Unpaved Crossing
Paved Crossing
Road Network
Unpaved Roads
Paved Roads
Stream Network
Streams 303d
6th Code HUC
Bull River Headwaters
Dry Creek*
East Fork Elk Creek
Elk Creek
Lower Bull River
Marten Creek
Middle Bull River
Swamp Creek
Upper Bull River
White Pine Creek
Bull River Headwaters
Dry Creek
Upper Bull River
Middle Bull River
Lower Bull River
Elk Creek
East Fork Elk Creek
Marten Creek
Swamp Creek
White Pine Creek
1 in = 4 miles
0 2 4 8 12
Miles


Figure 3 -Lower Clark Fork TMDL
2002 Level 4 EPA Ecoregions
Legend
Road Crossings
Selected Crossing
Parallel Segment
Unpaved Crossing
Paved Crossing
Road Network
Unpaved
Paved
Stream Network
Streams 303d
Ecoregions_2002
Clark Fork Valley and Mountains
Coeur d Alene Metasedimentary Zone
High Northern Rockies
Purcell-Cabinet-North Bitterroot Mountains
Bull River Headwaters
Dry Creek
Upper Bull River
Middle Bull River
Lower Bull River
Elk Creek
East Fork Elk Creek
Swamp Creek
Marten Creek
White Pine Creek
1 in = 4 miles
0 2 4 8 12
Miles


Figure 4 -Lower Clark Fork TMDL Ownership
Legend
Road Crossings
Selected Crossing
Parallel Segment
Unpaved Crossing
Paved Crossing
Road Network
Unpaved Roads
Paved Roads
Stream Network
Streams 303d
Ownership
Federal
Federal Roadless
Private
Private Roadless
State
Bull River Headwaters
Dry Creek
Upper Bull River
Middle Bull River
Lower Bull River
Elk Creek
East Fork Elk Creek
Swamp Creek
Marten Creek
White Pine Creek
1 in = 4 miles
0 2 4 8 12
Miles


Figure 5 -Lower Clark Fork TMDL
Soil Erosion Classification
Legend
Road Crossings
Selected Crossing
Parallel Segment
Unpaved Crossing
Paved Crossing
Road Network
Unpaved Roads
Paved Roads
Stream Network
Streams 303d
Soil Erosion Hazard
Severe
Moderate
Slight
Not Rated
Bull River Headwaters
Dry Creek
Upper Bull River
Middle Bull River
Lower Bull River
Elk Creek
East Fork Elk Creek
Swamp Creek
Marten Creek
White Pine Creek
1 in = 4 miles
0 2 4 8 12
Miles


Figure 6 -Lower Clark Fork TDML
Paved Roads within 100 ft and 200 ft of Surface Water
Legend
Paved Roads within 100 ft. Surface Water
Paved Roads within 200 ft. Surface Water
Road Network
Unpaved Roads
Paved Roads
Stream Network
Bull River Headwaters
Dry Creek
Upper Bull River
Middle Bull River
Lower Bull River
Elk Creek
East Fork Elk Creek
Swamp Creek
Marten Creek
White Pine Creek
1 in = 4 miles
0 2 4 8 12
Miles

ATTACHMENT A

Attached Tables

Table A-1. Sediment Listed Stream Segments – Lower Clark Fork River TPA

Waterbody MT76N003_()	**Stream Length (mi)**	**Most Recent 303(d) Listing**	**Impairment Listing**	**Probable Causes**
Bull River (040)	24.7	2008	Sediment/Siltation, Physical substrate habitat alterations	▪ Silviculture Activities ▪ Streambank Modifications / destabilization
Dry Creek (180)	3.5	2008	Sediment/Siltation	▪ Forest Roads (Road Construction and Use)
Marten Creek (090)	6.7	2008	Sediment/Siltation, Physical substrate habitat alterations	▪ Forest Roads (Road Construction and Use) ▪ Silviculture Activities ▪ Streambank Modifications / destabilization
White Pine Creek (120)	11.9	2008	Sediment/Siltation Alteration in stream-side or littoral vegetative covers	▪ Forest Roads (Road Construction and Use) ▪ Grazing in Riparian or Shoreline Zones ▪ Natural Sources ▪ Silviculture ▪ Streambank Modifications/destabilization ▪ Watershed Runoff following Forest Fire
Elk Creek (060)	8.1	2006	Sediment/Siltation	▪ Grazing in Riparian or Shoreline Zones ▪ Habitat Modification – other than Hydromodification
Swamp Creek (160)	13.9	2006	Sediment/Siltation	▪ Insufficient data to assess

Table A-2. Road Summary by Subwatershed, Land Ownership, USDA NRCS Soil Erosion Hazard Classification and Road Type

Table. A-2a. Lower Clark Fork Tributaries 303(d) Listed Streams Road Summary by 6th Code Subwatershed (USGS HUC 12)

6th Code Subwatershed (USGS HUC 12)	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 100 ft Streams (Mi)	Total Unpaved Road Density w/in 100 ft of Streams (Mi/Mi^2)
Bull River Headwaters	43.10	97.85	35	0.81	0	35	51.40	1.19	100%	1.12	0.03
Lower Bull River	41.57	68.48	13	0.31	5	18	44.96	1.08	81.2%	1.04	0.02
Middle Bull River	28.65	61.97	30	1.05	0	30	43.14	1.51	100%	1.83	0.06
Upper Bull River (without Dry Creek)	76.34	148.09	33	0.43	7	40	53.07	0.70	81.3%	2.08	0.03
Dry Creek	14.13	31.68	17	1.20	0	17	26.36	1.86	100%	0.79	0.06
Bull River Watershed	203.79	408.07	128	0.63	12	140	218.93	1.07	91.6%	6.86	0.03
East Fork Elk Creek	41.82	84.02	39	0.93	0	39	49.17	1.18	100%	3.23	0.08
Elk Creek	42.54	76.00	59	1.39	5	64	113.29	2.66	97.0%	3.55	0.08
Elk Creek Watershed	84.36	160.02	98	1.16	5	103	162.46	1.93	97.9%	6.78	0.08
Marten Creek	71.06	143.52	82	1.15	0	82	133.99	1.89	100%	4.91	0.07
Swamp Creek	54.67	98.21	15	0.27	1	16	31.24	0.57	99.5%	0.99	0.02
White Pine Creek	36.19	70.90	62	1.71	1	63	117.98	3.26	99.7%	4.12	0.11

Table A-2b. Road Summary by Land Ownership

Sub Watershed	Land Ownership	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 100 ft Streams (Mi)	Total Unpaved Road Density w/in 100 ft of Streams (Mi/Mi^2)
Bull River - Headwaters Lower Bull River Middle Bull River Upper Bull River	Federal	122.75	249.62	85	0.69	1	86	141.22	1.15	96%	4.07	0.03
	Federal-Roadless	55.98	93.12	2	0.04	0	2	1.24	0.02	90%	0.23	0.00
	Private - Roadless	0.09	0.08	0	0.00	0	0	0.43	4.75	7%	0.00	0.00
	Private	9.25	29.86	19	2.05	11	30	41.38	4.47	71%	1.13	0.12
	State	1.60	3.70	5	3.13	0	5	8.31	5.20	93%	0.62	0.39
	Total	189.67	376.38	111	0.59	12	123	192.57	1.02	90%	6.06	0.03
Dry Creek	Federal	8.47	18.87	15	1.77	0	15	25.87	3.05	100%	0.77	0.09
	Federal-Roadless	5.66	12.51	2	0.35	0	2	0.49	0.09	100%	0.03	0.00
	Private - Roadless	0.00	0.00	0	0.00	0	0	0.00	0.00	N/A	0.00	0.00
	Private	0.01	0.29	0	0.00	0	0	0.00	0.00	N/A	0.00	0.00
	State	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	14.13	31.67	17	1.20	0	17	26.36	1.86	100%	0.79	0.06
East Fork Elk Creek Elk Creek	Federal	46.14	81.18	52	1.13	1	53	95.97	2.08	100%	3.93	0.09
	Federal-Roadless	26.68	47.62	0	0.00	0	0	1.36	0.05	100%	0.04	0.00
	Private - Roadless	0.02	0.04	0	0.00	0	0	0.00	0.00	N/A	0.00	0.00
	Private	11.21	31.18	46	4.10	4	50	65.12	5.81	95%	2.80	0.25
	State	0.32	0.00	0	0.00	0	0	0.00	N/A	N/A	0.00	0.00
	Total	84.36	160.02	98	1.16	5	103	162.46	1.93	98%	6.78	0.08
Marten Creek	Federal	51.58	103.20	79	1.53	0	79	131.07	2.54	100%	4.77	0.09
	Federal-Roadless	19.26	38.72	1	0.05	0	1	1.63	0.08	100%	0.03	0.00
	Private - Roadless	0.00	0.00	0	0.00	0	0	0.00	0.00	N/A	0.00	0.00
	Private	0.21	1.60	2	9.39	0	2	1.30	6.09	100%	0.10	0.48
	State	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	71.06	143.52	82	1.15	0	82	133.99	1.89	100%	4.91	0.07
Swamp Creek	Federal	31.34	52.64	6	0.19	0	6	12.03	0.38	100%	0.29	0.01
	Federal-Roadless	18.87	36.68	0	0.00	0	0	0.34	0.02	100%	0.00	0.00
	Private - Roadless	0.01	0.01	0	0.00	0	0	0.00	0.00	N/A	0.00	0.00
	Private	4.45	8.88	9	2.02	1	10	18.87	4.24	99%	0.70	0.16
	State	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	54.67	98.21	15	0.27	1	16	31.24	0.57	99%	0.99	0.02
White Pine Creek	Federal	30.21	57.62	56	1.85	0	56	113.82	3.77	100%	3.92	0.13
	Federal-Roadless	5.00	9.23	2	0.40	0	2	0.76	0.15	100%	0.04	0.01
	Private - Roadless	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Private	0.99	4.05	4	4.06	1	5	3.41	3.46	91%	0.16	0.16
	State	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	36.19	70.90	62	1.71	1	63	117.98	3.26	100%	4.12	0.11

Table A-2c. Road Summary by USDA – NRCS Soil Erosion Hazard Classification

Sub Watershed	Soil Hazard Classification	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 100 ft Streams (Mi)	Total Unpaved Road Density w/in 100 ft of Streams (Mi/Mi^2)
Bull River Headwaters Lower Bull River Middle Bull River Upper Bull River	Moderate	11.20	37.79	26	2.32	2	28	33.98	3.03	84.9%	1.12	0.10
	Severe	168.91	287.69	61	0.36	2	63	130.11	0.77	96.2%	3.26	0.02
	Slight	9.32	48.89	24	2.57	7	31	28.45	3.05	71.1%	1.68	0.18
	Not Rated	0.23	2.01	0	0.00	1	1	0.03	0.15	48.1%	0.00	0.00
	Total	189.67	376.39	111	0.59	12	123	192.57	1.02	90.5%	6.06	0.03
Dry Creek	Moderate	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Severe	13.16	25.78	14	1.06	0	14	23.63	1.80	100%	0.60	0.05
	Slight	0.97	5.90	3	3.08	0	3	2.72	2.79	100%	0.19	0.19
	Not Rated	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	14.13	31.68	17	1.20	0	17	26.36	1.86	100%	0.79	0.06
East Fork Elk Creek Elk Creek	Moderate	1.92	5.36	11	5.72	0	11	9.00	4.68	100%	0.96	0.50
	Severe	76.45	119.57	58	0.76	3	61	129.51	1.69	98.6%	4.07	0.05
	Slight	5.89	34.24	29	4.92	2	31	23.95	4.07	93.3%	1.75	0.30
	Not Rated	0.10	0.85	0	0.00	0	0	0.00	0.03	100%	0.00	0.00
	Total	84.36	160.02	98	1.16	5	103	162.46	1.93	97.9%	6.78	0.08
Marten Creek	Moderate	1.50	8.12	11	7.32	0	11	9.89	6.58	100%	0.84	0.56
	Severe	67.11	112.98	52	0.77	0	52	113.57	1.69	100%	2.71	0.04
	Slight	2.10	20.38	18	8.56	0	18	10.40	4.95	100%	1.32	0.63
	Not Rated	0.35	2.03	1	2.89	0	1	0.14	0.39	100%	0.04	0.11
	Total	71.06	143.52	82	1.15	0	82	133.99	1.89	100%	4.91	0.07
Swamp Creek	Moderate	2.09	12.57	0	0.00	0	0	0.99	0.47	100%	0.00	0.00
	Severe	51.67	80.53	12	0.23	0	12	28.91	0.56	99.6%	0.92	0.02
	Slight	0.69	3.91	3	4.32	0	3	1.28	1.85	100%	0.07	0.10
	Not Rated	0.21	1.20	0	0.00	1	1	0.05	0.22	0%	0.00	0.00
	Total	54.67	98.21	15	0.27	1	16	31.24	0.57	99.5%	0.99	0.02
White Pine Creek	Moderate	2.51	6.43	8	3.18	0	8	9.23	3.67	100%	1.19	0.47
	Severe	32.38	52.24	43	1.33	0	43	103.21	3.19	100%	1.90	0.06
	Slight	1.30	12.23	11	8.49	1	12	5.54	4.28	94.6%	1.03	0.80
	Not Rated	0.00	0.00	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	Total	36.19	70.90	62	1.71	1	63	117.98	3.26	99.7%	4.12	0.11

Table A-2d. Road Summary by Road Type

Sub Watershed	Road Type	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 100 ft Streams (Mi)	Total Unpaved Road Density w/in 100 ft of Streams (Mi/Mi^2)
Bull River Headwaters Lower Bull River Middle Bull River Upper Bull River	1 - Impassable to motorized vehicles	N/A	N/A	39	N/A	0	39	65.34	N/A	100%	1.86	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	12	N/A	0	12	22.16	N/A	100%	0.83	N/A
	3 - Barriered / legally no admin use	N/A	N/A	15	N/A	0	15	24.84	N/A	100%	0.69	N/A
	4 - Open during bear season	N/A	N/A	45	N/A	12	57	80.24	N/A	77.1%	2.68	N/A
	Total	189.67	376.39	111	0.59	12	123	192.57	1.02	90.5%	6.06	0.032
Dry Creek	1 - Impassable to motorized vehicles	N/A	N/A	13	N/A	0	13	21.46	N/A	100%	0.52	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	3 - Barriered / legally no admin use	N/A	N/A	1	N/A	0	1	2.81	N/A	100%	0.04	N/A
	4 - Open during bear season	N/A	N/A	3	N/A	0	3	2.08	N/A	100%	0.23	N/A
	Total	14.13	31.68	17	1.20	0	17	26.36	1.86	100%	0.79	0.056
East Fork Elk Creek Elk Creek	1 - Impassable to motorized vehicles	N/A	N/A	15	N/A	0	15	27.70	N/A	100%	0.90	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	11	N/A	0	11	27.44	N/A	100%	0.53	N/A
	3 - Barriered / legally no admin use	N/A	N/A	3	N/A	0	3	9.06	N/A	100%	0.26	N/A
	4 - Open during bear season	N/A	N/A	69	N/A	5	74	98.26	N/A	96.6%	5.09	N/A
	Total	84.36	160.02	98	1.16	5	103	162.46	1.93	97.9%	6.78	0.080
Marten Creek	1 - Impassable to motorized vehicles	N/A	N/A	26	N/A	0	26	62.07	N/A	100%	1.78	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	21	N/A	0	21	23.73	N/A	100%	1.35	N/A
	3 - Barriered / legally no admin use	N/A	N/A	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	4 - Open during bear season	N/A	N/A	35	N/A	0	35	48.19	N/A	100%	1.78	N/A
	Total	71.06	143.52	82	1.15	0	82	133.99	1.89	100%	4.91	0.069
Swamp Creek	1 - Impassable to motorized vehicles	N/A	N/A	0	N/A	0	0	0.39	N/A	100%	0.00	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	1	N/A	0	1	6.61	N/A	100%	0.02	N/A
	3 - Barriered / legally no admin use	N/A	N/A	0	N/A	0	0	0.00	N/A	N/A	0.00	N/A
	4 - Open during bear season	N/A	N/A	14	N/A	1	15	24.24	N/A	99.3%	0.97	N/A
	Total	54.67	98.21	15	0.27	1	16	31.24	0.57	99.5%	0.99	0.018
White Pine Creek	1 - Impassable to motorized vehicles	N/A	N/A	19	N/A	0	19	53.44	N/A	100%	0.76	N/A
	2 - Restricted / Legally gated admin use	N/A	N/A	19	N/A	0	19	26.19	N/A	100%	0.77	N/A
	3 - Barriered / legally no admin use	N/A	N/A	0	N/A	0	0	1.39	N/A	100%	0.00	N/A
	4 - Open during bear season	N/A	N/A	24	N/A	1	25	36.96	N/A	98.9%	2.59	N/A
	Total	36.19	70.90	62	1.71	1	63	117.98	3.26	99.7%	4.12	0.114

Table A-3. Proposed Field Sites and Actual Assessed Field Sites

Sub Watershed	Land Ownership	Number of Field Sites Randomly Selected	Number of Assessed Sites		Soil Erosion Hazard Classification	Number of Field Sites Randomly Selected	Number of Assessed Sites
Bull River - Headwaters Lower Bull River Middle Bull River Upper Bull River	Federal	11	11		Moderate	11	11
	Federal-Roadless	0	0				
	Private - Roadless	0	0				
	Private	2	0				
	State	1	1		Severe	25	22
	Total	14	12				
Dry Creek	Federal	2	1				
	Federal-Roadless	0	0				
	Private - Roadless	0	0		Slight	14	10
	Private	0	0				
	State	0	0				
	Total	2	1				
East Fork Elk Creek Elk Creek	Federal	7	9		Not Rated	0	0
	Federal-Roadless	0	0				
	Private - Roadless	0	0				
	Private	6	2				
	State	0	0				
	Total	13	11				
Marten Creek	Federal	11	10		**Road Type Classification**	**Number of Field Sites Randomly Selected**	**Number of Assessed Sites**
	Federal-Roadless	0	0		1 - Impassable to motorized vehicles	8	0
	Private - Roadless	0	0				
	Private	0	0				
	State	0	0				
	Total	11	10		2 - Restricted / Legally gated admin use	9	8
Swamp Creek	Federal	1	1				
	Federal-Roadless	0	0				
	Private - Roadless	0	0				
	Private	1	1		3 - Barriered / legally no admin use	1	0
	State	0	0				
	Total	2	2				
White Pine Creek	Federal	7	7				
	Federal-Roadless	0	0		4 - Open during bear season	32	35
	Private - Roadless	0	0				
	Private	1	0				
	State	0	0				
	Total	8	7				

Table A-4. Detailed Extrapolated Sediment Load From Unpaved Road Crossings by HUC/303(d) Subwatershed – Existing Conditions

Sub Watershed	Land Ownership	Unpaved Crossings	Field Assessed Crossings	Average Sediment Load (t/y)	Total Sediment Load (t/y)
Bull River -Headwaters Lower Bull River Middle Bull River Upper Bull River	Federal	85	11	0.14	11.90
	Federal-Roadless	2	0	0.14	0.28
	Private	19	0	0.23	4.37
	State	5	1	0.02	0.10
	Total	111	12	N/A	16.65
Dry Creek	Federal	15	1	0.14	2.10
	Federal-Roadless	2	0	0.14	0.28
	Private	0	0	0.23	0
	State	0	0	0.02	0
	Total	17	1	N/A	2.38
East Fork Elk Creek Elk Creek	Federal	52	9	0.14	7.28
	Federal-Roadless	0	0	0.14	0
	Private	46	2	0.23	10.58
	State	0	0	0.02	0
	Total	98	11	N/A	17.86
Marten Creek	Federal	79	10	0.14	11.06
	Federal-Roadless	1	0	0.14	0.14
	Private	2	0	0.23	0.46
	State	0	0	0.02	0
	Total	82	10	N/A	11.66
Swamp Creek	Federal	6	0	0.14	0.84
	Federal-Roadless	0	0	0.14	0
	Private	9	1	0.23	2.07
	State	0	0	0.02	0
	Total	15	1	N/A	2.91
White Pine Creek	Federal	56	7	0.14	7.84
	Federal-Roadless	2	0	0.14	0.28
	Private	4	0	0.23	0.92
	State	0	0	0.02	0
	Total	62	7	N/A	9.04

Table A-5. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria

Location ID	Structure Type	Structure Diameter or Dimensions (ft)	Width	Culvert Slope	Bf in Riffle Above Culvert (ft)	Culvert/ BF ratio	Perch	Streambed Materials in Culvert	Final Classification	Notes/Comments
Fish passage evaluation criteria: Circular CMP 48" span and smaller										
BRH-FS-10	Steel	1.5	1.5	4	13	0.12	0	No	RED	Culvert extensions on downstream side- water chute- note pic 1785
MC-FS-25	Steel	1.5	1.5	7	3	0.50	0	Yes	RED	Seasonal flows, no flow currently
WPC-FS-35	Steel	1.5	1.5	2	13	0.12	0	No	RED	small wetland area above culvert, flow 0.5 cfs
UBR-FS-06	Steel	2	2	2	20	0.10	0	Yes	RED	Good flow sed contribution at downstream end.
BRH-FS-09	Steel	2	2	3	12	0.17	0	No	RED	Culvert offset 3ft to main entry flow 2-3 cfs
BRH-FS-11	Steel	2	2	3	5	0.40	20	No	RED	Several channels above culvert, 1 cfs. Well vegetated- giant cedar grove
MC-FS-16	Steel	2	2	6	12	0.17	1.5	No	RED	No Flow, seasonal
WPC-FS-29	Steel	2	2	25	4	0.50	1	No	RED	Flow; seasonal dry
WPC-FS-32	Steel	2	2	4	14	0.14	72	No	RED	Trickle: 0.25-0.50 cfs/ heavy veg/ particially blockade debris
EC-P-36	Steel	2	2	1	10	0.20	0	No	RED	Potholes at crossing, erosion both fill areas, trickle flow.
UBR-FS-05	Steel	2.5	2.5	2	17	0.15	6	No	RED	Major contributions at fill areas from road.
MC-FS-23	Steel	2.5	2.5	2	10	0.25	0	No	RED	No flow, seasonal high amount of debris - upstream area and veg.
UBR-S-04	Steel	3	3	1	18	0.17	0	Yes	RED	drains between two wetlands, low vel flow
BRH-FS-12	Steel	3	3	5	18	0.17	24	No	RED	-
MBR-FS-15	Steel	3	3	4	14	0.21	3	-	RED	Pond 2.5 ft deep, downstream
MC-FS-17	Steel	3	3	3	24	0.13	0	No	RED	1-2 cfs
MC-FS-19	Steel	3	3	5	11	0.27	5	No	RED	1-2 cfs, rocked up and downstream, recently installed culvert
MC-FS-21	Steel	3	3	5	10	0.30	3	No	RED	Recently Installed, no veg on fill, erosion present, 2-3 cfs.
MC-FS-22	Steel	3	3	2	14	0.21	2.5	No	RED	Well rocked upstream, 1-2 cfs, some erosion downstream on fill
MC-FS-24	2-Stl	3	3	1	20	0.15	0	No	RED	1-has flow, 3-4 cfs
EC-FS-28	Steel	3	3	30	8	0.38	0	No	RED	0.5 - 1 cfs
WPC-FS-33	Steel	3	3	6	12	0.25	96	No	RED	1-2 cfs, rocked around culvert, heavy veg.
EC-FS-37	Steel	3	3	2	12	0.25	2	No	RED	No flow, seasonal, pond below outlet.
EC-FS-41	Steel	3	3	5	10	0.30	0	Yes	RED	No flow, but evidence of good flow during run off
WPC-FS-30	Steel	3 X 4	4	2	13	0.31	6	No	RED	Flow 1-2 cfs / culvert at 20-30 degree angle to flow entry
WPC-FS-34	Steel	3 x 4 squashed	4	1	14	0.29	0	Yes	RED	No flow, seasonal , no apparent erosion or flow problems
Fish passage evaluation criteria: Circular CMP greater than 48" and less than 100% substrate cover										
MC-FS-20	Steel	5	5	2	18	0.28	4	No	RED	5-6 cfs, Ditch culvert delivers to downstream fill
BRH-FS-08	Steel	5	5	5	10	0.50	12	No	RED	Not much sediment input, lots of rocks at each end.
BRH-FS-13	Steel	3X5	5	8	13	0.38	8.4	No	RED	Large culvert, 3-5 cfs, pull over upper end culvert
WPC-FS-31	Concrete	4 X 11	11	1	18	0.61	0	Yes	GREY	Fill length width bridge dimensions, debris and sediment on bridge top.
ECFC-FS-43	Steel	4	4	8	17	0.24	12	No	RED	5-10 cfs, ruts and standing water on road.
EFEC-FS-42	Steel	3 X 4.5	4.5	7	8	0.56	0	No	RED	Culvert diagonal to road.
ED-P-40	Steel	5	5	2	10	0.50	0	Yes	GREY	No flow, very fine sediment in the bottom of culvert
EFEC-FS-39	Steel	5	5	2	8	0.63	24	No	RED	No flow, large cobbles a small boulder in streambed
EFEC-FS-38	Steel	5	5	5	12	0.42	12	No	RED	5-10 cfs, E. Fork Elk Creek
Legend:		High certainty of <u>not</u> providing juvenile fish passage		High certainty of providing juvenile fish passage		Additional and more detailed analysis is required		Field notes indicate flowing water at crossing		Montana Fish Wildlife & Parks, GIS Layer *Fish Species Distribution – Streams* indicates fish present. Metadata updated 1999 – 2009 and absence of species on the GIS layer is not evidence of absence in a stream.

Table A-6. Detailed Extrapolated Sediment Load from Unpaved Road Crossings by HUC/303(d) Subwatershed – Road Length Reduction

Sub Watershed	Land Ownership	Unpaved Crossings	Field Assessed Crossings	Average Sediment Load (t/y)	Total Sediment Load (t/y)
Bull River -Headwaters Lower Bull River Middle Bull River Upper Bull River	Federal	85	11	0.04	3.40
	Federal-Roadless	2	0	0.04	0.08
	Private	19	0	0.07	1.33
	State	5	1	0.02	0.10
	Total	111	12	N/A	4.91
Dry Creek	Federal	15	1	0.04	0.60
	Federal-Roadless	2	0	0.04	0.08
	Private	0	0	0.07	0
	State	0	0	0.02	0
	Total	17	1	N/A	0.68
East Fork Elk Creek Elk Creek	Federal	52	9	0.04	2.08
	Federal-Roadless	0	0	0.04	0
	Private	46	2	0.07	3.22
	State	0	0	0.02	0
	Total	98	11	N/A	5.30
Marten Creek	Federal	79	10	0.04	3.16
	Federal-Roadless	1	0	0.04	0.04
	Private	2	0	0.07	0.14
	State	0	0	0.02	0
	Total	82	10	N/A	3.34
Swamp Creek	Federal	6	0	0.04	0.24
	Federal-Roadless	0	0	0.04	0
	Private	9	1	0.07	0.63
	State	0	0	0.02	0
	Total	15	1	N/A	0.87
White Pine Creek	Federal	56	7	0.04	2.24
	Federal-Roadless	2	0	0.04	0.08
	Private	4	0	0.07	0.28
	State	0	0	0.02	0
	Total	62	7	N/A	2.60

Table A-7. Comparability of Field Data to WEPP:Road Parameters

WEPP:Road Variable	Road gradient (%)	Road length (ft)	Road width (ft)	Fill gradient (%)	Fill length (ft)	Buff gradient (%)	Buff length (ft)	Rock content (%)
Minimum Value	0.3%	3 ft	1 ft	0.3%	1 ft	0.3%	1 ft	0%
Maximum Value	40%	1000 ft	300 ft	150%	1000 ft	100%	1000 ft	100%
Measured Range from the Field Data	1 – 15 %	3 ft – 2 miles	8 – 28 ft	3 – 150 %	3 – 116 ft	0.3 – 65%	20 – 160 ft	20 – 80%
Non-compliant values	UBR-FS-07 (N/A)	UBR-FS-07 (N/A) MC-FS-25 (N/A) WPC-FS-30 (1000+) WPC-FS-31 (1000+) WPC-PP-01 (1000+) WPC-PP-05 (1000+) MC-PP-# (0.5 miles)	UBR-FS-07 (N/A) WPC-PP-05 (-)	Multiple entries (-)	Multiple entries (-)	Multiple entries (-)	Multiple entries (-) Multiple entries (150+)	Multiple entries (-)
Action Taken	Assumptions listed in Attachment C.	Assumptions listed in Attachment C.	Assumptions listed in Attachment C.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries. 150 ft entered for 150+	Assumptions listed in Attachment C.

ATTACHMENT B

Field Assessment Site Location Data

Field Assessment Site Location Information

SITEID	X	Y	Z	SITEID	X	Y	Z
BRH-FS-08	-115.7840	48.1719	2930.5	MC-FS-25	-115.7645	47.8725	2398.3
BRH-FS-09	-115.7833	48.1586	3004.7	SCr-FS-01	-115.6050	47.9117	2700.1
BRH-FS-10	-115.8046	48.1534	4372.4	SCr-P-02	-115.6636	47.9217	2552.5
BRH-FS-11	-115.7989	48.1529	3911.2	UBR-FS-05	-115.8621	48.1893	2526.6
BRH-FS-12	-115.7913	48.1431	3704.5	UBR-FS-06	-115.8211	48.1960	2432.3
DC-FS-03	-115.8823	48.1557	2482.8	UBR-FS-07	-115.8152	48.1938	2443.5
EC-FS-28	-115.9393	48.0128	3492.5	UBR-S-04	-115.8549	48.1969	2342.8
EC-FS-37	-115.9909	48.0141	2388.5	WPC-FS-29	-115.6923	47.7474	4908.1
EC-FS-41	-115.9072	48.0321	2394.4	WPC-FS-30	-115.6935	47.7285	3559.7
EC-P-36	-115.9959	48.0451	2493.4	WPC-FS-31	-115.6884	47.7338	3474.4
EC-P-40	-115.9527	48.0386	2348.5	WPC-FS-32	-115.6379	47.7344	4222.4
EFEC-FS-26	-115.9451	47.9964	4400.1	WPC-FS-33	-115.6505	47.7364	4015.8
EFEC-FS-27	-115.9532	48.0039	4235.6	WPC-FS-34	-115.6139	47.7607	2818.2
EFEC-FS-38	-115.9399	47.9245	3559.7	WPC-FS-35	-115.5596	47.7523	2549.2
EFEC-FS-39	-115.9592	47.9510	2837.9	Parallel Sites			
EFEC-FS-42	-115.9830	47.9729	2614.8	ELK-FS-06	-115.9385	47.9176	3914.0
EFEC-FS-43	-115.9390	47.9170	3937.0	ELK-FS-07	-115.9420	47.9287	3379.3
MBR-FS-13	-115.7517	48.1442	3433.9	ELK-FS-08	-115.9429	47.9294	3343.2
MBR-FS-14	-115.7478	48.1349	3137.6	MC-PP-01	-115.8238	47.8932	2641.1
MBR-FS-15	-115.7303	48.1254	2738.2	MC-PP-02	-115.8123	47.8933	2591.9
MC-FS-16	-115.8414	47.8671	5108.3	MC-PP-03	-115.8025	47.8924	2555.8
MC-FS-17	-115.8956	47.8572	3982.9	MC-PP-04	-115.7944	47.8912	2506.6
MC-FS-18	-115.9044	47.8619	3950.1	MC-PP-05	-115.7835	47.8888	2477.0
MC-FS-19	-115.9096	47.8679	3871.4	MC-PP-06	-115.7704	47.8813	2404.9
MC-FS-20	-115.9094	47.8690	3825.5	WPC-PP-01	-115.6666	47.7420	3264.4
MC-FS-21	-115.8963	47.8755	3425.2	WPC-PP-02	-115.6561	47.7437	3192.3
MC-FS-22	-115.8687	47.8884	2916.7	WPC-PP-03	-115.6475	47.7468	3070.9
MC-FS-23	-115.7468	47.8900	2565.6	WPC-PP-04	-115.6386	47.7511	2992.1
MC-FS-24	-115.7544	47.8806	2339.2	WPC-PP-05	-115.6294	47.7547	2900.3

ATTACHMENT C

WEPP: Road Model Adjustments and Custom Climates

WEPP: Road Model Adjustments

Heavily vegetated road conditions are not properly represented in the standard WEPP:Road assumption. As a result, William J. Elliott, author of the model, was consulted to determine how best to represent these roads within the confines of the model.

There are three traffic scenarios available in the model. For roads where vegetation has grown up on the edges, the no traffic scenario is most appropriate as this scenario grows a limited amount of vegetation on the road. It uses the same plant growth for the road that the high traffic used for the fillslope. The following table explains the model assumptions for the three traffic scenarios:

Traffic	**High**	**Low**	**None**
Erodibility	100%	25%	25%
Hydraulic Conductivity	100%	100%	100%
Vegetation on Road Surface	0	0	50%
Vegetation on fill	50%	50%	100% Forested
Buffer	Forested	Forested	Forested

Based on conversations with Dr. Elliott, it was not appropriate to use the forest buffer to describe the road as the hydraulic conductivity of the soil would be too high. However, the hydraulic conductivity of the fillslope would be reasonable to use to describe the road surface for a fully forested scenario. This means, for the fully vegetated/forested road surface scenario, minimize the road segment length, put the remainder of the road surface length and gradient into the fillslope box, and minimize the buffer length and gradient at stream crossings.

Parallel Road Adjustments

The WEPP:Road model has a maximum contributing road length of 1000-feet. According to Dr. Elliott, it is rare that the contributing road length ever exceeds this distance. As a result, any field assessed parallel road segment in excess of this distance was reduced to 1000-feet for modeling purposes.

Road Crossing Model Adjustments

Some road crossing locations had contributing road length on each side of the crossing, and road conditions were significantly different on each side. In these situations, each road segment was modeled separately and the two segments were then summed to get the total sediment load for the crossing. Also, some crossing locations were located at the convergence of two or more roads, with all roads contributing to sediment load at the crossing. In these cases, road segments were modeled separately and then summed to get the total sediment load for the crossing.

Rock Content

The rock percentage was not determined for road crossings that had a gravel over-layer. Rock fragments by volume is specified in the Appendix 1: Soil Parameters (Elliot et al, 1999). The values for graveled loam (65%) and graveled sand (65%) were input into the WEPP model.

Site Name	Road Design	Model Adjustments	Site Name	Road Design	Model Adjustments
BRH-FS-08	IV	Rock Fragment added per WEPP Appendix 1.	MC-FS-19	OU	
BRH-FS-09	OR	Rock Fragment added per WEPP Appendix 1.	MC-FS-20	OR	
BRH-FS-10	OR		MC-FS-21	OR	
BRH-FS-10	OR		MC-FS-22	OU	Rock Fragment added per WEPP Appendix 1.
BRH-FS-11	IV		MC-FS-23	OU	Rock Fragment added per WEPP Appendix 1.
BRH-FS-11	OU		MC-FS-24	OU	Rock Fragment added per WEPP Appendix 1.
BRH-FS-12	OU		MC-FS-25	OU	Road modeled as IV with minimum width and length per comments.
DC-FS-03	OR	Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	MC-PP-01	OU	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
ECFC-FS-43	IV	Assumed 8 ft of the 11 ft ditch width contributed to ruts	MC-PP-02	IV	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
EC-FS-28	IV		MC-PP-03	OR	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
EC-FS-37	OU	Rock Fragment added per WEPP Appendix 1.	MC-PP-04	IV	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
EC-FS-41	IV	Rock Fragment added per WEPP Appendix 1.	MC-PP-05	OR	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
EC-P-36	IV	Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	MC-PP-06	OU	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
EC-P-40	OU	Insloped, unrutted modeled as insloped, bare. Rock Fragment added per WEPP Appendix 1.	SCR-FS-01	IB	
EC-P-40	OU	Rock Fragment added per WEPP Appendix 1.	SCR-FS-01	OU	Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.
EFEC-FS-26	OU		SCR-P-02	OU	Rock Fragment added per WEPP Appendix 1.
EFEC-FS-27	OU		UBR- FS- 05	OU	Rock Fragment added per WEPP Appendix 1.
EFEC-FS-27	OR		UBR-FS-05	OR	Rock Fragment added per WEPP Appendix 1.
EFEC-FS-38	OU	Assumed 8 ft of the 11 ft ditch width contributed to ruts	UBR-FS-06	OU	Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.
EFEC-FS-39	OU		UBR-FS-07	IV	Road modeled as IV with minimum width and length per comments. Assumed silt loam.
EFEC-FS-42	IV		UBR-FS-07	OU	Road modeled with minimum width and length per comments. Assumed silt loam.
Road Design options: OU = Outslope unrutted road, OR = Outslope rutted road, IV = Inslope road with vegetated or rocked ditch, IB = Inslope road with bare ditch					

Site Name	Road Design	Model Adjustments	Site Name	Road Design	Model Adjustments
ELK-FS-06	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	UBR-S-04	OU	Rock Fragment added per WEPP Appendix 1.
ELK-FS-06	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	WPC-FS-29	IV	
ELK-FS-06	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	WPC-FS-30	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance. Rock Fragment added per WEPP Appendix 1.
ELK-FS-06	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	WPC-FS-31	IV	Limited road length to 1000 ft., Crowned road modeled as OR per WEPP Guidance. Rock Fragment added per WEPP Appenidx 1.
ELK-FS-06	OU	Limited road length to 1000 ft., Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	WPC-FS-32	OU	
ELK-FS-07	OU	Insloped, rutted modeled as outsloped, rutted per WEPP Guidance.	WPC-FS-32	OU	
ELK-FS-08	OU		WPC-FS-33	IV	
MBR-FS-13	OU		WPC-FS-33	OU	
MBR-FS-14	IV		WPC-FS-34	OU	Rock Fragment added per WEPP Appendix 1.
MBR-FS-14	IV		WPC-FS-35	OR	Rock Fragment added per WEPP Appendix 1.
MBR-FS-15	OU	Rock Fragment added per WEPP Appendix 1.	WPC-PP-01	OR	Limited road length to 1000 ft. Rock Fragment added per WEPP Appendix 1.
MBR-FS-15	IV	Rock Fragment added per WEPP Appendix 1.	WPC-PP-02	OR	Rock Fragment added per WEPP Appendix 1.
MC-FS-16	IV		WPC-PP-02	OR	Rock Fragment added per WEPP Appendix 1.
MC-FS-16	OR		WPC-PP-03	OR	Rock Fragment added per WEPP Appendix 1.
MC-FS-17	OR		WPC-PP-04	OR	Added road surface and rock fragment for gravel road.
MC-FS-18	OR		WPC-PP-05	OU	Limited road length to 1000 ft. Road modeled with minimum width and length per comments. Rock Fragment added per WEPP Appendix 1.
MC-FS-18	OR				

Road Design options: OU = Outslope unrutted road, OR = Outslope rutted road, IV = Inslope road with vegetated or rocked ditch, IB = Inslope road with bare ditch

Custom Climates:

Troy 18N +	
Modified by Rock:Clime on September 27, 2009 from TROUT CREEK RS MT 248380 0	
T MAX 30.20 38.00 46.10 56.50 66.90 74.10 81.70 82.40 71.20 55.40 38.40 30.20 deg F	
T MIN 16.10 20.00 24.40 29.70 36.60 43.10 46.20 45.70 38.90 31.80 25.80 18.60 deg F	
MEANP 4.34 2.88 2.74 2.33 2.55 2.62 1.44 1.52 2.20 2.93 5.25 4.79 in	
# WET 14.00 9.94 10.97 10.14 12.13 11.89 8.00 8.02 10.00 10.85 15.00 15.97	
silt loam soil	30 year run
Average annual precipitation 36 in	

Burke +	
Modified by Rock:Clime on September 27, 2009 from TROUT CREEK RS MT 248380 0	
T MAX 28.70 34.30 39.00 47.70 57.70 65.60 76.30 74.10 65.50 52.00 37.30 30.90 deg F	
T MIN 15.90 19.50 21.60 27.50 32.90 39.00 44.20 43.20 38.60 32.20 24.70 19.10 deg F	
MEANP 6.56 5.41 4.89 3.02 2.98 3.33 1.19 1.42 2.52 4.35 5.91 6.12 in	
# WET 19.89 15.92 15.77 12.09 12.96 11.89 5.93 7.11 7.89 12.08 16.90 18.00	
sandy loam soil	30 year run
Average annual precipitation 47 in	

ATTACHMENT D

WEPP: Road Modeling Results for Field Assessed Sites

WEPP: Road Modeling Results for Field Assessed Crossings

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
State Ownership																	
UBR-S-04	2342.75	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	121	20	150	5	0.3	1	65	0.3	0.1	28	38
Private Ownership																	
EC-P-40	2348.49	Sandy Loam	30	Insloped, bare ditch	graveled high	8	254	31	100	11	0.3	1	65	0.5	0.1	817	Summed
EC-P-40	2348.49	Sandy Loam	30	Outsloped, unrutted	graveled high	9	440	18	40	9	0.3	1	65	0.3	0	380	975
EC-P-36	2493.44	Sandy Loam	30	Outsloped, rutted	native low	9	162	15.5	85	3	0.3	1	35	0.6	0.4	107	87
SCR-P-02	2552.49	Sandy Loam	30	Outsloped, rutted	native high	4	402	16	75	7.5	0.3	1	65	0.4	0.1	303	301
Private Ownership							**419.3**									**Mean**	**0.23**
														25th	**0.097**	**Median**	**0.15**
														75th	**0.32**	**Maximum**	**0.49**
																Minimum	**0.04**
Federal Ownership																	
MC-FS-24	2339.24	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	2	122	27	150	8	0.3	1	65	0.4	0.1	49	77
EC-FS-37	2388.45	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	6	288	19.5	95	7	0.3	1	65	0.5	0.1	279	250
EC-FS-41	2394.37	Sandy Loam	30	Outsloped, unrutted	graveled high	2	396	22	45	12	0.3	1	0	0.1	0	261	84
MC-FS-25	2398.29	Silt Loam	30	Insloped, vegetated or rocked ditch	native none	9	3	1	10	6	0.3	1	50	0.1	0	0	0
UBR-FS-06	2432.25	Sandy Loam	30	Outsloped, rutted	native low	1	64	16.5	95	7	0.3	1	45	0.5	0.2	10	14
UBR-FS-07	2443.52	Silt Loam	30	Insloped, vegetated or rocked ditch	native low	1	3	1	85	12	0.3	1	80	0.1	0	0	Summed
UBR-FS-07	2443.52	Silt Loam	30	Insloped, vegetated or rocked ditch	native low	1	3	1	85	12	0.3	1	80	0.1	0	0	0
DC-FS-03	2482.84	Sandy Loam	30	Outsloped, rutted	native low	15	700	12.5	90	7	0.3	1	60	1.4	0.8	3,188	2982
UBR- FS- 05	2526.56	Sandy Loam	30	Outsloped, unrutted	graveled high	5	98	16	55	18	0.3	1	65	0.2	0	41	Summed
UBR-FS-05	2526.56	Sandy Loam	30	Outsloped, unrutted	graveled high	5	215	15	0.3	1	0.3	1	65	0.2	0	83	42
WPC-FS-35	2549.21	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	2	281	17	50	13	0.3	1	65	0.3	0.1	58	51
MC-FS-23	2565.62	Sandy Loam	30	Outsloped, unrutted	graveled high	6	511	21	105	8	0.3	1	65	0.3	0	341	206
EFEC-FS-42	2614.83	Sandy Loam	30	Outsloped, unrutted	native low	2	123	12	55	20	0.3	1	70	0.2	0	23	9
SCR-FS-01	2700.13	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	3	65	8	0.3	1	0.3	1	50	0.3	0	4	Summed
SCR-FS-01	2700.13	Sandy Loam	30	Outsloped, rutted	native low	5	90	9	0.3	1	0.3	1	45	0.6	0.4	15	10
MBR-FS-15	2738.19	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	3	130	14	50	116	0.3	1	65	0.2	0	124	Summed
MBR-FS-15	2738.19	Sandy Loam	30	Outsloped, unrutted	graveled high	5	300	10	50	116	0.3	1	65	0.1	0	76	275
WPC-FS-34	2818.24	Sandy Loam	30	Outsloped, unrutted	graveled low	4	177	17	60	10	0.3	1	65	0.2	0	36	16
EFEC-FS-39	2837.93	Sandy Loam	30	Outsloped, unrutted	native low	4	160	14	40	13	0.3	1	60	0.3	0.1	43	16
MC-FS-22	2916.67	Silt Loam	30	Insloped, vegetated or rocked ditch	graveled high	5	661	21	75	13	0.3	1	65	0.3	0.1	609	558
BRH-FS-08	2930.54	Sandy Loam	30	Outsloped, unrutted	graveled high	9	230	14	60	13	0.3	1	65	0.2	0	139	75

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
BRH-FS-09	3004.7	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	4	440	20	30	12	0.3	1	65	0.4	0.1	193	207
MBR-FS-14	3137.58	Silt Loam	30	Outsloped, unrutted	native low	4	22	12	0.3	1	0.3	1	55	0.7	0.9	5	Summed
MBR-FS-14	3137.58	Silt Loam	30	Outsloped, unrutted	native low	5	111	12	0.3	1	0.3	1	55	0.8	1.1	25	3
MC-FS-21	3425.2	Sandy Loam	30	Insloped, vegetated or rocked ditch	native low	7	112	19.5	80	32	0.3	1	70	0.6	0.2	248	194
MBR-FS-13	3433.89	Silt Loam	30	Outsloped, rutted	native low	5	82	16	85	15	0.3	1	25	0.6	0.8	75	47
WPC-FS-31	3474.41	Silt Loam	30	Outsloped, rutted	graveled high	6	1000	17	95	6	0.3	1	65	0.3	0.1	1,831	1706
EC-FS-28	3492.46	Sandy Loam	30	Outsloped, rutted	native none	6	99	6	80	41	0.3	1	55	0.4	0.1	17	10
EFEC-FS-38	3559.71	Sandy Loam	30	Outsloped, rutted	native low	8	132	8	90	20	0.3	1	80	1	0.5	95	81
WPC-FS-30	3559.71	Sandy Loam	30	Outsloped, rutted	graveled high	6	1000	19.5	75	10	0.3	1	65	0.6	0.2	2,642	2544
BRH-FS-12	3704.48	Sandy Loam	30	Outsloped, unrutted	native low	3	156	10	70	14	0.3	1	65	0.3	0.1	32	14
MC-FS-20	3825.46	Sandy Loam	30	Outsloped, unrutted	native low	5	138	18	85	17	0.3	1	80	0.5	0.2	59	41
MC-FS-19	3871.39	Sandy Loam	30	Outsloped, unrutted	native low	6	98	16	68	29	0.3	1	80	0.4	0.1	41	33
BRH-FS-11	3911.23	Sandy Loam	30	Outsloped, unrutted	native low	2	150	12	85	11	0.3	1	60	0.3	0.1	34	Summed
BRH-FS-11	3911.23	Sandy Loam	30	Outsloped, unrutted	native low	4	82	16	85	11	0.3	1	60	0.5	0.2	31	31
MC-FS-18	3950.13	Sandy Loam	30	Outsloped, unrutted	native low	9	156	21	110	36	0.3	1	80	0.5	0.2	137	Summed
MC-FS-18	3950.13	Sandy Loam	30	Outsloped, unrutted	native low	5	216	19	110	36	0.3	1	80	0.4	0.1	98	289
MC-FS-17	3982.94	Sandy Loam	30	Outsloped, unrutted	native low	5	158	18	110	9	0.3	1	60	0.6	0.2	68	43
WPC-FS-33	4015.75	Silt Loam	30	Outsloped, unrutted	native none	8	78	11.5	85	32	0.3	1	20	0.2	0.1	28	Summed
WPC-FS-33	4015.75	Silt Loam	30	Outsloped, unrutted	native none	8	68	11.5	85	32	0.3	1	20	0.2	0.1	24	12
WPC-FS-32	4222.44	Silt Loam	30	Outsloped, unrutted	native none	3	70	10	60	13	0.3	1	45	0.3	0.2	14	Summed
WPC-FS-32	4222.44	Silt Loam	30	Outsloped, unrutted	native none	5	97	10	60	13	0.3	1	45	0.4	0.2	22	6
EFEC-FS-27	4235.56	Silt Loam	30	Outsloped, rutted	native none	5	166	6	115	34	0.3	1	45	1.1	3	47	Summed
EFEC-FS-27	4235.56	Silt Loam	30	Outsloped, rutted	native none	3	119	6	115	34	0.3	1	45	0.9	2	16	40
BRH-FS-10	4372.35	Sandy Loam	30	Insloped, vegetated or rocked ditch	native low	7	170	16	65	15	0.3	1	60	1.1	0.6	193	Summed
BRH-FS-10	4372.35	Sandy Loam	30	Outsloped, unrutted	native low	7	30	12	65	15	0.3	1	60	0.5	0.2	10	167
EFEC-FS-26	4400.12	Silt Loam	30	Outsloped, rutted	native none	4	197	5.5	110	32	0.3	1	20	0.7	2.7	41	26
WPC-FS-29	4908.14	Silt Loam	30	Outsloped, unrutted	native low	5	201	11	80	37	0.3	1	55	0.4	0.2	42	47
MC-FS-16	5108.27	Silt Loam	30	Outsloped, unrutted	native none	5	161	14.5	70	21	0.3	1	70	0.5	0.3	50	Summed
MC-FS-16	5108.27	Silt Loam	30	Outsloped, unrutted	native none	7	182	14.5	70	21	0.3	1	70	0.6	0.5	71	32
ECFC-FS-43	5192	Sandy Loam	30	Outsloped, rutted	native low	9	390	10	90	12	0.3	1	60	1.2	0.6	620	552
Federal Results							**274.4**									**Mean**	**0.14**
														25th	**0.008**	**Median**	**0.02**
														75th	**0.10**	**Maximum**	**1.49**
																Minimum	**0.00**

WEPP: Road Modeling Results for Field Assessed Parallel Segments

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Elk Creek Parallel Segments																	
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	8	550	12	0.3	1	65	20	70	0.6	0.4	1,013	613
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	6	550	13	0.3	1	25	30	70	0.5	0.3	1,496	725
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	8	550	13	0.3	1	35	60	70	0.6	0.4	1,251	694
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	7	550	13	0.3	1	30	40	70	0.8	0.6	1,388	928
ELK-FS-06	3937.01	Sandy Loam	30	Outsloped, rutted	native low	8	550	12	0.3	1	30	20	70	0.8	0.6	1,403	1,058
ELK-FS-07	3379.27	Sandy Loam	30	Outsloped, rutted	native low	7	80	13	0.3	1	20	20	60	0.1	0	33	8
ELK-FS-08	3343.18	Sandy Loam	30	Outsloped, unrutted	native low	6	26	10	0.3	1	0.3	7.5	80	0	0	5	0
Elk Creek Parallel Segments Results											Mean	28.2				**Mean**	**0.29**
											Median	20		**25th**	**0.15**	**Median**	**0.35**
														75th	**0.41**	**Maximum**	**0.49**
																Minimum	**0.00**
Marten Creek Parallel Segments																	
MC-PP-01	2641.08	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	2	1000	23	0.3	1	1	80	65	0	0	146	10
MC-PP-02	2591.86	Sandy Loam	30	Outsloped, unrutted	graveled high	3	1000	23	3	5	1	150	65	0	0	542	0
MC-PP-03	2555.77	Sandy Loam	30	Outsloped, unrutted	graveled high	3	1000	20	0.3	3	0.3	150	65	0	0	467	0
MC-PP-04	2506.56	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	1000	23	6	4	1	75	65	0	0	75	5
MC-PP-05	2477.03	Sandy Loam	30	Outsloped, unrutted	graveled high	1	1000	23	4	10	1	150	65	0	0	481	0
MC-PP-06	2404.86	Sandy Loam	30	Outsloped, unrutted	graveled high	4	61	23	8	11	1	60	65	0	0	38	0
Marten Creek Parallel Segments Results											Mean	110.8				**Mean**	**0.001**
											Median	115		**25th**	**0.000**	**Median**	**0.000**
														75th	**0.002**	**Maximum**	**0.04**
																Minimum	**0.00**
White Pine Creek Parallel Segments																	
WPC-PP-01	3264.44	Sandy Loam	30	Outsloped, unrutted	graveled low	5	1000	19	60	23	0.3	1	65	0.2	0	230	157
WPC-PP-02	3192.26	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	9	210	23	50	7	0.3	150	65	0	0	145	Summed
WPC-PP-02	3192.26	Sandy Loam	30	Outsloped, unrutted	graveled low	9	210	20	50	7	0.3	150	65	0	0	85	0
WPC-PP-03	3070.87	Sandy Loam	30	Outsloped, unrutted	graveled low	5	293	22	55	18	1	41	65	0	0	78	0
WPC-PP-04	2992.13	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	5	727	25.5	70	20	1	120	65	0	0	476	16
WPC-PP-05	2900.26	Sandy Loam	30	Outsloped, unrutted	graveled low	8	1000	1	0.3	1	1	160	65	0	0	14	0
White Pine Creek Parallel Segments Results											Mean	103.7				**Mean**	**0.02**
											Median	135		**0.000**	**0.000**	**0.000**	**0.00**
														75th	**0.01**	**0.01**	**0.01**
																Minimum	**0.00**

Shaded cells in the Road length column represent two upstream sections of the culvert. These cells were summed prior to calculating the average road length for each crossing within a watershed.

Shaded cells in the last column were summed either because the road was crowned and was modeled as two widths (inslope and outslope portion) or because of the two contributing upstream road sections.

ATTACHMENT E

WEPP: Road Modeling Results for Field Assessed Sites with Road Length Reductions

WEPP: Road Modeling Results for Field Assessed Crossings: 200 feet maximum length

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
State Ownership																	
UBR-S-04	2342.75	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	121	20	150	5	0.3	1	65	0.3	0.1	28	38
Private Ownership																	
EC-P-40	2348.49	Sandy Loam	30	Insloped, bare ditch	graveled high	8	100	31	100	11	0.3	1	65	0.4	0	221	Summed
EC-P-40	2348.49	Sandy Loam	30	Outsloped, unrutted	graveled high	9	100	18	40	9	0.3	1	65	0.3	0	86	230
EC-P-36	2493.44	Sandy Loam	30	Outsloped, rutted	native low	9	162	15.5	85	3	0.3	1	35	0.6	0.4	107	87
SCR-P-02	2552.49	Sandy Loam	30	Outsloped, rutted	native high	4	200	16	75	7.5	0.3	1	65	0.4	0.1	135	120
Private Ownership																**Mean**	**0.07**
														25th	**0.052**	**Median**	**0.06**
														75th	**0.09**	**Maximum**	**0.12**
																Minimum	**0.04**
Federal Ownership																	
MC-FS-24	2339.24	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	2	122	27	150	8	0.3	1	65	0.4	0.1	49	77
EC-FS-37	2388.45	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	6	200	19.5	95	7	0.3	1	65	0.5	0.1	171	148
EC-FS-41	2394.37	Sandy Loam	30	Outsloped, unrutted	graveled high	2	200	22	45	12	0.3	1	0	0.1	0	132	43
MC-FS-25	2398.29	Silt Loam	30	Insloped, vegetated or rocked ditch	native none	9	3	1	10	6	0.3	1	50	0.1	0	0	0
UBR-FS-06	2432.25	Sandy Loam	30	Outsloped, rutted	native low	1	64	16.5	95	7	0.3	1	45	0.5	0.2	10	14
UBR-FS-07	2443.52	Silt Loam	30	Insloped, vegetated or rocked ditch	native low	1	3	1	85	12	0.3	1	80	0.1	0	0	Summed
UBR-FS-07	2443.52	Silt Loam	30	Insloped, vegetated or rocked ditch	native low	1	3	1	85	12	0.3	1	80	0.1	0	0	0
DC-FS-03	2482.84	Sandy Loam	30	Outsloped, rutted	native low	15	200	12.5	90	7	0.3	1	60	1.2	0.6	382	317
UBR- FS- 05	2526.56	Sandy Loam	30	Outsloped, unrutted	graveled high	5	98	16	55	18	0.3	1	65	0.2	0	41	Summed
UBR-FS-05	2526.56	Sandy Loam	30	Outsloped, unrutted	graveled high	5	102	15	0.3	1	0.3	1	65	0.2	0	39	30
WPC-FS-35	2549.21	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	2	200	17	50	13	0.3	1	65	0.3	0.1	46	40
MC-FS-23	2565.62	Sandy Loam	30	Outsloped, unrutted	graveled high	6	200	21	105	8	0.3	1	65	0.3	0	133	81
EFEC-FS-42	2614.83	Sandy Loam	30	Outsloped, unrutted	native low	2	123	12	55	20	0.3	1	70	0.2	0	23	9
SCR-FS-01	2700.13	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	3	65	8	0.3	1	0.3	1	50	0.3	0	4	Summed
SCR-FS-01	2700.13	Sandy Loam	30	Outsloped, rutted	native low	5	90	9	0.3	1	0.3	1	45	0.6	0.4	15	10
MBR-FS-15	2738.19	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	3	100	14	50	116	0.3	1	65	0.2	0	92	Summed
MBR-FS-15	2738.19	Sandy Loam	30	Outsloped, unrutted	graveled high	5	100	10	50	116	0.3	1	65	0.1	0	25	136
WPC-FS-34	2818.24	Sandy Loam	30	Outsloped, unrutted	graveled low	4	177	17	60	10	0.3	1	65	0.2	0	36	16
EFEC-FS-39	2837.93	Sandy Loam	30	Outsloped, unrutted	native low	4	160	14	40	13	0.3	1	60	0.3	0.1	43	16
MC-FS-22	2916.67	Silt Loam	30	Insloped, vegetated or rocked ditch	graveled high	5	200	21	75	13	0.3	1	65	0.3	0.1	162	144

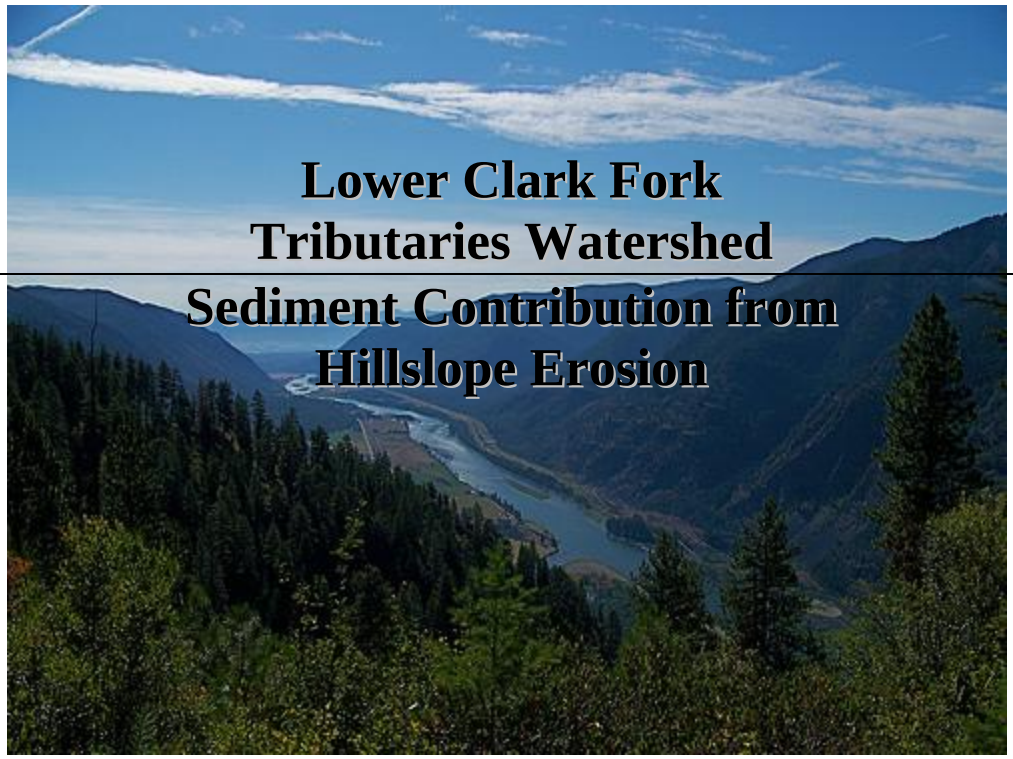
Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
BRH-FS-08	2930.54	Sandy Loam	30	Outsloped, unrutted	graveled high	9	200	14	60	13	0.3	1	65	0.2	0	121	65
BRH-FS-09	3004.7	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	4	200	20	30	12	0.3	1	65	0.4	0.1	80	82
MBR-FS-14	3137.58	Silt Loam	30	Outsloped, unrutted	native low	4	22	12	0.3	1	0.3	1	55	0.7	0.9	5	Summed
MBR-FS-14	3137.58	Silt Loam	30	Outsloped, unrutted	native low	5	111	12	0.3	1	0.3	1	55	0.8	1.1	25	3
MC-FS-21	3425.2	Sandy Loam	30	Insloped, vegetated or rocked ditch	native low	7	112	19.5	80	32	0.3	1	70	0.6	0.2	248	194
MBR-FS-13	3433.89	Silt Loam	30	Outsloped, rutted	native low	5	82	16	85	15	0.3	1	25	0.6	0.8	75	47
WPC-FS-31	3474.41	Silt Loam	30	Outsloped, rutted	graveled high	6	200	17	95	6	0.3	1	65	0.4	0.1	214	185
EC-FS-28	3492.46	Sandy Loam	30	Outsloped, rutted	native none	6	99	6	80	41	0.3	1	55	0.4	0.1	17	10
EFEC-FS-38	3559.71	Sandy Loam	30	Outsloped, rutted	native low	8	132	8	90	20	0.3	1	80	1	0.5	95	81
WPC-FS-30	3559.71	Sandy Loam	30	Outsloped, rutted	graveled high	6	200	19.5	75	10	0.3	1	65	0.6	0.2	297	286
BRH-FS-12	3704.48	Sandy Loam	30	Outsloped, unrutted	native low	3	156	10	70	14	0.3	1	65	0.3	0.1	32	14
MC-FS-20	3825.46	Sandy Loam	30	Outsloped, unrutted	native low	5	138	18	85	17	0.3	1	80	0.5	0.2	59	41
MC-FS-19	3871.39	Sandy Loam	30	Outsloped, unrutted	native low	6	98	16	68	29	0.3	1	80	0.4	0.1	41	33
BRH-FS-11	3911.23	Sandy Loam	30	Outsloped, unrutted	native low	2	118	12	85	11	0.3	1	60	0.3	0.1	27	Summed
BRH-FS-11	3911.23	Sandy Loam	30	Outsloped, unrutted	native low	4	82	16	85	11	0.3	1	60	0.5	0.2	31	28
MC-FS-18	3950.13	Sandy Loam	30	Outsloped, unrutted	native low	9	100	21	110	36	0.3	1	80	0.5	0.2	88	Summed
MC-FS-18	3950.13	Sandy Loam	30	Outsloped, unrutted	native low	5	100	19	110	36	0.3	1	80	0.4	0.1	45	162
MC-FS-17	3982.94	Sandy Loam	30	Outsloped, unrutted	native low	5	158	18	110	9	0.3	1	60	0.6	0.2	68	43
WPC-FS-33	4015.75	Silt Loam	30	Outsloped, unrutted	native none	8	78	11.5	85	32	0.3	1	20	0.2	0.1	28	Summed
WPC-FS-33	4015.75	Silt Loam	30	Outsloped, unrutted	native none	8	68	11.5	85	32	0.3	1	20	0.2	0.1	24	12
WPC-FS-32	4222.44	Silt Loam	30	Outsloped, unrutted	native none	3	70	10	60	13	0.3	1	45	0.3	0.2	14	Summed
WPC-FS-32	4222.44	Silt Loam	30	Outsloped, unrutted	native none	5	97	10	60	13	0.3	1	45	0.4	0.2	22	6
EFEC-FS-27	4235.56	Silt Loam	30	Outsloped, rutted	native none	5	100	6	115	34	0.3	1	45	0.8	1.6	19	Summed
EFEC-FS-27	4235.56	Silt Loam	30	Outsloped, rutted	native none	3	100	6	115	34	0.3	1	45	0.8	1.6	13	18
BRH-FS-10	4372.35	Sandy Loam	30	Insloped, vegetated or rocked ditch	native low	7	170	16	65	15	0.3	1	60	1.1	0.6	193	Summed
BRH-FS-10	4372.35	Sandy Loam	30	Outsloped, unrutted	native low	7	30	12	65	15	0.3	1	60	0.5	0.2	10	167
EFEC-FS-26	4400.12	Silt Loam	30	Outsloped, rutted	native none	4	197	5.5	110	32	0.3	1	20	0.7	2.7	41	26
WPC-FS-29	4908.14	Silt Loam	30	Outsloped, unrutted	native low	5	200	11	80	37	0.3	1	55	0.4	0.2	42	47
MC-FS-16	5108.27	Silt Loam	30	Outsloped, unrutted	native none	5	100	14.5	70	21	0.3	1	70	0.5	0.3	31	Summed
MC-FS-16	5108.27	Silt Loam	30	Outsloped, unrutted	native none	7	100	14.5	70	21	0.3	1	70	0.6	0.5	39	19
ECFC-FS-43	5192	Sandy Loam	30	Outsloped, rutted	native low	9	200	10	90	12	0.3	1	60	1.1	0.5	211	180
Federal Results																**Mean**	**0.04**
														25th	**0.008**	**Median**	**0.02**
														75th	**0.05**	**Maximum**	**0.16**
																Minimum	**0.00**

WEPP: Road Modeling Results for Field Assessed Parallel Segments: 400 feet maximum length

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Elk Creek Parallel Segments																	
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	8	400	13	0.3	1	25	30	70	0.6	0.3	577	330
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	6	400	13	0.3	1	35	60	70	0.5	0.2	856	394
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	8	400	13	0.3	1	30	40	70	0.5	0.3	715	370
ELK-FS-06	3914.04	Sandy Loam	30	Outsloped, rutted	native low	7	400	12	0.3	1	30	20	70	0.8	0.5	816	508
ELK-FS-06	3937.01	Sandy Loam	30	Outsloped, rutted	native low	8	400	12	0.3	1	65	20	70	0.8	0.5	811	584
ELK-FS-07	3379.27	Sandy Loam	30	Outsloped, rutted	native low	7	80	13	0.3	1	20	20	60	0.1	0	33	8
ELK-FS-08	3343.18	Sandy Loam	30	Outsloped, unrutted	native low	6	26	10	0.3	1	0.3	7.5	80	0	0	5	0
Elk Creek Parallel Segments Results											Mean	28.2				**Mean**	**0.16**
											Median	20		**25th**	**0.085**	**Median**	**0.19**
														75th	**0.23**	**Maximum**	**0.49**
																Minimum	**0.00**
Marten Creek Parallel Segments																	
MC-PP-01	2641.08	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	2	400	23	0.3	1	1	80	65	0	0	89	2
MC-PP-02	2591.86	Sandy Loam	30	Outsloped, unrutted	graveled high	3	400	23	3	5	1	150	65	0	0	217	0
MC-PP-03	2555.77	Sandy Loam	30	Outsloped, unrutted	graveled high	3	400	20	0.3	3	0.3	150	65	0	0	187	0
MC-PP-04	2506.56	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	400	23	6	4	1	75	65	0	0	64	1
MC-PP-05	2477.03	Sandy Loam	30	Outsloped, unrutted	graveled high	1	400	23	4	10	1	150	65	0	0	192	0
MC-PP-06	2404.86	Sandy Loam	30	Outsloped, unrutted	graveled high	4	61	23	8	11	1	60	65	0	0	38	0
Marten Creek Parallel Segments Results											Mean	110.8				**Mean**	**0.000**
											Median	115		**25th**	**0.000**	**Median**	**0.000**
														75th	**0.002**	**Maximum**	**0.04**
																Minimum	**0.00**
White Pine Creek Parallel Segments																	
WPC-PP-01	3264.44	Sandy Loam	30	Outsloped, unrutted	graveled low	5	400	19	60	23	0.3	1	65	0.2	0	230	63
WPC-PP-02	3192.26	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	9	210	23	50	7	0.3	150	65	0	0	145	Summed
WPC-PP-02	3192.26	Sandy Loam	30	Outsloped, unrutted	graveled low	9	210	20	50	7	0.3	150	65	0	0	85	0
WPC-PP-03	3070.87	Sandy Loam	30	Outsloped, unrutted	graveled low	5	293	22	55	18	1	41	65	0	0	78	0
WPC-PP-04	2992.13	Sandy Loam	30	Insloped, vegetated or rocked ditch	graveled low	5	400	25.5	70	20	1	120	65	0	0	476	2
WPC-PP-05	2900.26	Sandy Loam	30	Outsloped, unrutted	graveled low	8	400	1	0.3	1	1	160	65	0	0	14	0
White Pine Creek Parallel Segments Results											Mean	103.7				**Mean**	**0.01**
											Median	135		**0.000**	**0.000**	**0.000**	**0.00**
														75th	**0.01**	**0.01**	**0.01**
																Minimum	**0.00**

Shaded cells in the Road length column represent two upstream sections of the culvert. These cells were summed prior to calculating the average road length for each crossing within a watershed.
Shaded cells in the last column were summed either because the road was crowned and was modeled as two widths (inslope and outslope portion) or because of the two contributing upstream road sections.

ATTACHMENT 2 - SEDIMENT CONTRIBUTION FROM HILLSLOPE EROSION



Lower Clark Fork Tributaries Watershed Sediment Contribution from Hillslope Erosion

Prepared For:

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September 30, 2009

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1.0 SEDIMENT CONTRIBUTION FROM HILLSLOPE EROSION

1.1 Introduction

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, an assessment of potential sediment loading through the application of Best Management Practices (BMPs), and an assessment of the potential sediment loading before human alterations of the land cover. The BMP evaluated assumed modifications in upland management practices. 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 Lower Clark Fork Tributaries watershed 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 effect 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 Lower Clark Fork Tributaries 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.

1.2 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 BMP's, (4) 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 BMP's and upland management BMPs, and (5) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list before human affects. 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.

1.3 Modeling Scenarios

1.3.1 Management Scenarios

Four management scenarios were evaluated for the Lower Clark Fork Tributaries watershed. They include: (1) an existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) a riparian health BMP conditions scenario that considers improved riparian buffer zones; (3) a riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management; and (4) a natural conditions scenario that assumes removal of any and all anthropogenic land uses.

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 Lower Clark Fork Tributaries watershed were developed (open space), developed (low intensity), developed (medium intensity), pasture/hay, grasslands/herbaceous, 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 GEI Consultants (2005) for the Lower Clark Fork Tributaries Watershed, pursuant to fulfilling Avista Corporation's license requirments for their operation of the Cabinet Gorge and Noxon Rapids dams. . The GEI 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.

1.3.2 Historic Scenario

Upon entering a stream, eroded sediment is transported downstream by fluvial processes until ultimately flushed from the stream to its receiving waterbody or removed from the system as a landforming deposit. As a stream make take many years to process its sediment load, sediment delivered to a stream in the past may be the source of current sediment related stream impairments. In the Lower Clark Fork Tributaries watershed, historic forest fire and timber harvest events may have resulted in a higher level of current impairment than can be attributed to current conditions and land management practices.

To assist assessment of the potential current effects of past fire and harvest events in the Lower Clark Fork Tributaries watershed, a historic conditions scenario was developed and evaluated. Polygon data representing the bounds of known timber harvests and forest fires from 1910 through 2004 were obtained from the Kootenai National Forest. These polygons were then grouped by decade (for example, 1910-1919), and an annualized model run was performed for each decade using the fire and harvest polygons as a landcover adjustment per the method

outlined in section 1.5.7. All remaining parameters for the historic scenario replicate the existing conditions management scenario.

1.4 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 coverages 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. The USLE K factor is a standard component of the STATSGO soil survey. 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 MT DEQ and USFS. C-factors are intended to be conservatively representative of conditions in the Lower Clark Fork Tributaries watershed.

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 Lower Clark Fork Tributaries watershed.

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 GEI Consultants (2005). Riparian health ratings of high, moderate, low, and no riparian vegetation were assigned according to the professional judgment of the assessment team. The percent of each subwatershed's area falling in each category was reported.

1.5 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 was performed as follows:

1.5.1 Sub-basins

The Lower Clark Fork Tributaries watershed boundary and the sub-basin boundaries were defined using the USGS 6th code Hydrologic Unit Codes (HUC). Dry Creek is the only 303(d) listed stream that was not represented in the 6th code HUCs. The Dry Creek sub-basin was cut from the Upper Bull River West sub-basin using USGS topography as a guide to drainage divides. Additionally, a portion of the Elk Creek sub-basin extends across the state border into Idaho. As this area drains to Montana, it was included in this analysis. For reporting purposes, the sub-basin was divided along the state line to create the Elk Creek Idaho and Elk Creek sub-basins.



Figure 1-1. Sub-basin polygons for the Lower Clark Fork Tributaries Watershed.

1.5.2 Lower Clark Fork Tributaries Watershed DEM

The digital elevation model (DEM) for the Lower Clark Fork Tributaries watershed is the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area (specifically Bull River, Dry Creek, Elk Creek, Marten Creek, Swamp Creek, and White Pine Creek sub-basins), 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 Lower Clark Fork Tributaries watershed was used for these analyses. The DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Lower Clark Fork Tributaries watershed 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.

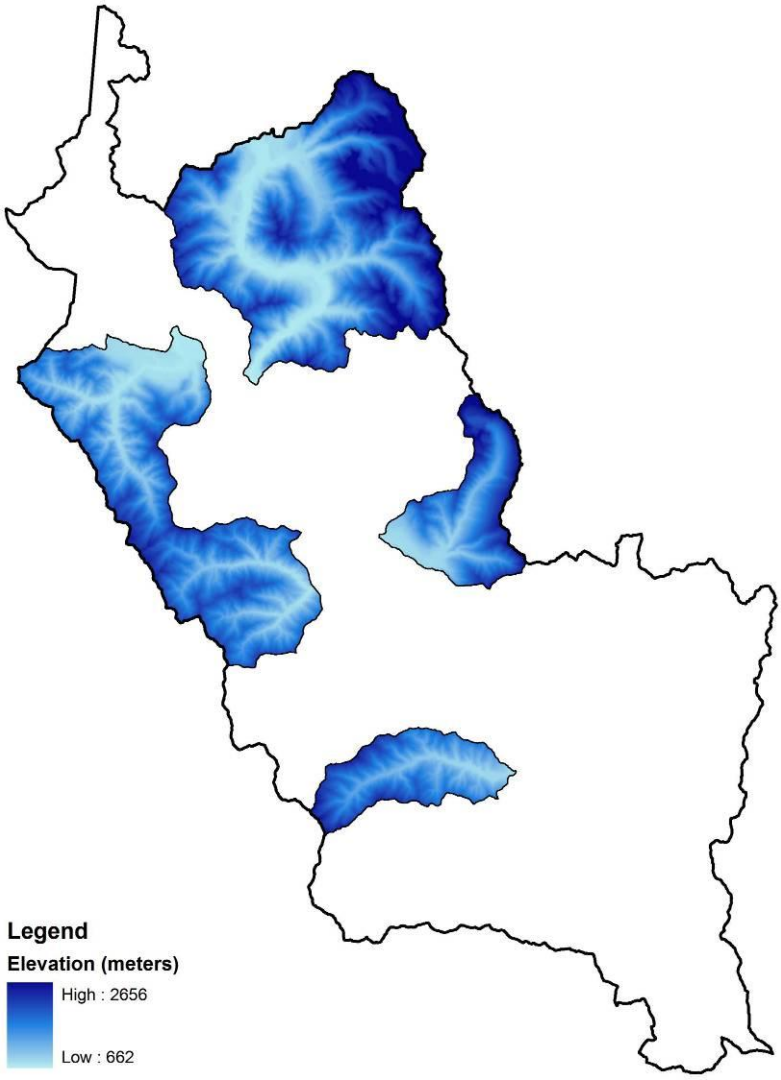


Figure 1-2. Digital Elevation Model (DEM) of the Lower Clark Fork Tributaries Watershed Prepared for Hydrologic Analysis.

1.5.3 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. 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 Lower Clark Fork Tributaries watershed, to match the project's standard grid definition.

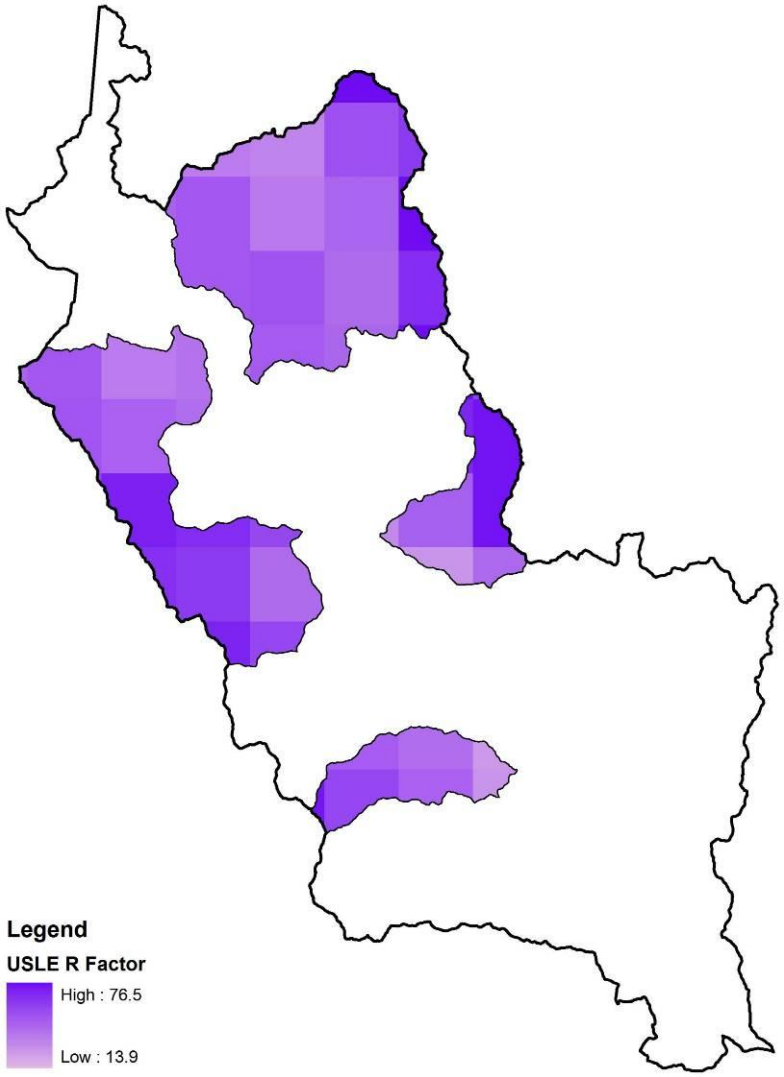


Figure 1-3. ULSE R-factor for the Lower Clark Fork Tributaries Watershed.

1.5.4 K-Factor

The soil erodibility factor grid was compiled from 1:250K STATSGO data, as published by the NRCS. STATSGO 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 STATSGO map unit polygons, and the polygon coverage was converted to a 10m analytic grid for use in the model. SSURGO data were considered for use, due to the higher resolution and currency of the SSURGO datasets. However, SSURGO data for the Lower Clark Fork Tributaries watershed did not contain the required K-factor.

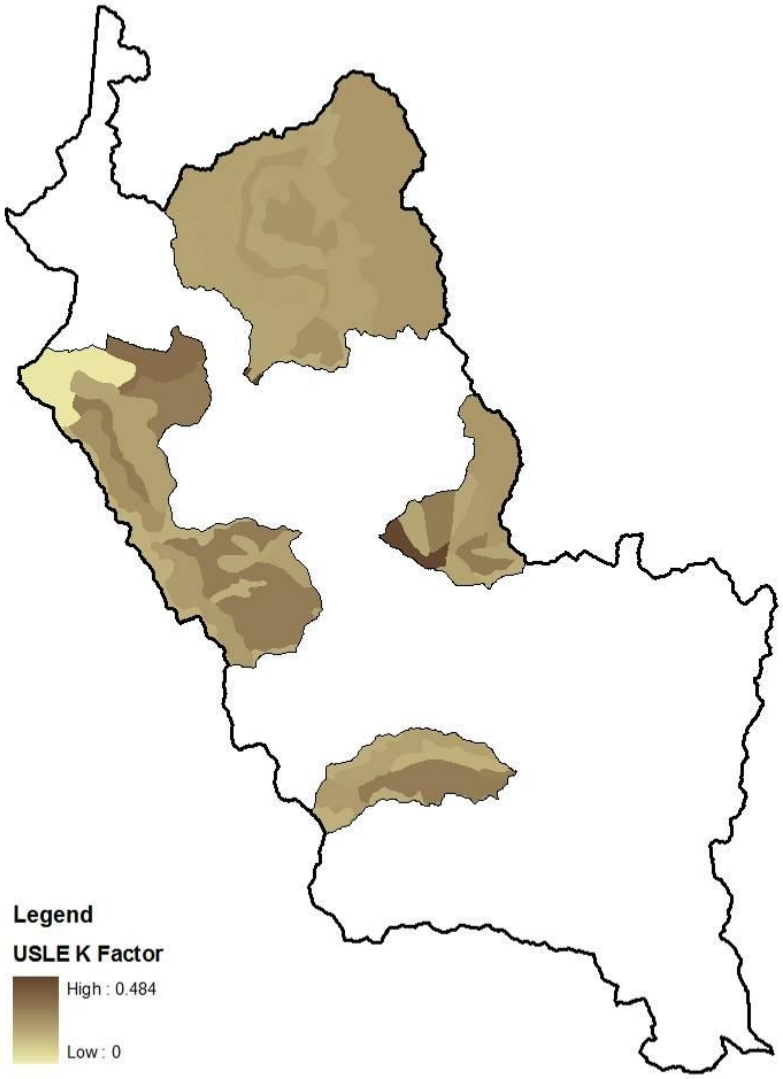


Figure 1-4. ULSE K-factor for the Lower Clark Fork Tributaries Watershed

1.5.5 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:

$LS = S_i (\lambda_i^{m+1} - \lambda_{i-1}^{m+1}) / (\lambda_I - \lambda_{i-1}) (72.6)^m$

Where:

λ_i = length in feet from top of slope to lower end of ith segment. This value was determined by applying GIS based surface analysis procedures to the Lower Clark Fork Tributaries watershed DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters. In accordance with research that indicates that, in practice, the slope length rarely exceeds 400 ft, λ was limited to that maximum value.

S_i = slope steepness factor for the ith segment.
= $10.8 \sin \theta + 0.03$ for $\theta < 9\%$
= $16.8 \sin \theta - 0.50$ for $\theta \geq 9\%$

m = a variable slope-length exponent.
= $\beta / (1 + \beta)$

and

B = ratio of rill to interrill erosion.
= $(\sin \theta / 0.0896) / [3.0 (\sin \theta)^{0.8} + 0.56]$

θ = slope angle as calculated by GIS based surface analysis procedures from the Lower Clark Fork Tributaries watershed DEM.

The LS factor grid was calculated from individual grids computed for each of these sub factors, using a simple ArcView Model Builder script.

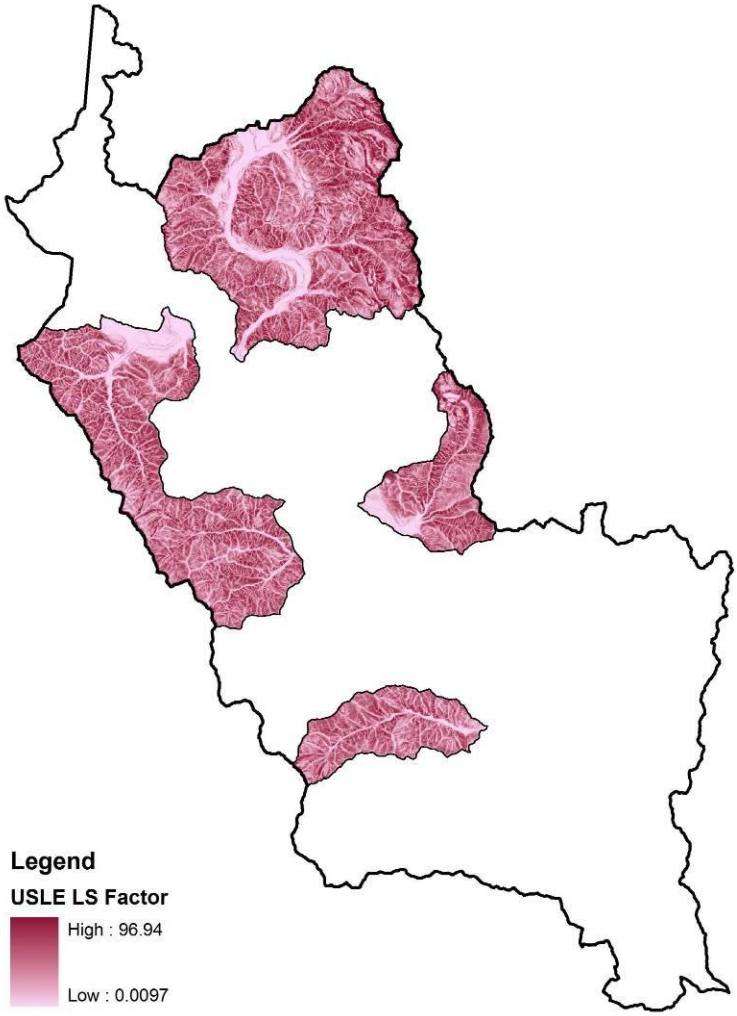


Figure 1-5. ULSE LS-factor for the Lower Clark Fork Tributaries Watershed

1.5.6 NLCD

The 2001 National Land Cover Dataset (NLCD) was obtained from USGS for use in establishing USLE C-factors for the Lower Clark Fork Tributaries watershed. 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 Lower Clark Fork Tributaries watershed are described as follows:

11. Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

12. Perennial Ice/Snow - All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.

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.

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.

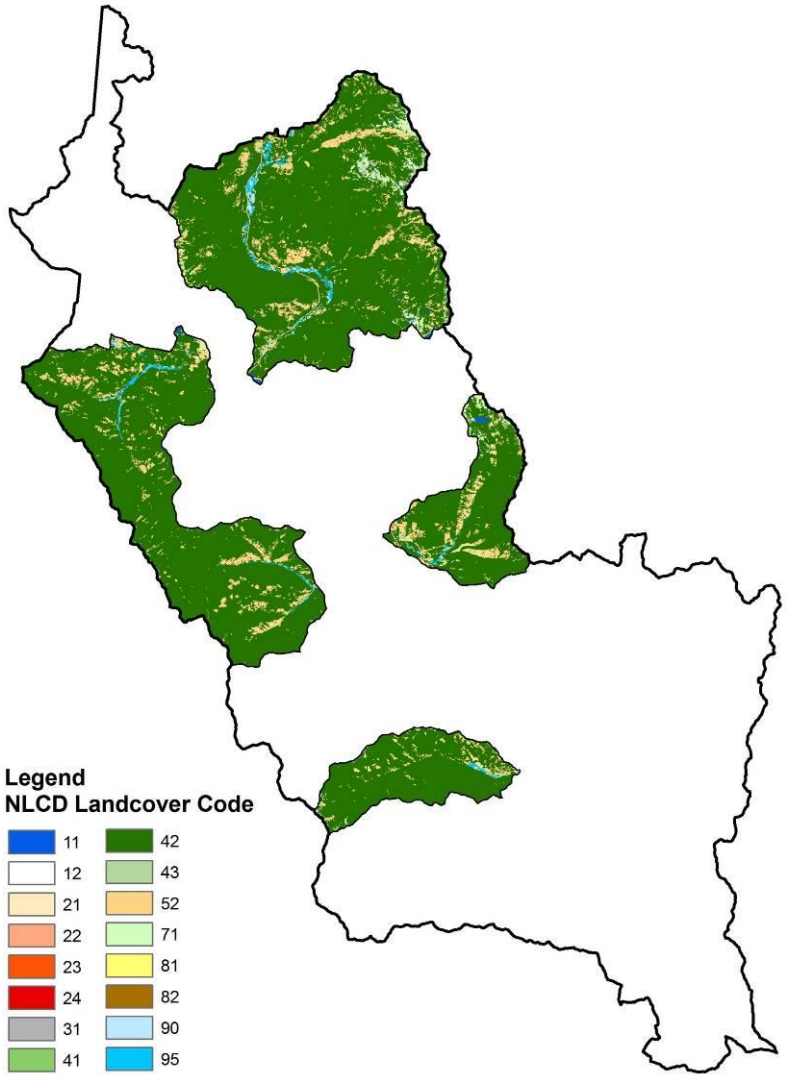


Figure 1-6. NLCD Landcover for the Lower Clark Fork Tributaries Watershed.

1.5.7 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 Lower Clark Fork Tributaries watershed, and the relative stability of that land use over the 7 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. As with other land uses in the valley, logging is a stable land use, but it is a land use that causes a land cover change that may effect sediment production.

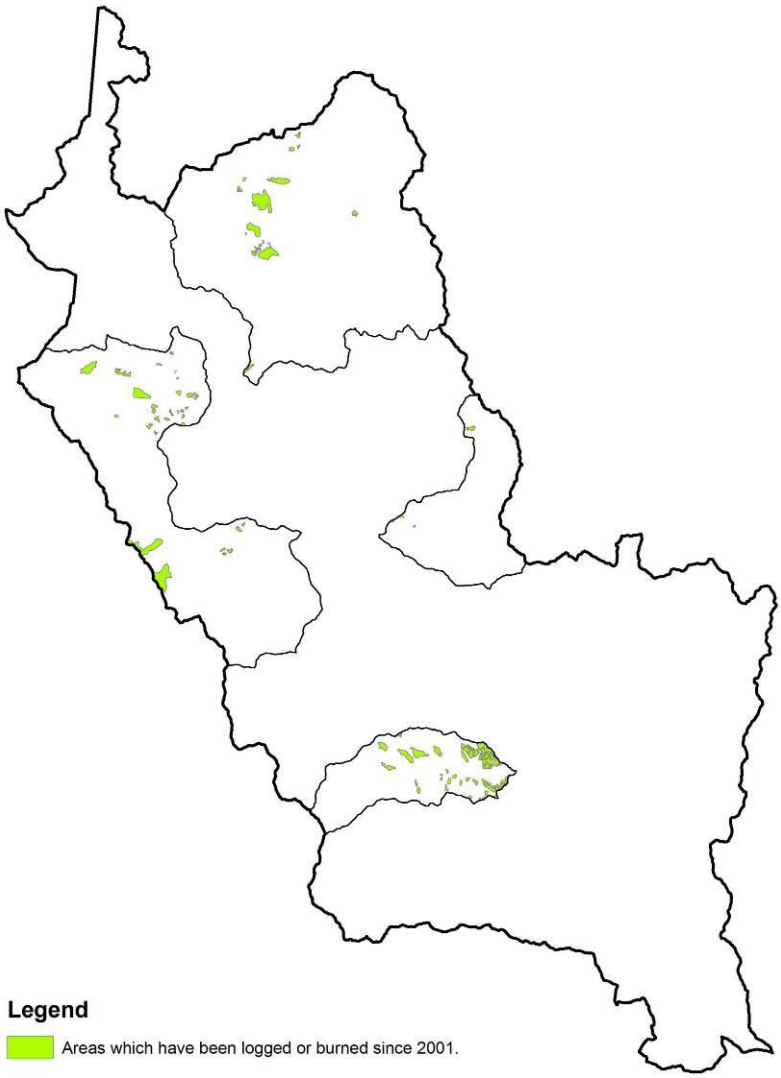


Figure 1-7. Logging and fire areas for the Lower Clark Fork Tributaries Watershed.

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 Lower Clark Fork Tributaries Watershed with the 2005 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 Lower Clark Fork Tributaries Watershed with the 2005 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 Lower Clark Fork Tributaries watershed.

1.5.8 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 Lower Clark Fork Tributaries watershed.

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 and USFS employees. A narrative description of the professional judgment involved in the selection of these factors and the NRCS table are provided in Attachment A.

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 Lower Clark Fork Tributaries watershed. The 'grasslands/herbaceous', and 'pasture/hay' 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.

To estimate the potential reduction in sediment production that might be accomplished under the natural conditions scenario, the model was re-run using a third C-factor reclassification scheme. For all anthropogenic land uses, 'developed, open space', 'developed, low intensity', 'developed, medium intensity', 'cultivated crops' and 'pasture/hay', the natural scenario assumed a conversion to forest or woody wetland land cover (both forest and woody wetland have the same c-factor). These are the assumed land covers of the areas in question before they were influenced by humans. No change was applied to the other land use types within the Lower Clark Fork Tributaries watershed from the desired conditions scenario.

The C-factors for the three scenarios are presented in **Table 1-1**.

Table 1-1 C-factors in the Lower Clark Fork Tributaries watershed.				
NLCD Code	**Description**	**C-Factor Existing Condition**	**C-Factor Desired Condition**	**C-Factor Natural Condition**
21	Developed, Open Space	0.003	0.003	0.003
22	Developed, Low Intensity	0.001	0.001	0.003
23	Developed, Medium Intensity	0.001	0.001	0.003
31	Barren Land	0.001	0.001	0.001
41	Deciduous Forest	0.003	0.003	0.003
42	Evergreen Forest	0.003	0.003	0.003
43	Mixed Forest	0.003	0.003	0.003
52	Shrub/Scrub	0.008	0.008	0.008
71	Grasslands/Herbaceous	0.020	0.013	0.013
81	Pasture/Hay	0.020	0.013	0.003
82	Cultivated Crops	0.240	0.150	0.003
90	Woody Wetlands	0.003	0.003	0.003
95	Emergent Herbaceous Wetlands	0.003	0.003	0.003
N/A	Transitional	0.006	0.003	0.003

Table 1-2 Changes in percent ground cover for agricultural land cover types between existing and improved management conditions.		
Land Cover	**Existing % Ground Cover**	**Improved % Ground Cover**
Grasslands/Herbaceous	75	85
Pasture/Hay	75	85
Cultivated Crops	20	40

1.5.9 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 Lower Clark Fork Watershed, and adjustment of that assessment to correspond to the subwatershed used for this modeling effort.

1.5.9.1 GEI Riparian assessment

The riparian corridor quality assessment is taken from the report, "Lower Clark Fork River Drainage Habitat Problem Assessment" (GEI Consultants, 2005). The riparian corridor quality assessment is based on professional expertise of the Aquatic Implementation Team (AIT), field observations, and surveys. Riparian corridors are referred to as having low (marginal/limited), moderate (some good, some marginal), or high (majority adequate for aquatic resources) quality. The absence of riparian vegetation (referred to as none) is an additional category describing the condition of the riparian corridor. It is understood that within each subwatershed, riparian conditions are not homogeneous. For this reason, the AIT used best professional judgment to estimate the percentage of the riparian corridor within each sub watershed that was of high, moderate, low, or none quality.

The riparian corridor assessment included mainstem and main fork only. For channels classified as type A and B by the Rosgen classification system, the riparian area evaluated included 100 feet on either side of the channel (area affected by trees). For streams classified as Rosgen C or E channels, the area affecting the belt width (usually more than 100 feet on either side of the channel) was evaluated. Roads and extensive un-vegetated gravel/cobble were included in the "riparian vegetation not present" or "none" category.

1.5.9.2 Correcting for Differences in Subwatershed Delineation

The sub-basin division used for the GEI Consultants report 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 GEI Consultants report, the TMDL riparian quality was taken to be the area weighted average of the contributing GEI sub-basins. Where the TMDL sub-basin was a subdivision of a larger sub-basin in the GEI Consultants report, the riparian quality for the larger sub-basin was used as is.

The results of the riparian quality assessment from the GEI Consultants report and the correlation of sub-basins are shown in **Table 1-3**.

Table 1-3 Riparian quality assessment and sub-basin correlation.

TMDL Sub-basin Name and Area	GEI Consultants Sub-basin Name	Existing Conditions Riparian Quality	Percent of GEI Sub-basin	GEI Sub-basin Area (acres)	Percent of TMDL Sub-basin Area	Weighted Riparian Quality Percent by Area	TMDL Sub-basin Riparian Quality	Percent of TMDL Sub-basin for Existing Conditions
Bull River Headwaters (24,192 acres)	North Fork Bull River	High	95	7,092	29.3%	27.9	High	93
		Moderate	5			1.5		
		Low	0			0		
		None	0			0	Moderate	7
	Middle Fork Bull River	High	90	7,858	32.5%	29.2		
		Moderate	10			3.3		
		Low	0			0	Low	0
		None	0			0		
	South Fork Bull River	High	95	9,242	38.2%	36.3		
		Moderate	5			1.9	None	0
		Low	0			0		
		None	0			0		
Dry Creek (5,429 acres)	Bull River	High	35	44,973	100%	35	High	35
		Moderate	30			30	Moderate	30
		Low	30			30	Low	30
		None	5			5	None	5
Upper Bull River West (28,364 acres)	Bull River	High	35	44,973	100%	35	High	35
		Moderate	30			30	Moderate	30
		Low	30			30	Low	30
		None	5			5	None	5
Upper Bull River East (16,951 acres)	East Fork Bull River	High	70	16,951	100%	70	High	70
		Moderate	25			25	Moderate	25
		Low	5			5	Low	5
		None	0			0	None	0

Table 1-3 Riparian quality assessment and sub-basin correlation (continued).

TMDL Sub-basin Name and Area	GEI Consultants Sub-basin Name	Existing Conditions Riparian Quality	Percent of GEI Sub-basin	GEI Sub-basin Area (acres)	Percent of TMDL Sub-basin Area	Weighted Riparian Quality Percent by Area	TMDL Sub-basin Riparian Quality	Percent of TMDL Sub-basin for Existing Conditions
Lower Bull River (16,330 acres)	Bull River	High	35	44,973	70.3%	24.6	High	38
		Moderate	30			21.1		
		Low	30			21.1	Moderate	33
		None	5			3.5		
	Copper Gulch	High	45	4,843	29.7%	13.4	Low	24
		Moderate	40			11.9		
		Low	10			3.0	None	5
		None	5			1.5		
Elk Creek Idaho (3,983 acres)	West Fork Elk Creek		Unknown	7,734	100%		same as Elk Creek	
East Fork Elk Creek (16,111 acres)	East Fork Elk Creek	High	30	16,111	100%	30	High	30
		Moderate	40			40	Moderate	40
		Low	25			25	Low	25
		None	5			5	None	5
Elk Creek (16,872 acres)	West Fork Elk Creek		Unknown	7,734	22.8%			
	Elk Creek	High	20	13,022	77.2%	20	High	20
		Moderate	30			30	Moderate	30
		Low	45			45	Low	45
		None	5			5	None	5
Swamp Creek (22,931 acres)	Swamp Creek	High	60	22,931	100%	60	High	60
		Moderate	20			20	Moderate	20
		Low	15			15	Low	15
		None	5			5	None	5

Table 1-3 Riparian quality assessment and sub-basin correlation (continued).

TMDL Sub-basin Name and Area	GEI Consultants Sub-basin Name	Existing Conditions Riparian Quality	Percent of GEI Sub-basin	GEI Sub-basin Area (acres)	Percent of TMDL Sub-basin Area	Weighted Riparian Quality Percent by Area	TMDL Sub-basin Riparian Quality	Percent of TMDL Sub-basin for Existing Conditions
Marten Creek (29,504 acres)	Marten Creek	High	20	17,717	60.0%	12.0	High	22
		Moderate	40			24.0		
		Low	30			18.0	Moderate	48
		None	10			6.0		
	South Fork Marten Creek	High	25	11,787	40.0%	10.0	Low	22
		Moderate	60			24.0		
		Low	10			4.0	None	8
		None	5			2.0		
White Pine Creek (19,966 acres)	White Pine Creek	High	40	19,966	100%	40	High	40
		Moderate	30			30	Moderate	30
		Low	20			20	Low	20
		None	10			10	None	10

1.5.10 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 redeposited a short distance downslope however, and most sediment produced from a hillslope erosion event does not travel so far as to be delivered to a stream channel. As TMDL questions deal specifically with sediment delivered to the stream, a method of accounting for redeposition and ultimate delivery to streams is required.

With USLE based models, this accounting of sediment redeposition 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, we incorporate riparian zone health and its effect on sediment delivery into our distance based sediment delivery ratio.

1.5.10.1 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 1-8**.

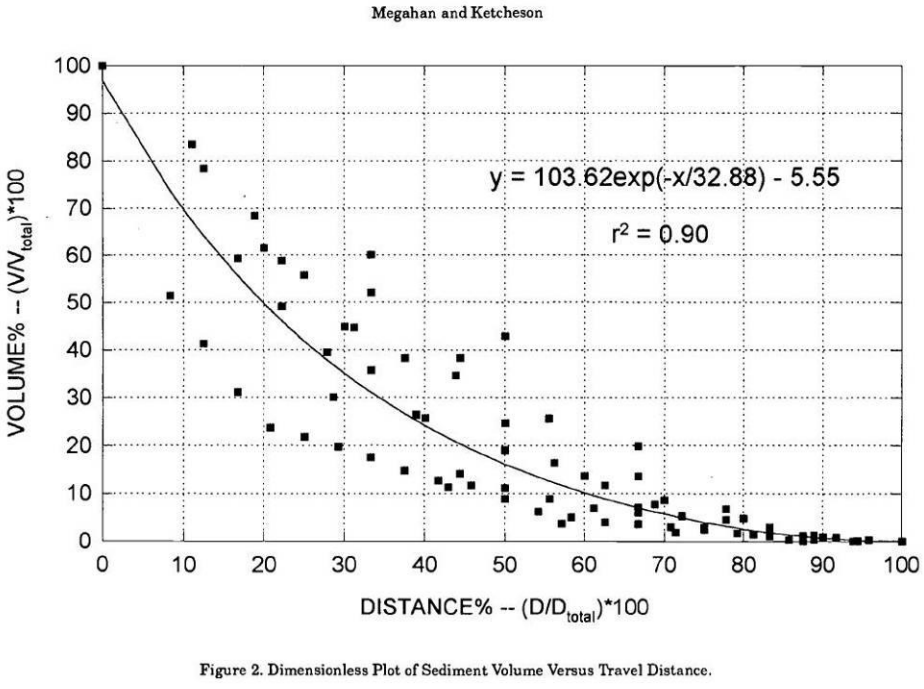


Figure 2. Dimensionless Plot of Sediment Volume Versus Travel Distance.

Figure 1-8. 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 1-8, 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

1.5.10.2 Subwatershed 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 1.5.10.1) 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 Lower Clark Fork Tributaries watersheds. Conversely, this analysis conservatively assumes that a 100 foot wide riparian zone without vegetation cover (corresponding to a riparian health assessment of 'none') would only filter 10% of incoming sediment from reaching its stream. An approximately equal apportionment of the remaining

range in sediment reduction efficency between the 'poor' and 'good' riparian assessment categories results in the riparian health/sediment delivery relationship shown in Figure 1-9

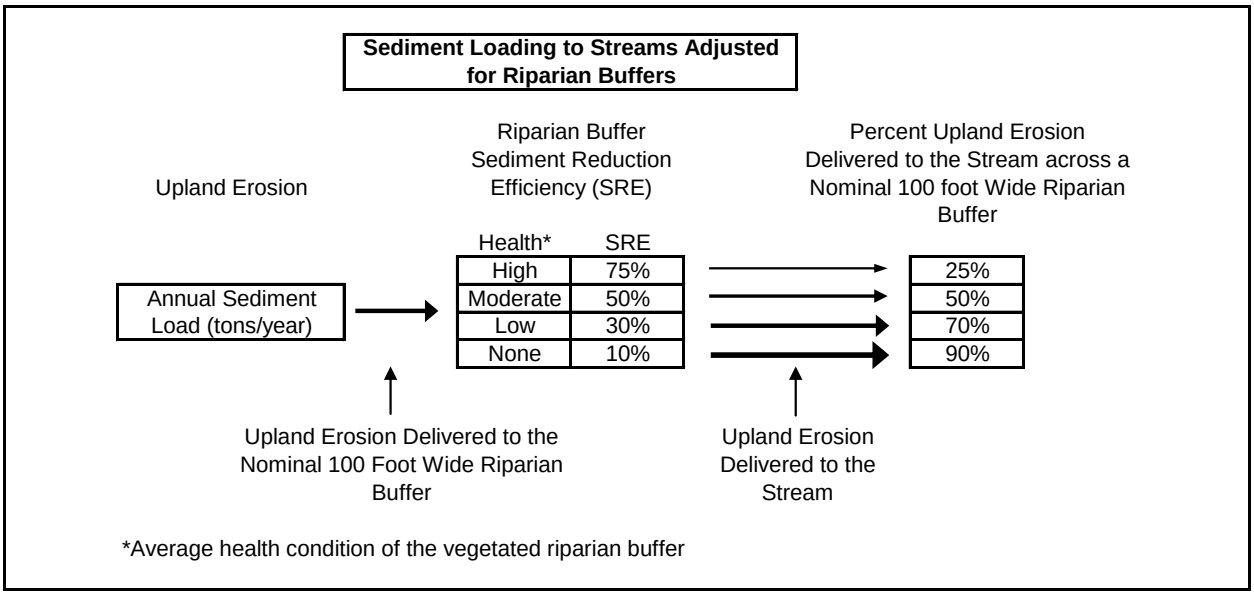


Figure 1-9. USLE Upland Sediment Load Delivery Adjusted for Riparian Buffer Capacity

Applying this relationship to the Lower Clark Fork Tributaries 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 sub-basin in each of the four riparian health classes, multiplying by the assumed sediment delivery efficiency reduction for each class (75% for high quality, 50% for a moderate quality, 30% for a low quality, and 10% for none) and summing for each stream. An example calculation is presented in **Table 1-4.**

Table 1-4 Example of Calculation of Riparian Health SDR Factor for Bull River Headwaters.

Existing Riparian Quality	Percent of GEI Sub-basin	Weighted Percent of TMDL Sub-basin by Area	Percent of GEI Sub-basin	Weighted Percent of TMDL Sub-basin by Area	Percent of GEI Sub-basin	Weighted Percent of TMDL Sub-basin by Area	Sub-Total Percent of TMDL Sub-basin	Weighted Sediment Reduction Percentage Existing Conditions
	North Fork Bull River		Middle Fork Bull River		South Fork Bull River			
High	95	95 * 0.293 = 27.9	90	90 * 0.325 = 29.2	95	95 * 0.382 = 36.3	27.9+29.2+ 36.2 = 93.4	0.934 * 0.75 = 0.70
Moderate	5	5 * 0.293 = 1.5	10	10 * 0.325 = 3.3	5	5 * 0.382 = 1.9	1.5+3.3+1. 9 = 6.6	0.066 * 0.50 = 0.03
Low	0	0 * 0.293 = 0	0	0 * 0.293 = 0	0	0 * 0.293 = 0	0+0+0 = 0	0 * 0.30 = 0
None	0	0 * 0.293 = 0	0	0 * 0.293 = 0	0	0 * 0.293 = 0	0+0+0 = 0	0 * 0.10 = 0
Total	100		100		100		100	0.70 + 0.03 + 0 + 0 = 0.73
Therefore the sediment delivered to the stream is 1 – 0.73 = 0.27 or 27% of the total calculated sediment load.								

The riparian health assessment based Sediment Reduction Percentage computed for each sub-basin of interest is presented in **Table 1-5.** 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 moderate quality riparian health to high quality and an area with low quality riparian health would improve to moderate quality.

A riparian health assessment was not completed for the Elk Creek Idaho sub-basin. The Elk Creek Idaho sub-basin was assumed to be similar to the Elk Creek sub-basin and assigned a sediment delivery reduction of 41%.

Table 1-5 Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Sub-Basin for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Sub-Basin for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage
Bull River Headwaters	High	93	70	100	75	
	Moderate	7	3	0	0	
	Low	0	0	0	0	
	None	0	0	0	0	
	Total	100	**73**	100	**75**	**2**
Dry Creek	High	35	26	65	49	
	Moderate	30	15	30	15	
	Low	30	9	0	0	
	None	5	1	5	1	
	Total	100	**51**	100	**65**	**14**
Upper Bull River West	High	35	26	65	49	
	Moderate	30	15	30	15	
	Low	30	9	0	0	
	None	5	1	5	1	
	Total	100	**51**	100	**65**	**14**
Upper Bull River East	High	70	53	95	71	
	Moderate	25	13	5	3	
	Low	5	2	0	0	
	None	0	0	0	0	
	Total	100	**68**	100	**74**	**6**
Lower Bull River	High	38	28	65	53	
	Moderate	33	16	60	23	
	Low	24	7	0	0	
	None	5	1	5	1	
	Total	100	**52**	100	**77**	**25**
Elk Creek Idaho	High	20	15	50	38	
	Moderate	30	15	45	23	
	Low	45	14	0	0	
	None	5	1	5	1	
	Total	100	**45**	100	**62**	**17**

Table 1-5 Sediment reduction percentage based on riparian health assessment.						
Sub-Basin	**Riparian Quality**	**Percent of TMDL Sub-Basin for Existing Conditions**	**Weighted Sediment Reduction Percentage Existing Conditions**	**Percent of TMDL Sub-Basin for BMP Conditions**	**Weighted Sediment Reduction Percentage BMP Conditions**	**Change in Sediment Reduction Percentage**
East Fork Elk Creek	High	30	23	70	53	
	Moderate	40	20	25	13	
	Low	25	8	0	0	
	None	5	1	5	1	
	Total	100	**52**	100	**67**	**15**
Elk Creek	High	20	15	50	38	
	Moderate	30	15	45	23	
	Low	45	14	0	0	
	None	5	1	5	1	
	Total	100	**45**	100	**62**	**17**
Swamp Creek	High	60	45	80	60	
	Moderate	20	10	15	8	
	Low	15	5	0	0	
	None	5	1	5	1	
	Total	100	**61**	100	**69**	**8**
Marten Creek	High	22	16	70	52	
	Moderate	48	24	22	11	
	Low	22	7	0	0	
	None	8	1	8	1	
	Total	100	**48**	100	**64**	**16**
White Pine Creek	High	40	30	70	53	
	Moderate	30	15	20	10	
	Low	20	6	0	0	
	None	10	1	10	1	
	Total	100	**52**	100	**64**	**12**

1.5.10.3 Sediment Delivery Ratio - Example Calculation

To create a final, subwatershed specific SDR, Megahan and Ketcheson's dimensionless equation relating percent sediment volume to percent travel distance (**Figure 1-8**) was scaled to each subwatershed by using its riparian health assessment based 100 ft Sediment Reduction Percentage to derive a site specific maximum sediment travel distance. For each subwatershed, the following method was applied:

1 From the subwatershed's Riparian Health Assessment, determine the expected % sediment delivery across a nominal 100 foot wide riparian zone.

Example:
Per Table 1-5, the Bull River Headwaters subwatershed's expected sediment delivery across a **100** foot wide riparian zone is (100%-73% reduction) = **27%** 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 =

27% = 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 subwatershed.

Example:
27% = 103.62exp(-((**100**/Dtotal)*100)/32.88) -5.55

Dtotal = **100**/(-0.3288*ln((**27**+5.55)/103.62))

Dtotal = **263** feet

4 Restate the M&K equation using the subwatershed's calculated maximum sediment travel distance (Dtotal) to arrive at an integrated Distance and Riparian Health based Sediment Deliver Ratio (SDR) for that subwatershed.

Example:
Within the Bull River Headwaters subwatershed, 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/263)*100)/32.88) -5.55

By this method, the Sediment Delivery Ratio for each analytical pixel in a Lower Clark Fork Tributaries subwatershed 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 subwatershed specific Riparian Health derived maximum sediment travel distance.

1.5.11 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 professional 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 Lower Clark Fork watershed. 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 Lower Clark Fork Riparian Health Assessment data to derive site-specific scalings of the dimensionless equation for Lower Clark Fork subwatersheds, 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 90% sediment reduction at 100 feet, deriving a Dtotal value that may be used to estimate the % 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 % delivery for that portion of the path is 10%, 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 10%. 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 Lower Clark Fork TMDL purposes. Discussion: The USLE is an empirical model developed initially for eastern US crop lands, 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 Lower Clark Fork 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 Lower Clark Fork. The implementation of that SDR method used here is further fit to the Lower Clark Fork 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 Lower Clark Fork watershed have not been tested empirically. Use of the results for relative comparison (as between subwatersheds 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.

1.6 Results

1.6.1 Management Scenarios

Figures 1-10 through 1-13 present the USLE based hillslope model's prediction of existing and potential conditions graphically. **Tables 1-6 through 1-10** present the prediction of existing and potential conditions numerically, broken out by 6th code HUC (as modified to represent the 303d listed streams) and existing land cover type. **Tables 1-6 through 1-10** also present 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, Lower Bull River is a sum of the results for that sub-basin plus the results for Upper Bull River East, Upper Bull River West, Dry Creek, and Bull River Headwaters.

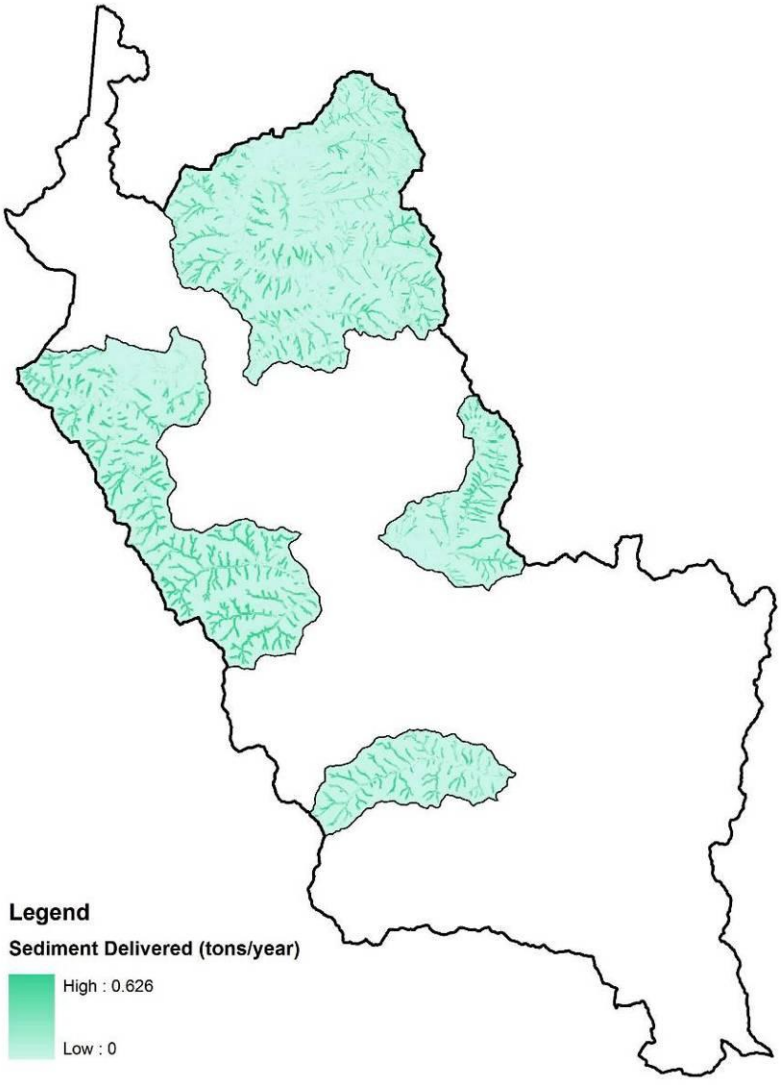


Figure 1-10. Upland Erosion Sediment Load for Existing Conditions Scenario 1.

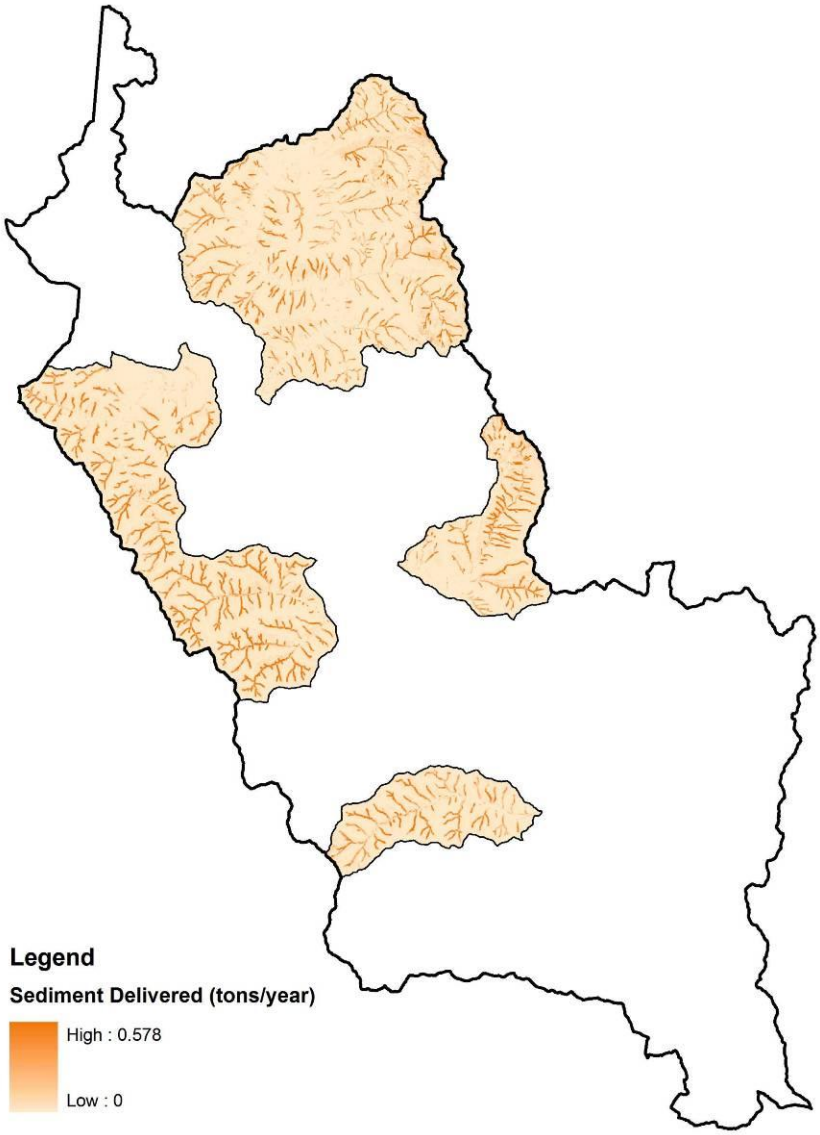


Figure 1-11. Upland Erosion Sediment Load for Existing Upland Conditions and BMP Riparian Health Conditions Scenario 2.

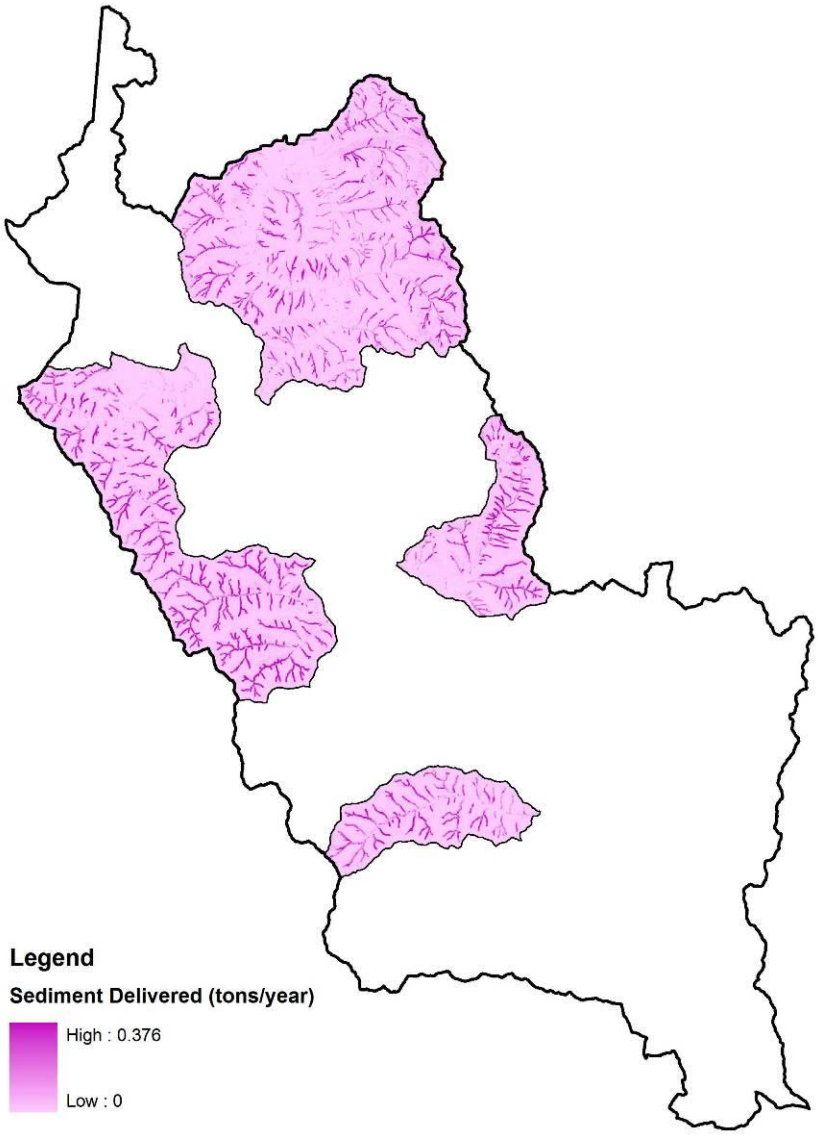


Figure 1-12. Upland Erosion Sediment Load for BMP Upland and Riparian Health Conditions Scenario 3.

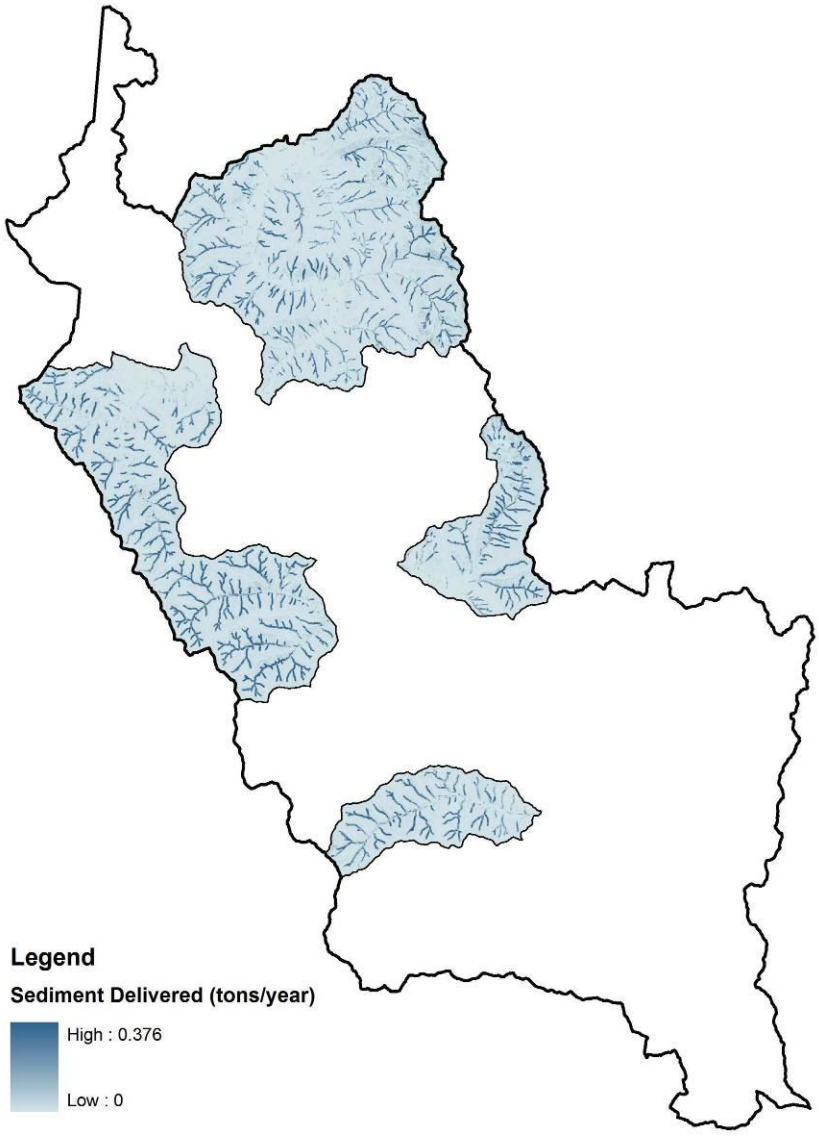


Figure 1-13. Upland Erosion Sediment Load for Natural Conditions Scenario 4.

Table 1-6 Delivered Sediment Load by Land Cover Type for the Bull River Watershed									
			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Bull River Headwaters	Evergreen Forest	19,670	1,086.4	1,027.6	5%	1,027.6	5%	1,027.6	5%
	Shrub/Scrub	2,201	251.2	240.2	4%	240.2	4%	240.2	4%
	Transitional	28	0.6	0.6	0%	0.3	50%	0.3	50%
	Grassland/Herbaceous	1,737	416.2	399.1	4%	259.4	38%	259.4	38%
	Emergent Herbaceous Wetland	1	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Woody Wetlands	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Barren Land	363	4.9	4.7	4%	4.7	4%	4.7	4%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	2	0.8	0.8	3%	0.5	37%	0.1	86%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**24,002**	**1,760.0**	**1,673.0**	**5%**	**1,532.7**	**13%**	**1,532.3**	**13%**
Dry Creek	Evergreen Forest	5,157	453.8	313.9	31%	313.9	31%	313.9	31%
	Shrub/Scrub	238	23.7	14.7	38%	14.7	38%	14.7	38%
	Transitional	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Grassland/Herbaceous	29	5.2	2.9	45%	1.9	64%	1.9	64%
	Emergent Herbaceous Wetland	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Woody Wetlands	1	0.1	0.1	19%	0.1	19%	0.1	19%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**5,426**	**482.7**	**331.5**	**31%**	**330.5**	**32%**	**330.5**	**32%**

*Value is below reporting limit.

Table 1-6 Delivered Sediment Load by Land Cover Type for the Bull River Watershed (continued)

			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Upper Bull River West	Evergreen Forest	22,760	1,979.8	1,365.7	31%	1,365.7	31%	1,365.7	31%
	Shrub/Scrub	2,748	390.7	272.4	30%	272.4	30%	272.4	30%
	Transitional	1,121	134.8	92.6	31%	46.3	66%	46.3	66%
	Grassland/Herbaceous	218	36.8	25.3	31%	16.4	55%	16.4	55%
	Emergent Herbaceous Wetland	707	4.6	2.9	36%	2.9	36%	2.9	36%
	Woody Wetlands	486	2.2	1.4	34%	1.4	34%	1.4	34%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	187	8.1	4.9	39%	4.9	39%	4.9	39%
	Deciduous Forest	31	9.7	7.7	20%	7.7	20%	7.7	20%
	Developed, Low Intensity	68	0.7	0.5	34%	0.5	34%	1.4	-98%
	Pasture/Hay	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	4	1.3	1.0	19%	0.6	49%	0.0*	99%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**28,330**	**2,568.6**	**1,774.4**	**31%**	**1,718.9**	**33%**	**1,719.2**	**33%**
Upper Bull River East	Evergreen Forest	14,454	1,095.9	878.0	20%	878.0	20%	878.0	20%
	Shrub/Scrub	1,750	558.3	455.2	18%	455.2	18%	455.2	18%
	Transitional	3	0.1	0.1	0%	0.0	50%	0.0	50%
	Grassland/Herbaceous	570	179.4	154.9	14%	100.7	44%	100.7	44%
	Emergent Herbaceous Wetland	9	0.2	0.2	23%	0.2	23%	0.2	23%
	Woody Wetlands	5	0.1	0.1	23%	0.1	23%	0.1	23%
	Barren Land	17	0.1	0.1	0%	0.1	0%	0.1	0%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	30	14.1	11.7	17%	11.7	17%	11.7	17%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	4	1.7	1.4	17%	0.9	46%	0.2	88%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**16,841**	**1,849.8**	**1,501.5**	**19%**	**1,446.8**	**22%**	**1,446.1**	**22%**

*Value is below reporting limit.

Table 1-6 Delivered Sediment Load by Land Cover Type for the Bull River Watershed (continued)

			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Lower Bull River	Evergreen Forest	14,376	1,212.9	644.0	47%	644.0	47%	644.0	47%
	Shrub/Scrub	1,221	188.4	100.3	47%	100.3	47%	100.3	47%
	Transitional	44	0.7	0.7	0%	0.3	50%	0.3	50%
	Grassland/Herbaceous	35	30.6	15.0	51%	9.7	68%	9.7	68%
	Emergent Herbaceous Wetland	156	1.2	0.6	48%	0.6	48%	0.6	48%
	Woody Wetlands	171	3.7	1.9	49%	1.9	49%	1.9	49%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	143	3.4	1.6	52%	1.6	52%	1.6	52%
	Deciduous Forest	90	16.1	8.6	47%	8.6	47%	8.6	47%
	Developed, Low Intensity	29	0.2	0.1	59%	0.1	59%	0.3	-22%
	Pasture/Hay	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Mixed Forest	6	0.4	0.2	53%	0.2	53%	0.2	53%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**16,269**	**1,457.6**	**772.9**	**47%**	**767.3**	**47%**	**767.5**	**47%**
Bull River Total	Evergreen Forest	76,417	5,828.7	4,229.1	27%	4,229.1	27%	4,229.1	27%
	Shrub/Scrub	8,158	1,412.2	1,082.8	23%	1,082.8	23%	1,082.8	23%
	Transitional	1,196	136.1	93.9	31%	46.9	66%	46.9	66%
	Grassland/Herbaceous	2,589	668.1	597.1	11%	388.1	42%	388.1	42%
	Emergent Herbaceous Wetland	873	6.0	3.7	38%	3.7	38%	3.7	38%
	Woody Wetlands	663	6.1	3.5	43%	3.5	43%	3.5	43%
	Barren Land	380	5.0	4.8	4%	4.8	4%	4.8	4%
	Developed, Open Space	330	11.6	6.6	0%	6.6	0%	6.6	0%
	Deciduous Forest	151	39.9	28.0	30%	28.0	30%	28.0	30%
	Developed, Low Intensity	97	0.9	0.6	0%	0.6	0%	1.7	0%
	Pasture/Hay	6	2.5	2.2	12%	1.4	43%	0.3	87%
	Mixed Forest	6	0.4	0.2	0%	0.2	0%	0.2	0%
	Cultivated Crops	4	1.3	1.0	0%	0.6	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**90,869**	**8,118.8**	**6,053.4**	**25%**	**5,796.3**	**29%**	**5,795.7**	**29%**

*Value is below reporting limit. Note: Results for the Bull River Total sub-basin is a sum of the results for the Bull River Headwaters, Dry Creek, Upper Bull River West, Upper Bull River East, and Lower Bull River sub-basins.

Table 1-7 Delivered Sediment Load by Land Cover Type for the Elk Creek Watershed

			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Elk Creek Idaho	Evergreen Forest	3,632	468.7	285.8	39%	285.8	39%	285.8	39%
	Shrub/Scrub	350	92.6	49.1	47%	49.1	47%	49.1	47%
	Transitional	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Grassland/Herbaceous	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Emergent Herbaceous Wetland	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Woody Wetlands	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**3,982**	**561.3**	**334.9**	**40%**	**334.9**	**40%**	**334.9**	**40%**
East Fork Elk Creek	Evergreen Forest	14,782	2,041.5	1,305.2	36%	1,305.2	36%	1,305.2	36%
	Shrub/Scrub	860	240.6	136.2	43%	136.2	43%	136.2	43%
	Transitional	290	16.6	11.4	31%	5.7	66%	5.7	66%
	Grassland/Herbaceous	14	12.8	5.0	61%	3.3	75%	3.3	75%
	Emergent Herbaceous Wetland	102	2.0	1.3	36%	1.3	36%	1.3	36%
	Woody Wetlands	2	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	27	6.1	3.4	44%	3.4	44%	3.4	44%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Mixed Forest	5	0.6	0.3	53%	0.3	53%	0.3	53%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**16,082**	**2,320.3**	**1,462.8**	**37%**	**1,455.3**	**37%**	**1,455.3**	**37%**

*Value is below reporting limit.

Table 1-7 Delivered Sediment Load by Land Cover Type for the Elk Creek Watershed (continued)

			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Elk Creek	Evergreen Forest	13,633	1,056.6	648.9	39%	648.9	39%	648.9	39%
	Shrub/Scrub	1,897	216.3	120.2	44%	120.2	44%	120.2	44%
	Transitional	598	80.5	47.4	41%	23.7	71%	23.7	71%
	Grassland/Herbaceous	134	1.3	0.4	65%	0.3	77%	0.3	77%
	Emergent Herbaceous Wetland	374	8.3	5.0	40%	5.0	40%	5.0	40%
	Woody Wetlands	96	1.0	0.5	47%	0.5	47%	0.5	47%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	1	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Deciduous Forest	71	11.3	6.1	46%	6.1	46%	6.1	46%
	Developed, Low Intensity	9	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Pasture/Hay	3	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Mixed Forest	13	0.4	0.2	44%	0.2	44%	0.2	44%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**16,828**	**1,375.8**	**828.9**	**40%**	**805.1**	**41%**	**805.1**	**41%**
Elk Creek Total	Evergreen Forest	32,047	3,566.9	2,239.9	37%	2,239.9	37%	2,239.9	37%
	Shrub/Scrub	3,106	549.5	305.5	44%	305.5	44%	305.5	44%
	Transitional	888	97.1	58.8	39%	29.4	70%	29.4	70%
	Grassland/Herbaceous	148	14.1	5.4	61%	3.5	75%	3.5	75%
	Emergent Herbaceous Wetland	476	10.3	6.2	39%	6.2	39%	6.2	39%
	Woody Wetlands	97	1.0	0.6	46%	0.6	46%	0.6	46%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	1	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Deciduous Forest	98	17.4	9.5	45%	9.5	45%	9.5	45%
	Developed, Low Intensity	9	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Pasture/Hay	3	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Mixed Forest	18	1.0	0.5	50%	0.5	50%	0.5	50%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**36,892**	**4,257.4**	**2,626.5**	**38%**	**2,595.2**	**39%**	**2,595.3**	**39%**

*Value is below reporting limit. Note: Results for the Elk Creek Total sub-basin is a sum of the results for the Elk Creek Idaho, East Fork Elk Creek, and Elk Creek sub-basins.

Table 1-8 Delivered Sediment Load by Land Cover Type for the Swamp Creek Watershed									
			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Swamp Creek	Evergreen Forest	18,620	1,779.0	1,428.5	20%	1,428.5	20%	1,428.5	20%
	Shrub/Scrub	2,780	534.4	420.5	21%	420.5	21%	420.5	21%
	Transitional	65	10.8	8.2	24%	4.1	62%	4.1	62%
	Grassland/Herbaceous	961	282.4	228.2	19%	148.4	47%	148.4	47%
	Emergent Herbaceous Wetland	153	1.7	1.4	17%	1.4	17%	1.4	17%
	Woody Wetlands	94	1.0	0.8	19%	0.8	19%	0.8	19%
	Barren Land	11	0.1	0.1	0%	0.1	0%	0.1	0%
	Developed, Open Space	38	0.7	0.5	26%	0.5	26%	0.5	26%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	12	0.0*	0.0*	0%	0.0*	0%	0.1	-113%
	Pasture/Hay	55	6.8	5.5	18%	3.6	47%	0.8	88%
	Mixed Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Cultivated Crops	6	2.0	1.5	24%	0.9	53%	0.0*	99%
	Developed, Medium Intensity	1	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Total	**22,796**	**2,618.9**	**2,095.4**	**20%**	**2,008.9**	**23%**	**2,005.3**	**23%**

*Value is below reporting limit.

Table 1-9 Delivered Sediment Load by Land Cover Type for the Marten Creek Watershed									
			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
Marten Creek	Evergreen Forest	26,174	4,226.5	2,627.7	38%	2,627.7	38%	2,627.7	38%
	Shrub/Scrub	2,312	890.0	534.1	40%	534.1	40%	534.1	40%
	Transitional	763	114.4	70.9	38%	35.4	69%	35.4	69%
	Grassland/Herbaceous	85	42.5	18.7	56%	12.1	71%	12.1	71%
	Emergent Herbaceous Wetland	167	5.5	3.4	38%	3.4	38%	3.4	38%
	Woody Wetlands	20	0.9	0.6	36%	0.6	36%	0.6	36%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	5	1.2	0.6	51%	0.6	51%	0.6	51%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	3	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Pasture/Hay	2	0.0*	0.0*	0%	0.0*	0%	0.0*	0%
	Mixed Forest	5	1.0	0.4	64%	0.4	64%	0.4	64%
	Cultivated Crops	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**29,536**	**5,282.0**	**3,256.2**	**38%**	**3,214.2**	**39%**	**3,214.3**	**39%**

*Value is below reporting limit.

Table 1-10 Delivered Sediment Load by Land Cover Type for the White Pine Creek Watershed									
			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 **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**	Upland Erosion Sediment Load for **Natural** Conditions and **BMP** Riparian Health **(tons/year)**	**Percent Change from Existing**
White Pine Creek	Evergreen Forest	16,706	1,628.7	1,167.0	28%	1,167.0	28%	1,167.0	28%
	Shrub/Scrub	1,139	160.4	107.0	33%	107.0	33%	107.0	33%
	Transitional	1,650	124.5	85.9	31%	42.9	66%	42.9	66%
	Grassland/Herbaceous	285	60.9	42.4	30%	27.6	55%	27.6	55%
	Emergent Herbaceous Wetland	149	1.2	0.8	29%	0.8	29%	0.8	29%
	Woody Wetlands	5	0.2	0.1	29%	0.1	29%	0.1	29%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Deciduous Forest	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Pasture/Hay	22	0.3	0.3	18%	0.2	46%	0.0*	88%
	Mixed Forest	3	0.1	0.1	0%	0.1	0%	0.1	0%
	Cultivated Crops	2	1.5	1.1	27%	0.7	54%	0.0*	99%
	Developed, Medium Intensity	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**19,961**	**1,977.7**	**1,404.6**	**29%**	**1,346.4**	**32%**	**1,345.6**	**32%**

*Value is below reporting limit.

1.6.2 Historic Scenario

Figure 1-14 presents the historic timber harvest and forest fire event polygons, color coded according to decadal groupings.

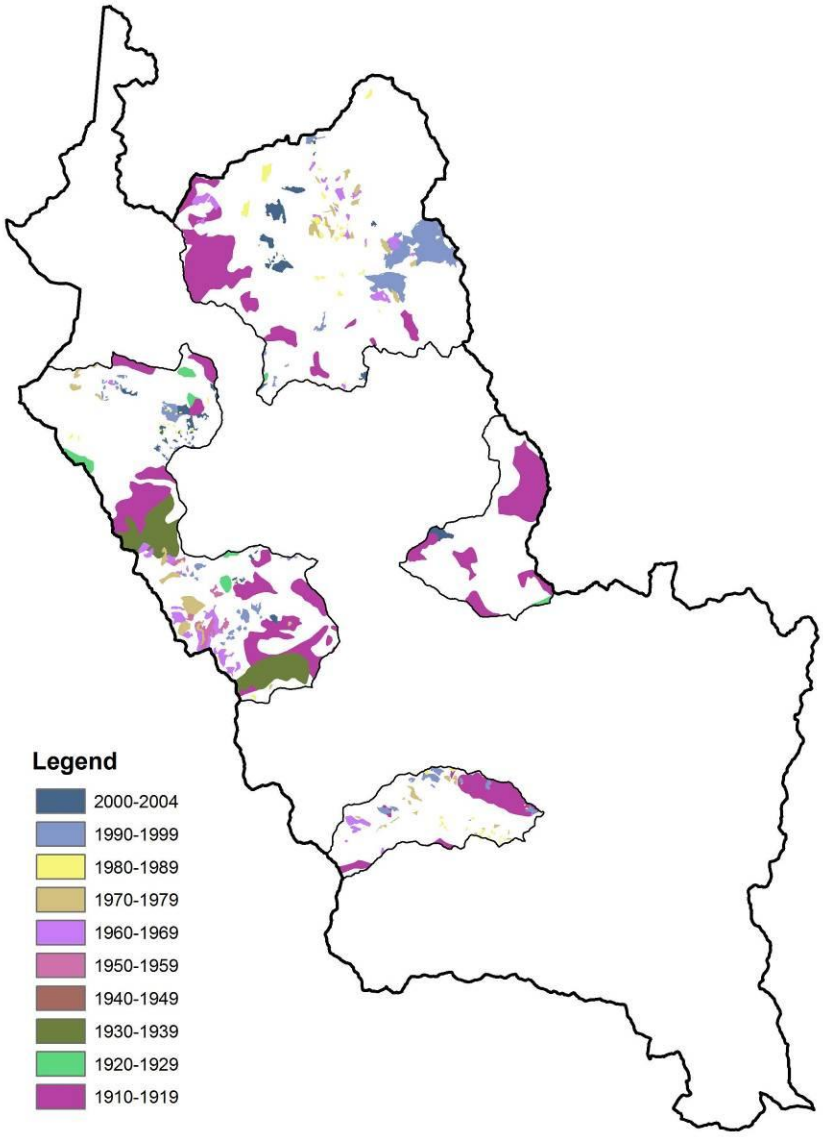


Figure 1-14. Areas that have been logged or burned for a given decade within the Lower Clark Fork Tributaries watershed.

Figure 1-15 presents the estimated annualized sediment delivery to streams from the 'transitional' landcover category for each decadal grouping, broken out by sub watershed. It thus presents the influence of timber harvest and fire events on those subwatersheds for the time periods of interest. **Figure 1-16** presents the total estimated annualized sediment delivery to streams for each decadal grouping, broken out by sub watershed. This permits evaluation of the effects of historic fire and logging on individual subwatersheds, as well as comparison to existing conditions estimates.

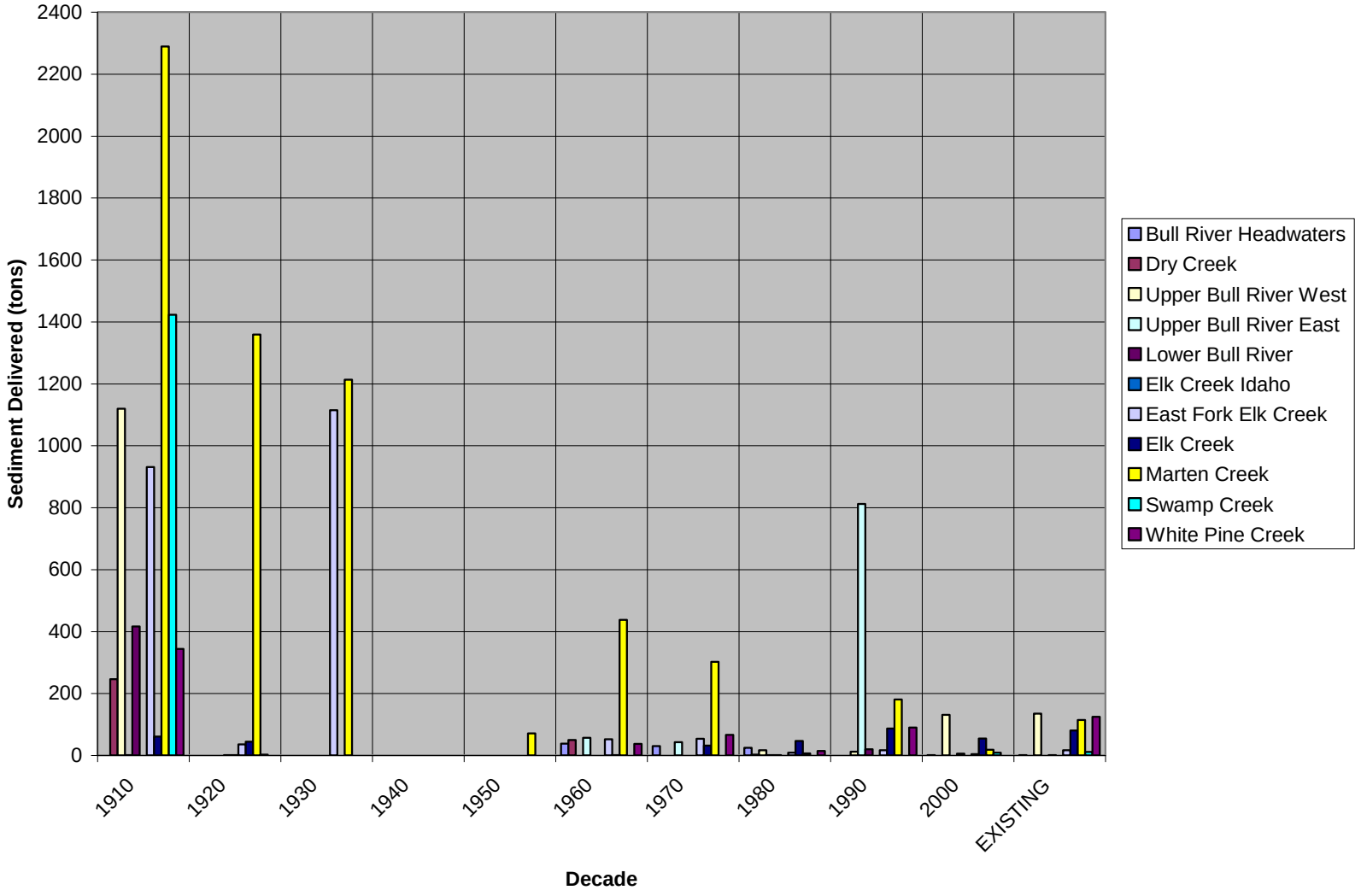


Figure 1-15. Estimated quantity of sediment delivered to the streams from the transitional land use areas within each sub-basin for each decade evaluated.

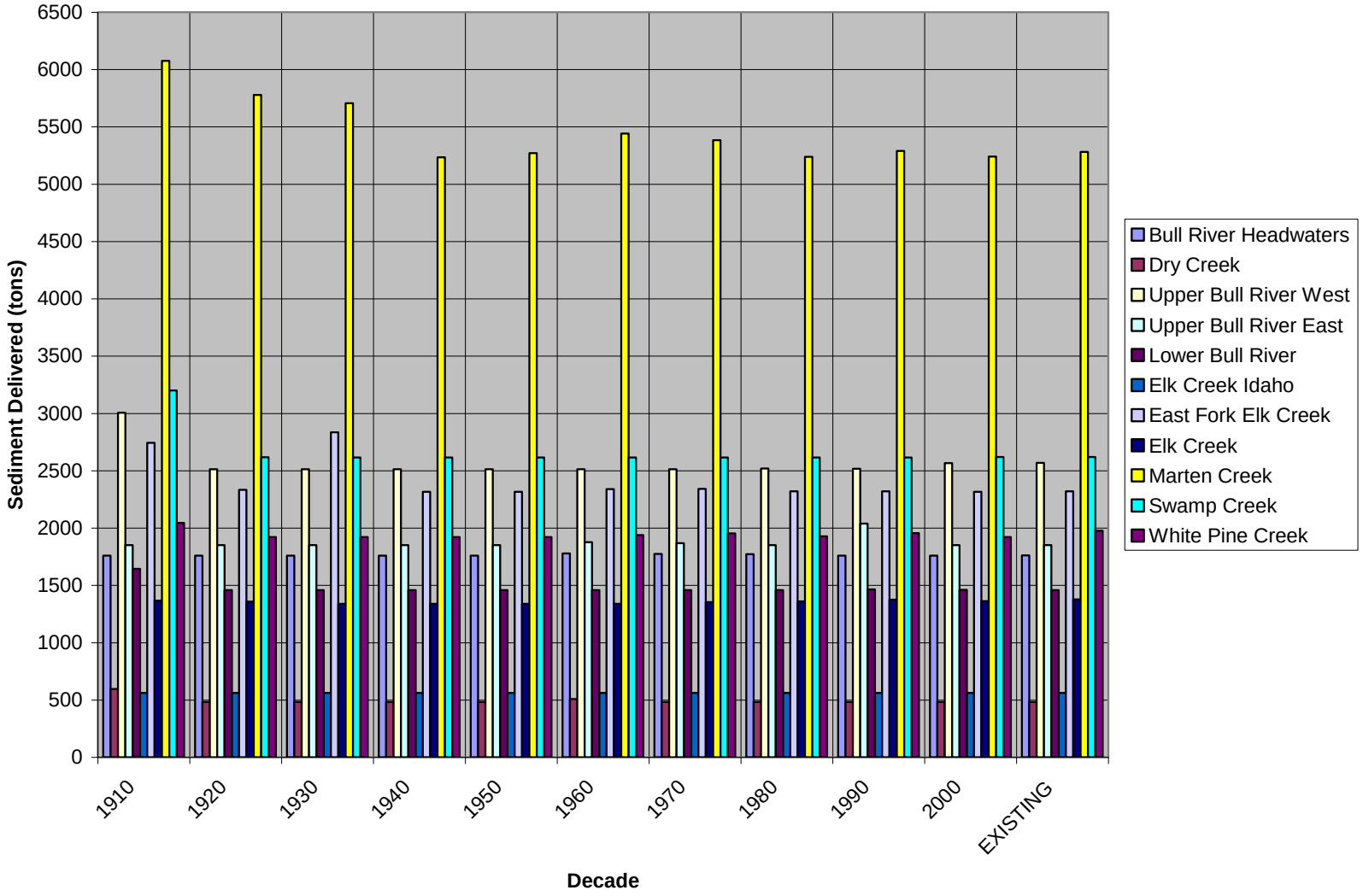


Figure 1-16. Total estimated quantity of sediment delivered to the streams from all land use areas within each sub-basin for each decade evaluated.

Table 1-11 through **Table 1-15** present the estimated sediment delivered from annual timber harvest and/or fire events for each decadal grouping, for each sub watershed. Results are broken out by landcover categories 'transitional' (includes the fire and harvest areas) and 'other' (all other lancovers/land uses). The results from each decade with the most significant effect from annual events are presented in bold.

The following are some general observations of the Historic Scenario results:

- The 1910 fire affected the most sub-basins and covered the largest area.
- For the Lower Clark Fork Tributaries TMDL sub-basins, there were no reported logging or fires in the decade 1940-1949.
- From 1910-1939, the predominant transitional polygon type was fire.
- After 1960, the predominant transitional polygon type was timber harvest.
- The Marten Creek sub-basin has experienced a large fire or harvest impact in almost every decade reviewed, except 1940-1949 and 1980-1989.
- Most events in most sub watersheds have marginal estimated effect on total sediment delivered for the watershed as a whole. Severe events such as the 1910 fires are estimated here to have resulted in a 20-30% increase in annual sediment delivery.

Table 1-11 Estimated sediment delivered from annual events within each decade for the Marten Creek Watershed.

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Marten Creek	**1910-1919**	**Other**	**3,785.7**	**22,537**	**76%**
		Transitional	**2,288.9**	**6,993**	**24%**
	1920-1929	Other	4,419.0	26,501	90%
		Transitional	1,358.7	3,028	10%
	1930-1939	Other	4,492.1	26,836	91%
		Transitional	1,213.0	2,694	9%
	1940-1949	Other	5,234.7	29,530	100%
		Transitional	0.0	0	0%
	1950-1959	Other	5,199.0	28,890	98%
		Transitional	70.6	640	2%
	1960-1969	Other	5,004.7	28,338	96%
		Transitional	437.4	1,192	4%
	1970-1979	Other	5,081.6	28,605	97%
		Transitional	302.3	925	3%
	1980-1989	Other	5,231.6	29,481	100%
		Transitional	6.1	49	0%
	1990-1999	Other	5,108.3	28,973	98%
		Transitional	180.8	557	2%
	2000-2004	Other	5,222.1	29,379	99%
		Transitional	18.1	151	1%
	Existing	Other	5,167.7	28,773	97%
		Transitional	114.4	763	3%

Table 1-12 Estimated sediment delivered from annual events within each decade for the Bull River Watershed.

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Bull River Headwaters	1910-1919	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	1920-1929	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	1930-1939	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	1940-1949	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	1950-1959	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	1960-1969	**Other**	**1,740.7**	**23,611**	**98%**
		Transitional	**38.0**	**391**	**2%**
	1970-1979	Other	1,744.4	23,426	98%
		Transitional	29.8	575	2%
	1980-1989	Other	1,746.6	23,712	99%
		Transitional	24.5	289	1%
	1990-1999	Other	1,759.7	24,001	100%
		Transitional	0.0	0	0%
	2000-2004	Other	1,759.4	23,973	100%
		Transitional	0.6	28	0%
	Existing	Other	1,759.5	23,974	100%
		Transitional	0.6	28	0%
Dry Creek	**1910-1919**	**Other**	**349.0**	**3,956**	**73%**
		Transitional	**246.0**	**1,470**	**27%**
	1920-1929	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	1930-1939	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	1940-1949	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	1950-1959	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	1960-1969	Other	457.9	5,069	93%
		Transitional	49.3	357	7%
	1970-1979	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	1980-1989	Other	481.2	5,359	99%
		Transitional	2.3	68	1%
	1990-1999	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	2000-2004	Other	482.7	5,426	100%
		Transitional	0.0	0	0%
	Existing	Other	482.7	5,426	100%
		Transitional	0.0	0	0%

Table 1-12 Estimated sediment delivered from annual events within each decade for the Bull River Watershed (continued).

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Upper Bull River West	**1910-1919**	**Other**	**1,885.7**	**23,657**	**83%**
		Transitional	**1,119.3**	**4,675**	**17%**
	1920-1929	Other	2,511.6	28,329	100%
		Transitional	0.0	0	0%
	1930-1939	Other	2,511.6	28,329	100%
		Transitional	0.0	0	0%
	1940-1949	Other	2,511.6	28,329	100%
		Transitional	0.0	0	0%
	1950-1959	Other	2,511.6	28,329	100%
		Transitional	0.0	0	0%
	1960-1969	Other	2,511.5	28,290	100%
		Transitional	0.1	38	0%
	1970-1979	Other	2,511.6	28,329	100%
		Transitional	0.0	0	0%
	1980-1989	Other	2,502.7	28,029	99%
		Transitional	16.3	299	1%
	1990-1999	Other	2,505.7	28,214	100%
		Transitional	11.8	114	0%
	2000-2004	Other	2,435.6	27,266	96%
		Transitional	131.1	1,063	4%
	Existing	Other	2,433.8	27,209	96%
		Transitional	134.8	1,121	4%
Upper Bull River East	1910-1919	Other	1,849.3	16,811	100%
		Transitional	0.8	29	0%
	1920-1929	Other	1,849.7	16,840	100%
		Transitional	0.0	0	0%
	1930-1939	Other	1,849.7	16,840	100%
		Transitional	0.0	0	0%
	1940-1949	Other	1,849.7	16,840	100%
		Transitional	0.0	0	0%
	1950-1959	Other	1,849.7	16,840	100%
		Transitional	0.0	0	0%
	1960-1969	Other	1,819.9	16,361	97%
		Transitional	56.9	479	3%
	1970-1979	Other	1,825.3	16,517	98%
		Transitional	42.7	322	2%
	1980-1989	Other	1,849.2	16,817	100%
		Transitional	1.1	23	0%
	1990-1999	**Other**	**1,226.1**	**12,909**	**77%**
		Transitional	**811.9**	**3,931**	**23%**
	2000-2004	Other	1,849.7	16,837	100%
		Transitional	0.1	3	0%
	Existing	Other	1,849.7	16,838	100%
		Transitional	0.1	3	0%

Table 1-12 Estimated sediment delivered from annual events within each decade for the Bull River Watershed (continued).

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Lower Bull River	**1910-1919**	**Other**	**1,227.3**	**14,716**	**90%**
		Transitional	**416.2**	**1,549**	**10%**
	1920-1929	Other	1,456.8	16,210	100%
		Transitional	1.1	54	0%
	1930-1939	Other	1,457.3	16,264	100%
		Transitional	0.0	0	0%
	1940-1949	Other	1,457.3	16,264	100%
		Transitional	0.0	0	0%
	1950-1959	Other	1,457.3	16,264	100%
		Transitional	0.0	0	0%
	1960-1969	Other	1,457.1	16,241	100%
		Transitional	0.4	24	0%
	1970-1979	Other	1,457.3	16,264	100%
		Transitional	0.0	0	0%
	1980-1989	Other	1,456.9	16,222	100%
		Transitional	0.8	42	0%
	1990-1999	Other	1,444.9	16,083	99%
		Transitional	19.4	181	1%
	2000-2004	Other	1,454.0	16,155	99%
		Transitional	5.4	109	1%
	Existing	Other	1,457.0	16,226	100%
		Transitional	0.7	44	0%
Bull River Total	**1910-1919**	**Other**	**7,071.1**	**83,141**	**92%**
		Transitional	**1,782.3**	**7,723**	**8%**
	1920-1929	Other	8,060.6	90,806	100%
		Transitional	1.1	54	0%
	1930-1939	Other	8,061.2	90,860	100%
		Transitional	0.0	0	0%
	1940-1949	Other	8,061.2	90,860	100%
		Transitional	0.0	0	0%
	1950-1959	Other	8,061.2	90,860	100%
		Transitional	0.0	0	0%
	1960-1969	Other	7,987.2	89,572	99%
		Transitional	144.7	1,288	1%
	1970-1979	Other	8,021.4	89,962	99%
		Transitional	72.5	898	1%
	1980-1989	Other	8,036.6	90,139	99%
		Transitional	45.0	721	1%
	1990-1999	Other	7,419.2	86,633	95%
		Transitional	843.1	4,226	5%
	2000-2004	Other	7,981.5	89,657	99%
		Transitional	137.1	1,203	1%
	Existing	Other	7,982.7	89,673	99%
		Transitional	136.1	1,196	1%

Table 1-13 Estimated sediment delivered from annual events within each decade for the Elk Creek Watershed.

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Elk Creek Idaho	1910-1919	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1920-1929	**Other**	**561.1**	**3,945**	**99%**
		Transitional	**0.5**	**36**	**1%**
	1930-1939	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1940-1949	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1950-1959	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1960-1969	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1970-1979	Other	561.2	3,967	100%
		Transitional	0.2	14	0%
	1980-1989	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	1990-1999	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	2000-2004	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
	Existing	Other	561.3	3,981	100%
		Transitional	0.0	0	0%
East Fork Elk Creek	1910-1919	Other	1,811.3	13,026	81%
		Transitional	931.1	3,054	19%
	1920-1929	Other	2,298.0	15,898	99%
		Transitional	35.2	181	1%
	1930-1939	**Other**	**1,721.4**	**12,772**	**79%**
		Transitional	**1,114.2**	**3,308**	**21%**
	1940-1949	Other	2,315.6	16,079	100%
		Transitional	0.0	0	0%
	1950-1959	Other	2,315.6	16,078	100%
		Transitional	0.0	1	0%
	1960-1969	Other	2,287.3	15,804	98%
		Transitional	51.8	275	2%
	1970-1979	Other	2,288.8	15,966	99%
		Transitional	53.5	113	1%
	1980-1989	Other	2,311.4	16,051	100%
		Transitional	8.4	28	0%
	1990-1999	Other	2,303.9	16,015	100%
		Transitional	16.4	65	0%
	2000-2004	Other	2,312.9	15,962	99%
		Transitional	4.2	117	1%
	Existing	Other	2,303.7	15,792	98%
		Transitional	16.6	290	2%

Table 1-13 Estimated sediment delivered from annual events within each decade for the Elk Creek Watershed (continued).

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Elk Creek	1910-1919	Other	1,306.2	15,405	92%
		Transitional	60.6	1,422	8%
	1920-1929	Other	1,313.2	16,232	96%
		Transitional	44.2	594	4%
	1930-1939	Other	1,337.6	16,826	100%
		Transitional	0.0	0	0%
	1940-1949	Other	1,337.6	16,826	100%
		Transitional	0.0	0	0%
	1950-1959	Other	1,337.6	16,826	100%
		Transitional	0.0	0	0%
	1960-1969	Other	1,337.0	16,789	100%
		Transitional	0.9	37	0%
	1970-1979	Other	1,321.8	16,625	99%
		Transitional	31.5	201	1%
	1980-1989	Other	1,312.5	16,689	99%
		Transitional	46.7	137	1%
	1990-1999	**Other**	**1,288.0**	**16,303**	**97%**
		Transitional	**87.1**	**523**	**3%**
	2000-2004	Other	1,308.6	16,327	97%
		Transitional	54.3	499	3%
	Existing	Other	1,295.3	16,230	96%
		Transitional	80.5	598	4%
Elk Creek Total	**1910-1919**	**Other**	**3,678.9**	**32,412**	**88%**
		Transitional	**991.7**	**4,475**	**12%**
	1920-1929	Other	4,172.3	36,075	98%
		Transitional	79.8	811	2%
	1930-1939	Other	3,620.3	33,579	91%
		Transitional	1,114.2	3,308	9%
	1940-1949	Other	4,214.6	36,886	100%
		Transitional	0.0	0	0%
	1950-1959	Other	4,214.6	36,885	100%
		Transitional	0.0	1	0%
	1960-1969	Other	4,185.6	36,574	99%
		Transitional	52.7	312	1%
	1970-1979	Other	4,171.8	36,558	99%
		Transitional	85.2	328	1%
	1980-1989	Other	4,185.2	36,721	100%
		Transitional	55.1	165	0%
	1990-1999	Other	4,153.3	36,299	98%
		Transitional	103.5	588	2%
	2000-2004	Other	4,182.8	36,270	98%
		Transitional	58.4	616	2%
	Existing	Other	4,160.3	36,003	98%
		Transitional	97.1	888	2%

Table 1-14 Estimated sediment delivered from annual events within each decade for the Swamp Creek Watershed.

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
Swamp Creek	**1910-1919**	**Other**	**1,777.4**	**16,775**	**74%**
		Transitional	**1,422.7**	**6,015**	**26%**
	1920-1929	Other	2,614.0	22,654	99%
		Transitional	2.7	136	1%
	1930-1939	Other	2,615.3	22,776	100%
		Transitional	0.3	15	0%
	1940-1949	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	1950-1959	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	1960-1969	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	1970-1979	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	1980-1989	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	1990-1999	Other	2,615.4	22,791	100%
		Transitional	0.0	0	0%
	2000-2004	Other	2,609.4	22,523	99%
		Transitional	8.9	267	1%
	Existing	Other	2,608.1	22,731	100%
		Transitional	10.8	65	0%

Table 1-15 Estimated sediment delivered from annual events within each decade for the White Pine Creek Watershed.

Sub-Basin	Time Period	Land Use	Sediment Delivered (tons)	Area (acres)	% Area
White Pine Creek	**1910-1919**	**Other**	**1,701.5**	**16,711**	**84%**
		Transitional	**344.0**	**3,244**	**16%**
	1920-1929	Other	1,920.9	19,955	100%
		Transitional	0.0	0	0%
	1930-1939	Other	1,920.9	19,955	100%
		Transitional	0.0	0	0%
	1940-1949	Other	1,920.9	19,955	100%
		Transitional	0.0	0	0%
	1950-1959	Other	1,920.9	19,955	100%
		Transitional	0.0	0	0%
	1960-1969	Other	1,901.6	19,628	98%
		Transitional	37.1	327	2%
	1970-1979	Other	1,887.7	19,605	98%
		Transitional	66.1	350	2%
	1980-1989	Other	1,913.0	19,746	99%
		Transitional	14.5	209	1%
	1990-1999	Other	1,864.2	19,353	97%
		Transitional	90.1	602	3%
	2000-2004	Other	1,920.9	19,955	100%
		Transitional	0.0	0	0%
	Existing	Other	1,853.3	18,311	92%
		Transitional	124.5	1,650	8%

1.7 References

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Attachment A – Assignment of USLE C-factors to NLCD Landcover Values

The NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland" (Figure A-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 Lower Clark Fork Tributaries watershed. 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 Lower Clark Fork Tributaries watershed was estimated by Confluence.

Table A-1 provides the C-factors for all land use types within the sub-basins of interest in the Lower Clark Fork Tributaries watershed for the existing conditions. The C-factors for the 'barren land', 'developed, low intensity', and 'developed, medium intensity' land uses are the same C-factors previously recommended by Richard Fasching, the NRCS Montana State Agronomist, for other hillslope USLE modeling efforts.

Table A-2 provides the C-factors for all land use types within the sub-basins of interest in the Lower Clark Fork Tributaries watershed for the desired well managed scenario. The percent ground cover was increased by 10% over the existing percentage for the 'grassland/herbaceous' and 'pasture/hay' 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.

Table A-3 provides the C-factors for all land use types within the sub-basins of interest in the Lower Clark Fork Tributaries watershed for the natural scenario. For all anthropogenic land uses, 'developed, open space', 'developed, low intensity', 'developed, medium intensity', 'cultivated crops' and 'pasture/hay', the natural scenario assumed a conversion to forest or woody wetland land use (both forest and woody wetland have the same c-factor). These are the assumed land uses of these areas before they were influenced by humans.

These tables were reviewed and approved by NRCS (Neal Svendsen) and USFS (Craig Neesvig) employees familiar with the Lower Clark Fork Tributaries watershed.

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 A-1. NRCS C-factor table

Table A-1 C-factors for land cover types in the Lower Clark Fork Tributaries watershed for existing conditions.							
NLCD #	**Name**	**Type and Height of Raised Canopy**	**Percent Canopy Cover[1]**	**Type**	**Percent Ground Cover**	**C-factor**	**Percent of Watershed**
42	Evergreen forest	trees	75	G	95-100	0.003	84.7%
52	Shrub/scrub	appreciable brush	25	G	85	0.008	8.7%
N/A	Transitional	no appreciable canopy	-	G	90	0.006	2.6%
71	Grassland/herbaceous	no appreciable canopy	-	G	75	0.020	2.0%
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003	0.9%
90	Woody Wetlands	trees	25	G	95-100	0.003	0.4%
31	Barren land	-	-	-	-	0.001	0.19%
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003	0.18%
41	Deciduous forest	trees	75	G	95-100	0.003	0.12%
22	Developed, low intensity	-	-	-	-	0.001	0.06%
81	Pasture/Hay	no appreciable canopy	-	G	75	0.020	0.04%
43	Mixed forest	trees	75	G	95-100	0.003	0.02%
82	Cultivated Crops	no appreciable canopy	-	G	20	0.240	0.01%
23	Developed, medium intensity	-	-	-	-	0.001	0.001%

Notes:
1) Canopy cover percents were selected based on the land cover class definition.

Table A-2 C-factors for land cover types in the Lower Clark Fork Tributaries watershed for desired conditions.							
NLCD #	**Name**	**Type and Height of Raised Canopy**	**Percent Canopy Cover[1]**	**Type**	**Percent Ground Cover**	**C-factor**	**Percent of Watershed**
42	Evergreen forest	trees	75	G	95-100	0.003	84.7%
52	Shrub/scrub	appreciable brush	25	G	85	0.008	8.7%
N/A	Transitional	trees	75	G	95-100	0.003	2.6%
71	Grassland/herbaceous	no appreciable canopy	-	G	85	0.013	2.0%
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003	0.9%
90	Woody Wetlands	trees	25	G	95-100	0.003	0.4%
31	Barren land	-	-	-	-	0.001	0.19%
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003	0.18%
41	Deciduous forest	trees	75	G	95-100	0.003	0.12%
22	Developed, low intensity	-	-	-	-	0.001	0.06%
81	Pasture/Hay	no appreciable canopy	-	G	85	0.013	0.04%
43	Mixed forest	trees	75	G	95-100	0.003	0.02%
82	Cultivated Crops	no appreciable canopy	-	G	40	0.150	0.01%
23	Developed, medium intensity	-	-	-	-	0.001	0.001%

Notes:

1) Canopy cover percents were selected based on the land cover class definition.

Table A-3 C-factors for land cover types in the Lower Clark Fork Tributaries watershed for natural conditions.							
NLCD #	**Name**	**Type and Height of Raised Canopy**	**Percent Canopy Cover[1]**	**Type**	**Percent Ground Cover**	**C-factor**	**Percent of Watershed**
42	Evergreen forest	trees	75	G	95-100	0.003	84.7%
52	Shrub/scrub	appreciable brush	25	G	85	0.008	8.7%
N/A	Transitional	trees	75	G	95-100	0.003	2.6%
71	Grassland/herbaceous	no appreciable canopy	-	G	85	0.013	2.0%
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003	0.9%
90	Woody Wetlands	trees	25	G	95-100	0.003	0.4%
31	Barren land	-	-	-	-	0.001	0.19%
21	Developed, open space	trees	75	G	95-100	0.003	0.18%
41	Deciduous forest	trees	75	G	95-100	0.003	0.12%
22	Developed, low intensity	trees	75	G	95-100	0.003	0.06%
81	Pasture/Hay	trees	25	G	95-100	0.003	0.04%
43	Mixed forest	trees	75	G	95-100	0.003	0.02%
82	Cultivated Crops	trees	25	G	95-100	0.003	0.01%
23	Developed, medium intensity	trees	75	G	95-100	0.003	0.001%

Notes:
1) Canopy cover percents were selected based on the land cover class definition.