Tobacco Planning Area Sediment TMDLs and Framework Water Quality Improvement Plan

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ACRONYMS

Acronym	Definition
AFO	Animal Feeding Operation
ARM	Administrative Rules of Montana
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CAFO	Concentrated (or Confined) Animal Feed Operations
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CN	Curve Number
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EPA	Environmental Protection Agency (U.S.)
FS	Forest Service
FWP	Fish, Wildlife, and Parks (Montana)
GIS	Geographic Information System
INFISH	Inland Native Fish Strategy
IR	Integrated Report
KNF	Kootenai National Forest
KRN	Kootenai River Network
LA	Load Allocation
LWD	Large Woody Debris
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
MGD	Million Gallons per Day
MMI	Multi-Metric Index
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
NBS	Near Bank Stress
NHD	National Hydrography Data[set]
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
PIBO	PACFISH/INFISH Biological Opinion
RHCA	Riparian Habitat Conservation Area
SAP	Sampling and Analysis Plan
SMZ	Streamside Management Zone
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service

Acronym	Definition
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VFS	Vegetated Filter Strips
WARSSS	Watershed Assessment of River Stability and Sediment Supply
WEPP	Water Erosion Prediction Project
WLA	Wasteload Allocation
WRP	Watershed Restoration Plans

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DOCUMENT SUMMARY

This document presents total maximum daily loads (TMDL) and a framework water quality improvement plan for eight streams in the Tobacco TMDL Planning Area (TPA), including the Tobacco River, Fortine Creek, Sinclair Creek, Therriault Creek, Deep Creek, Swamp Creek, Edna Creek, and Lime Creek (see **Map A-1** found in **Appendix A**). The Montana Department of Environmental Quality (DEQ) develops TMDLs and submits them to the U.S. Environmental Protection Agency (EPA) for approval. The Montana Water Quality Act requires DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDLs provide an approach to improve water quality so that streams and lakes can support and maintain their state-designated beneficial uses.

The majority of the Tobacco River watershed is located in Lincoln County in northwest Montana, with a small section located in Flathead County (**Map A-1, Appendix A**). The Tobacco River watershed is sparsely populated. Eureka is the largest town with 1,017 residents, according to the 2000 census. The majority of the land (67.5%) in the Tobacco River watershed is public land managed by the United States Forest Service. Private land holdings account for 28.8% and are primarily located in the valley bottoms adjacent to stream corridors and in the vicinity of Eureka. Evergreen forest is the dominate land cover in the Tobacco River watershed at almost 75%. Only small areas of the watershed have been cultivated. Significant economic activities include rural land development and associated construction, forest management and associated timber products, and recreation.

The Tobacco River forms at the confluence of Grave and Fortine Creeks and flows into the Kootenai River at Lake Koocanusa near the town of Eureka. DEQ split the Tobacco watershed into two areas for TMDL development, one being the Grave Creek TMDL Planning Area (TPA), and the other the Tobacco TPA. A Grave Creek sediment TMDL was developed separately in 2005 (Montana Department of Environmental Quality, 2005). All TMDLs in this document address excess sediment within each of the eight streams identified above. Although DEQ recognizes that there are other pollutant impairment problems in the Tobacco TPA, such as temperature and nutrients, this document only provides TMDLs for sediment. Future TMDL work will be required to address the additional pollutant problems not addressed by the sediment TMDLs in this document.

Sediment was identified as impairing aquatic life and coldwater fishes. Excess sediment often alters aquatic insect communities, reduces fish spawning success, reduces desirable stream habitat, and increases turbidity. Water quality restoration goals (TMDL targets and TMDL allocations) focus on instream measures of sediment impacts and continued implementation of land management improvements to reduce excess sediment entering streams. DEQ believes that once the water quality goals are met, all water uses currently affected by sediment will be restored for the eight streams with sediment TMDLs.

Sediment loads were quantified for the following major source categories: bank erosion, upland erosion, roads, and construction stormwater runoff. Distinctions were made between natural and preventable human caused sediment loads for all source categories, with the most significant sediment loading linked historic timber harvest, unpaved road crossings, and removal or alteration of vegetation along streams. It is concluded that total sediment load reductions ranging from 8 to 25% for each stream will satisfy the TMDL water quality goals, with most reductions in the 8 to 14% range. These small reductions are consistent with potential water quality recovery from past practices and the fact that several

streams are close to satisfying the water quality goals based on the instream measures of sediment impacts.

Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads, for harvesting timber, for grazing livestock, and for developing subdivisions. Implementation of most water quality improvement measures described in this plan is based on voluntary actions by watershed stakeholders and landowners. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL document, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a locally developed watershed restoration plan consistent with DEQ and EPA recommendations.

A flexible approach to most TMDL implementation activities is necessary. This can be accomplished via adaptive management linked to additional knowledge gained through BMP implementation and future monitoring. The plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Table DS-1 summarizes the Tobacco TPA streams with sediment TMDLs prepared within this document. The sediment TMDLs were written for *sedimentation / siltation* impairment causes.

Table DS-1. Waterbodies in the Tobacco TMDL Planning Area with Completed Sediment TMDLs Contained in this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Type of TMDL Prepared	Impaired Uses
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	Sedimentation / Siltation*	**Sediment***	Aquatic Life, Cold Water Fishery
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	Sedimentation / Siltation	**Sediment**	Aquatic Life
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	Sedimentation / Siltation	**Sediment***	Aquatic Life, Cold Water Fishery
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	Sedimentation / Siltation	**Sediment***	Aquatic Life, Cold Water Fishery
Sinclair Creek**, confluence of un-named tributary, Lat -114.945 Long 48.908, to mouth (Tobacco River)	MT76D004_091	Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	Sedimentation / Siltation	**Sediment***	Aquatic Life, Cold Water Fishery
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	Sedimentation / Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	Sedimentation / Siltation	**Sediment***	Aquatic Life, Cold Water Fishery

* Sediment TMDL also addresses a closely linked habitat alteration impairment cause
** Sinclair Creek was investigated per stakeholder recommendations; a sediment TMDL was prepared because the water quality results are consistent with sediment impairment

1.0 INTRODUCTION

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

1.1 BACKGROUND

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

Montana's water quality designated use classification system includes the following uses:

- fish and aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

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

Montana's biennial IR identifies all the state's impaired waterbody segments, all of which are indexed to the National Hydrography Dataset (NHD). The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL. TMDLs are not required for non-pollutant impairments. **Table A-1** in **Appendix A** identifies impaired waters for the Tobacco TPA from Montana's 2010 303(d) List, as well as non-pollutant impairment causes included in Montana's "2010 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

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

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Quantifying the magnitude of pollutant contribution from their sources

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

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

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

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists all of the sediment and sediment–related impairment causes from the "2010 Water Quality Integrated Report" that are addressed in this document (also see **Map 1** in **Appendix A**). Additionally, data collected on the lower segment of Sinclair Creek (MT76D004_091) during this project indicated a sediment water quality problem. Because many of the water quality targets were not satisfied for Sinclair Creek (see **Section 5.4.2.5**), a TMDL was written for this segment.

TMDLs are completed for each waterbody – pollutant combination, and this document contains eight TMDLs (seven identified in **Table 1-1** plus Sinclair Creek). There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. **Section 6** provides some basic water quality solutions to address both the sediment-related non-pollutant causes and sediment pollutant causes of impairment.

Although DEQ recognizes that there are other pollutant listings for the Tobacco TPA without completed TMDLs (**Table A-1** in **Appendix A**), this document only addresses those identified in **Table 1-1**. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. Future TMDL work will be required to address the additional pollutant problems not addressed by the sediment TMDLs in this document.

Table 1-1. Water Quality Impairment Causes for the Tobacco TMDL Planning Area in the "2010 Water Quality Integrated Report" Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Addressed by sediment TMDL
		Sedimentation / Siltation	Sediment	Sediment TMDL completed
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	Sedimentation / Siltation	Sediment	Sediment TMDL completed
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Addressed by sediment TMDL
		Sedimentation / Siltation	Sediment	Sediment TMDL completed

Table 1-1. Water Quality Impairment Causes for the Tobacco TMDL Planning Area in the "2010 Water Quality Integrated Report" Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Addressed by sediment TMDL
		Sedimentation / Siltation	Sediment	Sediment TMDL completed
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Addressed by sediment TMDL
		Sedimentation / Siltation	Sediment	Sediment TMDL completed
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	Siltation, Sedimentation	Sediment	Sediment TMDL completed
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Addressed by sediment TMDL
		Sedimentation / Siltation	Sediment	Sediment TMDL completed

1.3 DOCUMENT LAYOUT

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

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

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

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

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

Section 6.0 TMDL Implementation Framework: Water Quality Restoration and Monitoring Recommendations:
Discusses water quality restoration objectives and presents a framework monitoring strategy to meet the identified objectives and TMDLs.

Section 7.0 Public Participation:
Describes other agencies and stakeholder groups who were involved with the planning and development of this document, and the public participation process used during this project.

2.0 TOBACCO RIVER WATERSHED DESCRIPTION

This section includes a summary of the physical and social profile of the Tobacco River watershed excerpted from the "Tobacco River Watershed Description." The entire watershed description is contained in **Appendix B**; associated maps are contained in **Appendix A**.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Tobacco River watershed.

2.1.1 Location

The majority of the Tobacco River watershed is located in Lincoln County in northwest Montana, with a small section (a portion of the Lime Creek watershed) located in Flathead County (**Map A-1**, **Appendix A**). The Tobacco River is a fifth order watershed draining approximately 440 mi^2 (282,000 acres) between the Kootenai River on the west, the Whitefish Range on the east, and the Salish Mountains to the south. The Tobacco River is located south of the United States-Canadian border and north of the Fisher River watershed. The Tobacco River forms at the confluence of Grave and Fortine Creeks and flows into the Kootenai River at Lake Koocanusa near the town of Eureka. The mainstem of the Tobacco River and six tributaries are included on the 2010 303(d) List of impaired waterbodies. These tributaries include: Edna, Fortine, Grave, Lime, Swamp and Therriault Creeks (**Map A-1, Appendix A**).

2.1.2 Climate

The average precipitation ranges from 16 inches/year at Fortine and 14 inches/year at Eureka, while average snowfall averages between 47 and 60 inches/year at higher elevations. May and June are consistently the wettest months of the year and winter precipitation is dominated by snowfall. Temperature patterns reveal that July is the hottest month and January is the coldest throughout the watershed. Summertime highs are typically in the high 70s to low 80s Fahrenheit, and winter lows fall to approximately 11˚F. **Map A-2** in **Appendix A** shows the average annual precipitation in the Tobacco River watershed.

2.1.3 Hydrology

Streamflows are at their highest between May and June, which also sees the greatest amount of precipitation. Historical data indicate peak flows on the Tobacco River in May average approximately 750 cubic feet per second (cfs). However, flows from 2,300 to 3,180 cfs have been recorded in the month of May. The last 50 years of data from the Tobacco River USGS gaging station show on average a mean monthly discharge below 150 cfs for August through February. Rain on snow events occur periodically in early fall or spring, producing high flows over short periods of time.

2.1.4 Geology and Soils

Much of the soil in the Tobacco valley is relatively erodible as it is compiled of glacial deposits that create sandy loams (**Maps A-3** and **A-4**, **Appendix A**). Majority of the bedrock in the area belongs to the Belt Supergroup of Precambrian age. Highly erodible, unconsolidated Quaternary alluvium is found in the Grave Creek valley bottom and lower Tobacco River. Belt series rock is found in the Swamp Creek, Grave Creek, and upper Fortine and Meadow areas.

2.2 SOCIAL PROFILE

The following information describes the social profile of the Tobacco River watershed.

2.2.1 Land Ownership

The majority of the land (67.5% or 298 square miles) in the Tobacco River watershed is public land managed by the U.S. Forest Service. Private land holdings account for 28.8% (127 square miles) and are primarily located in the valley bottoms adjacent to stream corridors. The remaining 3.8% of land is owned by the state of Montana (2.6%), Plum Creek Timber Company (0.3%), The Nature Conservancy (0.2%), and the U.S. Bureau of Reclamation (0.1%). **Map A-6** in **Appendix A** shows land ownership in the Tobacco River watershed.

2.2.2 Land Use and Land Cover

Evergreen forest is the dominate land cover in the Tobacco River watershed at almost 75%. Shrubland comprises just over 10% and grasslands/herbaceous makes up approximately 7% of the land area. In direct correlation, timber production is the primary land use in the watershed. Historically, much of the watershed has been logged and riparian habitat altered by log drives, riparian harvest, and road construction. Only small areas of the watershed have been cultivated. **Map A-5** in **Appendix A** shows the types of land cover and land use of the Tobacco River watershed.

2.2.3 Population

The Tobacco River watershed is sparsely populated. Eureka is the largest town with 1,017 residents, according to the 2000 census. Census data indicates the population is growing with a count of 4,000 people in the watershed in 2000 and 5,423 in 2007. Primary employment is in services, retail trade, and manufacturing.

2.3 FISH AND AQUATIC LIFE

As a tributary to the Kootenai River, the Tobacco River and its tributaries provide important spawning and rearing habitat for fluvial and adfluvial fish populations that produce some of western Montana's popular sport fisheries, such as brook trout (*Salvelinus fontinalis)* and rainbow trout (*Oncorhynchus mykiss*). Streams in this watershed also support species of special concern, including Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), Bull trout (*Salvelinus confluentus)* and Torrent sculpin *(Cottus rhotheus)*. Westslope cutthroat trout are found throughout the watershed, but may be mostly hybridized except in isolated headwater stream segments (**Map A-9**, **Appendix A**). Bull trout are also listed as threatened under the Endangered Species Act. Most Bull trout from Lake Koocanusa migrate up the Tobacco River and spawn in Grave Creek where the population appears stable or increasing based on redd and juvenile counts for the past 10 to 15 years. **Map A-10** in **Appendix A** shows the distribution of bull trout in the Tobacco River watershed. In Montana, the Torrent sculpin is found only in the Kootenai River system. The Torrent sculpin is listed as a state sensitive species, but is known to inhabit the Tobacco River and its tributaries.

3.0 MONTANA WATER QUALITY STANDARDS

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

Montana's water quality standards include four main parts:

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

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Tobacco TMDL Planning Area streams can be found **Appendix C**.

3.1 TOBACCO TMDL PLANNING AREA STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams and lakes within the Tobacco River watershed, other than Deep Creek, are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses:

- 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
- Agricultural and industrial waters supply

Deep Creek is classified as A-1, which must be maintained suitable for all of the same uses as B-1, as well as drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. At the time Deep Creek was classified, it was apparently being used as the drinking water supply for the town of Fortine. The language "for removal of naturally occurring impurities" implies a higher level of protection, given the drinking water use.

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix C**.

Seven waterbody segments in the Tobacco TPA are listed in the "2010 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). Waterbodies that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL.

DEQ describes impairment as either partially supporting or not supporting, based on assessment results. Not supporting is applied to not meeting a drinking water standard, and is also applied to conditions

where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use.

Table 3-1. Waterbodies in the Tobacco TMDL Planning Area in Montana's "2010 Water Quality Integrated Report" and their Beneficial Use Support Status

Waterbody & Location Description	Waterbody ID	Use Class	Agriculture	Aquatic Life	Cold Water Fishery	Drinking Water	Industry	Primary Contact Recreation
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	A-1	F	P	P	F	F	P
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	B-1	F	P	F	F	F	F
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	B-1	F	P	P	F	F	P
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	B-1	F	N	N	N	F	P
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	B-1	F	P	P	F	F	P
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	B-1	F	P	P	F	F	F
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	B-1	F	P	P	F	F	F

F = Fully Supporting, P = Partially Supporting, N = Not Supporting

3.2 WATER QUALITY STANDARDS

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that are designed to protect the designated uses. For the sediment TMDL development process in the Tobacco TPA, only the narrative standards are applicable.

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

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

The specific sediment narrative water quality standards that apply to the Tobacco River watershed are summarized below. More detailed descriptions of Montana's surface water standards and Montana's reference approach are provided in **Appendix C**.

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

4.0 DEFINING TMDLS AND THEIR COMPONENTS

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

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

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

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

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

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

Development of each TMDL has four major components:

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

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

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

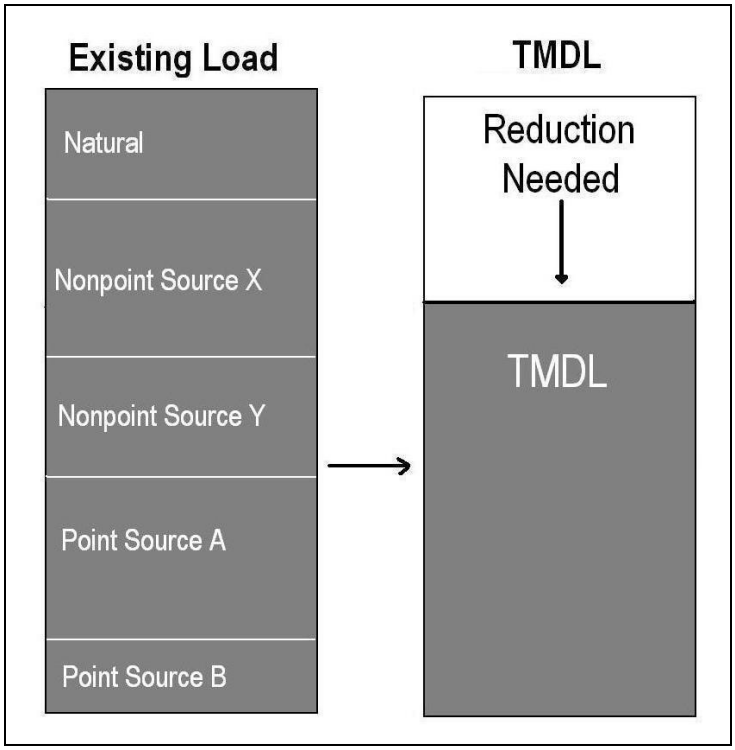

Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

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

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

4.2 Quantifying Pollutant Sources

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

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

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

4.3 Establishing the Total Allowable Load

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

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

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

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

4.4 Determining Pollutant Allocations

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

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

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

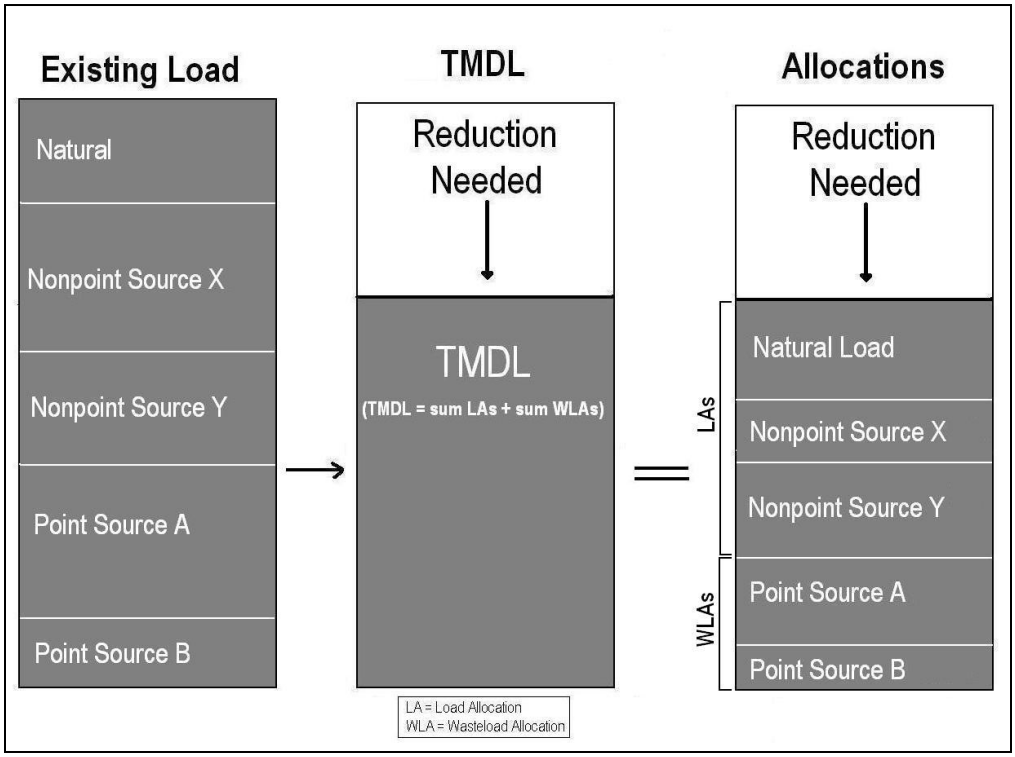

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

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

5.0 SEDIMENT TMDL DEVELOPMENT

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

5.1 MECHANISM OF EFFECTS OF EXCESS SEDIMENT ON BENEFICIAL USES

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

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

5.2 STREAM SEGMENTS OF CONCERN

A total of seven waterbody segments in the Tobacco TPA appeared on the 2010 Montana 303(d) List due to sediment impairments (**Table 5-1**). These include: Deep Creek, Edna Creek, Fortine Creek, Lime Creek, Swamp Creek, Therriault Creek and the Tobacco River. As shown in **Table 5-1**, many of the waterbodies with sediment impairments are also listed for habitat and flow alterations, which are non-pollutant forms of pollution frequently associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

Sinclair Creek (MT76D004_091 and MT76D004_092), a tributary to the Tobacco River, was not on the 303(d) list but was identified as having insufficient data to assess beneficial use support and was also evaluated as part of TMDL development based on stakeholder concerns.

Table 5-1. Waterbody Segments in the Tobacco TPA with Sediment Listings and Possible Sediment-related Listings on the 2010 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	Sedimentation/ Siltation	
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & flow alterations
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	Sedimentation/ Siltation	Alteration in streamside or littoral vegetative covers & flow alterations
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	Sedimentation/ Siltation	
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	Sedimentation/ Siltation	Physical substrate habitat alterations

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

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

5.3.1 Summary of Information Sources

To characterize sediment conditions for TMDL development purposes, a sediment data compilation was completed and additional monitoring was performed during 2008. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- DEQ 2008 Sediment and Habitat Assessments
- Relevant Local and Regional Reference Data
- GIS data layers and publications regarding historical land usage, channel stability, and sediment conditions

5.3.2 DEQ Assessment Files

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected by DEQ on most waterbodies between 2003 and 2008 (denoted as “DEQ Monitoring Sites” in **Figure 5-1**) as well as other historical information collected or obtained by DEQ. The most common quantitative data that will

be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale.

5.3.3 DEQ's 2008 Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters were collected in 2008 from 18 reaches on 8 waterbodies to aid in TMDL development (**Figure 5-1**). To aid in the characterization of bank erosion, an additional 14 reaches were assessed in 2008 for bank erosion severity and source identification (**Figure 5-1**). Note that although a sediment TMDL was completed for Grave Creek in 2005, one of the assessed reaches was on Clarence Creek, a tributary to Grave Creek. The site on Clarence Creek was included to help characterize bank erosion and collect additional sediment/habitat data in the Grave Creek watershed using the same protocols as the 2008 assessments performed within the rest of the Tobacco Creek watershed.

Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influences sediment transport and deposition. The next step in the aerial assessment involved identification of near-stream land uses since land management practices can have a significant influence on stream morphology and sediment characteristics. The resulting product was a stratification of streams into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, provided the basis for selecting the above-referenced monitoring reaches. Although ownership is not part of the reach type category, because of the distribution of private and federal land within the watershed, most reach type categories contain predominantly either private or public lands.

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

The field parameters assessed in 2008 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 2000 feet

(depending on the channel bankfull width) that were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data are contained in the 2008 monitoring summary report (**Appendix D**).

5.3.4 Relevant Local and Regional Reference Data

Regional reference data was derived from Kootenai National Forest (KNF) reference sites and the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). There is reference data for channel morphology parameters (i.e., width/depth and entrenchment) for 151 sites assessed within all districts of the KNF between 1992 and 1999 and then a more extensive reference dataset (i.e., channel morphology, fine sediment, and habitat measures) for 77 sites within the Libby District collected between 1995 and 2004. The Libby District lies entirely within the Northern Rockies (Level III) and Salish Mountains (Level IV). The PIBO reference dataset (http://www.fs.fed.us/biology/fishecology/emp/) includes USFS and BLM sites throughout the Pacific Northwest, but to increase the comparability of the data to conditions in the Tobacco River watershed, only data collected within the Canadian Rockies and Northern Rockies ecoregions were evaluated. This includes data from the 67 sites in the Canadian Rockies and 31 sites in the Northern Rockies collected between 2001 and 2009.

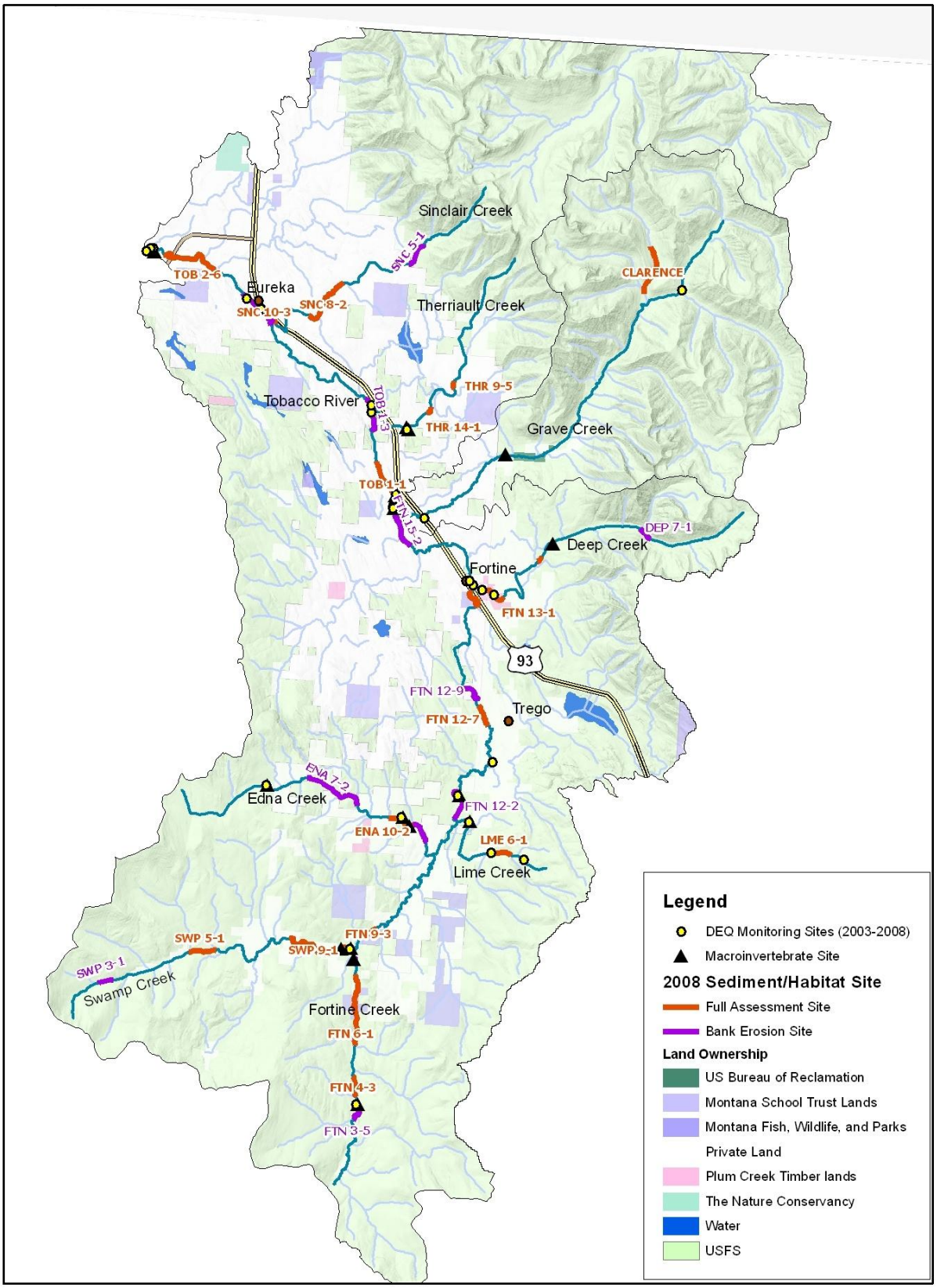

Figure 5-1. Reaches Assessed by DEQ in 2008 and Historical DEQ Monitoring Sites

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

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confine-ment*	Reach Type	Number of Reaches	Number of Full Monitoring Sites	*Number of Bank Erosion/ BEHI Monitoring Sites*
Canadian Rockies	0 - 2%	2	U	CR-0-2-U	17	4	
		3	U	CR-0-3-U	1		
		4	C	CR-0-4-C	1		
			U	CR-0-4-U	9		
	2 - 4%	1	U	CR-2-1-U	3		
		2	C	CR-2-2-C	1		
			U	CR-2-2-U	7		
		3	U	CR-2-3-U	6	1	
		4	U	CR-2-4-U	2		
	4 - 10%	1	U	CR-4-1-U	6		
		2	C	CR-4-2-C	3		
			U	CR-4-2-U	6	1 (Clarence)	2
		3	U	CR-4-3-U	5	1	
		4	U	CR-4-4-U	1		
	> 10%	1	C	CR-10-1-C	2		
			U	CR-10-1-U	6		
		2	U	CR-10-2-U	2		
Northern Rockies	0 - 2%	1	U	NR-0-1-U	1		
		2	U	NR-0-2-U	4		
		3	U	NR-0-3-U	24	3	2
		4	U	NR-0-4-U	32	3	4
		5	U	NR-0-5-U	11	2	2
	2 - 4%	1	U	NR-2-1-U	3		
		2	U	NR-2-2-U	5		1
		3	U	NR-2-3-U	12	1	1
	4 - 10%	1	U	NR-4-1-U	3		
		2	U	NR-4-2-U	7		2
		3	U	NR-4-3-U	4	2	
	> 10%	1	U	NR-10-1-U	2		
Totals:					**187**	**18**	**14**

*U = Unconfined, C = Confined per DEQ's stratification methodology

5.4 Water Quality Targets and Comparison to Existing Conditions

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

In developing targets, natural variation throughout the river continuum must be considered. As discussed in more detail in **Section 3** and **Appendix C**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is utilizing reference site data, but modeling,

professional judgment, and literature values may also be used. DEQ defines "reference" as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic and current land use activities. Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations due to climate, bedrock, soils, hydrology and other natural physiochemical differences yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity.

The basis for the value for each water quality target varies depending on the availability of reference data and sampling method comparability to the 2008 DEQ data. As discussed in **Appendix C**, there are several statistical approaches DEQ uses for target development; they include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired, the sampled streams are assumed to be severely degraded, and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset or the 25th percentile of the sample dataset (if reference data are not available) is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, the representativeness and range of variability of the data, the severity of human disturbance to streams within the watershed, and size of the dataset. For each target, descriptive statistics were generated relative to any available reference data (e.g., KNF, Libby District, or PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given towards the most protective reference dataset. Additionally, the target value for some parameters may apply to all streams in the Tobacco River watershed, whereas others may be stratified by bankfull width, reach type characteristics (i.e., ecoregion, gradient, stream order, and/or confinement), or by Rosgen stream type if those factors are determined be important drivers for certain target parameters. Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit margin of safety (MOS) and are achievable. The MOS is discussed in additional detail in **Section 5.8.2**.

5.4.1 Water Quality Targets

The sediment water quality targets for the Tobacco River watershed are summarized in **Table 5-3** and described in detail in the sections that follow. Listed in order of preference, sediment-related targets for the Tobacco River watershed are based on a combination of reference data from the KNF, reference data from the Canadian Rockies and Northern Rockies portion of the PIBO dataset, and sample data from the DEQ 2008 sampling effort. **Attachment C** provides a summary of the DEQ 2008 sample data and a description of associated field protocols.

Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999), water quality targets for the Tobacco watershed are comprised of a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e., fine sediment and biological indices). Target parameters and values are based on the current best available information, but they will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one or more target

values does not necessarily equate to a determination that the information supports impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values.

Table 5-3. Sediment Targets for the Tobacco TPA

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of fine surface sediment in riffles via pebble count (reach average)	6mm ≤ 15% 2mm ≤ 8%
	Percentage of fine surface sediment < 6mm in riffles and pool tails via grid toss (reach average)	≤ 8%
Channel Form and Stability	Bankfull width/depth ratio (reach median)	B & C stream types with bankfull width < 30ft: ≤ 21 B & C stream types with bankfull width > 30ft: ≤ 35 E stream types: ≤ 8
	Entrenchment ratio (reach median)	B stream types: > 1.4
		C stream types: > 2.7
		E stream types: > 2.3
Instream Habitat	Residual pool depth (reach average)	< 20' bankfull width : ≥ 0.8 (ft)
		20' - 35' bankfull width : ≥ 1.2 (ft)
		> 35' bankfull width : ≥ 1.6 (ft)
	Pools/mile	< 20' bankfull width : ≥ 75
		20' - 35' bankfull width: ≥ 42
		> 35' bankfull width : ≥ 31
		Tobacco River: : ≥ 12
	LWD/mile	< 20' bankfull width : ≥ 359
		20' - 35' bankfull width : ≥ 242
		> 35' bankfull width : ≥ 104
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 57% understory shrub cover
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment impairment thresholds	Mountain MMI ≥ 63
		O/E ≥ 0.80

5.4.1.1 Fine Sediment

The percent of surface fines less than 6 mm and 2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard, et al., 1984; Suttle, et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species, and because the particle size defined as “fine” is

variable and some assessment methods measure surficial sediment while others measure also include subsurface fine sediment, literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle, et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10 to 40 percent fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea, et al., 2000). Bryce, et al. (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment < 2mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development, but because increasing concentrations of fine sediment are known to be harmful to aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix C**, and consistent with Montana's water quality standard for sediment as described in **Section 3.2.1**.

Ecoregion Considerations

Because geology and soils can be significant differentiating factors between ecoregions, fine sediment targets were initially evaluated within the context of the Level III and IV ecoregions within the Tobacco TPA. Most sediment-listed waterbodies in the Tobacco TPA are in the Northern Rockies Level III ecoregion and largely within the Salish Mountain Level IV ecoregion. The remainder of sediment-listed or evaluated streams in the TPA (i.e., Therriault, Grave, Deep, and Sinclair creeks) originate in the Canadian Rockies Level III ecoregion and Western Canadian Rockies Level IV ecoregion but flow into the Northern Rockies. Fine sediment values are similar between these ecoregions for pebble counts and grid tosses within the 2008 DEQ Tobacco sample dataset and for grid tosses within the PIBO reference dataset. Additionally, the interquartile range and median of the median particle size (D50) in PIBO streams were similar between the Level IV ecoregions, which are at a finer scale than Level III. Therefore, achievable fine sediment conditions are assumed to be similar throughout the watershed and Tobacco TPA fine sediment targets are not broken out by ecoregion.

Riffle Substrate Percent Fine Sediment < 6mm and < 2mm via Pebble Count

Surface fine sediment measured in riffles by the modified (Wolman, 1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2008 were performed in three riffles per sampling reach for a total of at least 300 particles. For DEQ data collected in 2003, pebble counts at each reach were performed from bankfull to bankfull in a single representative riffle for a total of at least 100 particles.

Pebble count reference data are available from the Libby District of the KNF. Pebble counts for the Libby District were a composite of riffles and pools, which can increase the fine sediment percentage relative to a riffle-only pebble count; in a review of the field forms, pools did not typically increase the overall percentage of fines, indicating results between the Libby District and Tobacco sample dataset are comparable. The target for riffle substrate percent fine sediment is based on the 75th percentile of the KNF Libby District reference dataset and is set at less than or equal to 15% < 6mm and 8% < 2mm. The target for sediment < 6mm is similar to that set in other TMDLs for the Northern Rockies (e.g., Lower Clark Fork: 10%, Grave Creek and Prospect Creek: 15%, Yaak: 20%), and the target for < 2mm is close to the macroinvertebrate minimum effect level of 10% found by Bryce et al. (2010). Rosgen E channels tend to have a higher percentage of fine sediment than B and C channels (which comprise most of the 2008 DEQ assessment reaches), but the KNF Libby District dataset only contains two E channel sites. The percent fines values at the reference sites are 1% and 16% for < 6mm and 0% and 8% < 2mm. Therefore, the 15% < 6mm and 8%< 2mm targets will be applied to all channel types but because of the general

trend for E channels and the small samples size of reference E channels, the target will carry less weight for E channels. Target values should be compared to the reach average value from pebble counts.

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

Grid toss measurements in riffles and pool tails are an alternative measure to pebble counts that assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer, et al., 1993) was used to estimate the percent surface fine sediment < 6mm in riffles and pool tails in the Tobacco River watershed, and three tosses, or 147 points, were performed and then averaged for each assessed riffle and for the spawning gravel substrate portion of each assessed pool tail.

Grid toss reference data are contained in the PIBO dataset but only for pool tails. The 75th percentile of the PIBO reference data for pool tails is 18% and the median is 8%. In the 2008 Tobacco sample dataset, pool tail grid toss values were very low with percentiles as follows: 25th= 1, median = 3%, and 75th = 10%. This information suggests a potential variation in assessment methods between PIBO and the DEQ pool grid toss method. This is further supported by the fact that data sets used for setting pool grid toss targets in other TMDL watersheds have resulted in values closer to the median of the PIBO data (8%) and the 75th percentile of the Tobacco dataset (10%). Therefore, the grid toss target for fine sediment < 6mm is < 8% for pool tails consistent with the PIBO median values, the Tobacco dataset, and results from other TMDL projects.

In the 2008 Tobacco sample dataset, riffle grid toss values were also very low with percentiles as follows: 25th= 1, median = 3%, and 75th = 8%. Because there is no reference data to use as a basis for the riffle grid toss target, the 75th percentile of pool tail grid toss values in the sample dataset compared favorably to the median of PIBO reference values, and other sample dataset percentiles (25th and median) are well below literature values, the riffle grid toss target is based on the 75th percentile of the sample dataset to help identify those reaches that have relatively high levels of fines. Therefore, the grid toss target for fine sediment < 6mm is 8% for riffles.

Using the same logic as applied for the pebble count targets, the grid toss target will apply to all channel types but will hold less weight for E channels. Similar to the pebble count target for < 6mm, the riffle and pool tail grid toss targets are similar to values set in several other TMDLs within the Northern Rockies (St. Regis, Prospect Creek, and Grave Creek TMDLs (i.e., values ranged from 8-10%)). For each habitat area, the target should be assessed based on the reach average grid toss value.

5.4.1.2 Channel Form and Stability

Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are dimensionless values representing fundamental aspects of channel morphology. Each provides a measure of channel stability, as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e., riffles, pools, and near bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald, et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in-channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood

events versus having energy dissipation on the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Rosgen, 1996; Knighton, 1998; Rowe, et al., 2003). Width/depth and entrenchment ratios were calculated for each 2008 assessment reach based on 5 riffle cross section measurements.

Width/Depth Ratio Target Development

There is reference riffle width/ratio data for the KNF, KNF Libby District, and PIBO, but because the Libby District data is a subset of the KNF dataset, only the KNF and PIBO reference data were reviewed as potential targets. The 2008 Tobacco dataset is primarily comprised of B and C channels, and although on average B channels tend to have a smaller width/depth ratio than C channels (Rosgen, 1996), the ratio can vary quite a bit between small and larger streams. Because the waterbodies in the 2008 Tobacco dataset range in bankfull width (BFW) from 13 to 96 feet (median=23ft, 75th=34ft) and the reaches evaluated in 2008 were all estimated to have the potential to be a Rosgen B and/or C channel, target values are combined for B and C channels and expressed by BFW. Both reference datasets have BFW values that range from approximately 5ft to 50ft, but the PIBO dataset has a much greater number of larger streams (KNF: median=15ft, 75th=21ft; PIBO: median=30ft, 75th=39ft).

The KNF value for smaller streams (bankfull width < 30 ft) is preferred over the PIBO data because of the KNF data represents a more local regional reference data set, the KNF data has a significantly higher sample size of 94 versus the 44 for the PIBO data set, the values are consistent with sediment targets for similar stream sizes in other DEQ sediment TMDL documents, and because the KNF data provides the appropriate level of water quality protection based on results and observations regarding achievable width to depth ratio potential for the assessed streams. Unfortunately the KNF reference sample size for larger streams (bankfull width > 30) is only 7, whereas the equivalent PIBO sample size is 47. Therefore, the width/depth ratio target for B and C streams with a BFW less than 30 feet will be ≤ 21 based on the 75th percentile of the KNF reference data and the target for B and C streams with a BFW equal to or greater than 30 feet will be ≤ 35 based on the 75th percentile of PIBO reference (**bolded** in **Table 5-4**). The streams in the PIBO dataset are not broken out by Rosgen channel type but based on a review of reference-based width/depth ratio targets ranging from 29-33 for large B/C channels in the St. Regis, Grave Creek, and Prospect Creek TMDLs, 35 is an appropriate target for larger B/C channels within the Tobacco TPA. Lime Creek was the only stream identified as a different channel type (i.e., E), and although the sample size is smaller than desired, the target for E channels will be ≤ 8 based on the 75th percentile of E channel in the KNF dataset because the PIBO dataset is not broken out by stream type. The target width/depth ratios are set at less than or equal to those values indicated by channel type and BFW in **Table 5-4**.

Table 5-4. The 75th Percentiles of Reference Data used for Width/Depth Ratio Target Development

Data Source	Category	Sample Size	75th Percentile W/D
KNF Reference	B/C channels BFW < 30’	94	**21**
KNF Reference	B/C channels BFW > 30’	7	29
KNF Reference	E channels	3	**8**
PIBO Reference	BFW < 30’	44	27
PIBO Reference	BFW > 30’	47	**35**

Entrenchment Ratio Target Development

Because higher values are more desirable for entrenchment ratio, the target value for entrenchment ratio is set at greater than or equal to the 25th percentile of the KNF reference data (**Table 5-5**). When comparing assessment results to target values, more weight will be given to those values that fail to

satisfy the identified target and fail to meet the minimum value associated with literature values for Rosgen stream type (i.e., B=1.4-2.2 ± 0.2, C & E 2.2 ± 0.2) (Rosgen, 1996) and reaches with multiple potential channel types will be evaluated using the lowest target value (e.g., Target for B3/C3 = 1.4).

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

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

5.4.1.3 Instream Habitat Measures

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

Residual Pool Depth

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

Although the residual pool depth measure is similar between DEQ's method and both reference methods, the definition of a pool can vary between the methods. Out of both available reference datasets, the core definition of pools for the PIBO protocol is closer to the definition used for the DEQ 2008 Tobacco sample dataset where pools were defined as depressions in the streambed bounded by a "head crest" at the upstream end and "tail crest" at the downstream end with a maximum depth that is at least 1.5 times the pool tail depth (Kershner, et al., 2004). The Libby District dataset defines pools as slack water areas occupying at least one-third of the bankfull channel with a scour feature and hydraulic control.

DEQ further defined pools as large, medium or small depending on the width of the pool in relation to the stream's bankfull width, whereas the PIBO protocol only counts pools greater than half the wetted channel width. In comparison to the PIBO dataset, the DEQ dataset could have a higher pool frequency and more pools with a smaller residual pool depth since the DEQ protocol has no minimum pool width requirement. In comparison to the Libby dataset, the DEQ dataset could have a lower pool frequency

since some slack water areas in the Libby District dataset might not meet the head crest to tail crest ratio requirement used by DEQ.

Based on the differences in protocol between the Libby District and Tobacco sample datasets, and the median of the Tobacco sample dataset comparing favorably to the median and 25th percentiles of both reference datasets (indicating high residual pool depth values in the Tobacco TPA), the target for residual pool depth is greater than or equal to the 25th percentile of PIBO reference data. Although none of the channels in the PIBO reference dataset are as wide as the Tobacco River and there are no target values for other similar sized systems in northwestern Montana, residual pool depth tends to increase with channel size and 1.6 feet should be a reasonable target value for the Tobacco River. The target values are shown in bold in **Table 5-6** and expressed by channel BFW, and they should be assessed based on the reach average residual pool depth value. Because residual pool depths can indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis using the data collected in 2008 as a baseline. Future monitoring should document an improving trend (i.e., deeper pools) at sites which fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-6. Percentiles of Reference Data and 2008 Tobacco Sample Data for Residual Pool Depth (ft) used for Target Development

Category	Libby Reference			PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	25th	n	Median	75th
< 20’ BFW	57	0.8	0.6	19	1.1	**0.8**	5	1.2	1.5
20-35’ BFW	18	1.4	1.2	42	1.2	**0.9**	10	1.2	1.6
> 35’ BFW (including Tobacco River)	0	--	--	37	1.9	**1.6**	3	1.9	2.1

Targets are shown in **bold**.

Pool Frequency

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

Based on the differences in pool definition between the Libby District reference dataset and the 2008 Tobacco sample dataset (described above), the target for pool frequency is based on the PIBO reference dataset. Because the median pool frequency values in PIBO reference dataset compare favorably to both the 25th percentile of the Libby District reference data and the median of the 2008 Tobacco sample data (**Table 5-7**), the pool frequency target is greater than or equal to the median of the PIBO dataset (**bold** in **Table 5-7**). The pool frequency targets are similar to the INFISH Riparian Management Objectives (U.S. Department of Agriculture, Forest Service, 1995a) as well as reference data from the Swan River and Grave Creek watersheds (Montana Department of Environmental Quality, 2005) (**Table 5-8**). Pools per mile should be calculated based the number of measured pools per reach and then scaled up to give a frequency per mile.

Because pool frequency tends to decline as stream size increases and the PIBO dataset only includes streams with a BFW up to 50 feet, 31 pools/mile is likely too high of a target for the Tobacco River. The

target for the C channel reaches of lower Grave Creek in the Grave Creek TMDL (Montana Department of Environmental Quality, 2005) is 12 pools/mile based on an internal reference reach, which is less than the 25th percentile of streams in the PIBO dataset (i.e., BFW = 35 – 50 ft), and will be applied as the target for the Tobacco River. Both reaches assessed in 2008 exceeded this value, indicating it is an achievable target, but it may be modified in the future as more relevant reference data are collected.

Table 5-7. Percentiles of Reference Data and 2008 Tobacco Sample Data for Pool Frequency (pools/mile) used for Pool Frequency Target Development

Category	Libby Reference			PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	25th	n	Median	75th
< 20' BFW	57	114	81	19	**75**	53	5	84	85
20-35' BFW	18	53	38	42	**42**	30	10	71	90
> 35' BFW	0	--	--	37	**31**	19	3	32	48
Tobacco River	Target value = **12** pools/mile based on Grave Creek reference reach								

Targets are shown in **bold**

Table 5-8. INFISH and Reference Pool Frequency Values by Channel Bankfull Width (BFW)

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

Large Woody Debris

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

For DEQ sampling in 2008, wood was counted as LWD if it was greater than 9 feet long or two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton, et al., 1997). The LWD count for both available reference datasets was compiled using a different definition of LWD than the 2008 DEQ sample dataset; if measurements were conducted within the same reach, the Libby District LWD count would likely be less than the DEQ LWD count because the protocol only counted wood if it was larger than 6 inches in diameter and longer than the BFW, and the PIBO LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. For streams with a BFW greater than 35 feet, the DEQ sample dataset median was much less than the 25th percentile of the PIBO reference data, but for other channel widths, the median fell in the middle of the 25th percentile and median of the PIBO data and was close to the median of the Libby District reference data (**Table 5-9**). Because the protocol for both reference datasets differs from the DEQ protocol and the Libby District data is the preferred reference data, the LWD target is greater than or equal to the median of the Libby District dataset (**bolded** in **Table 5-9**). For channels with a BFW greater than 35 feet, the 25th percentile of the PIBO dataset was considered but determined to be too high relative to the 2008 sample dataset. Reference data from the Swan River watershed for streams with a bankfull width had a 25th percentile of

104 LWD/mile and a 75th percentile of 210 LWD/mile (Montana Department of Environmental Quality, 2004). The 25th percentile of reference data for streams greater than 35 feet in the Swan River watershed closely corresponds to the 75th percentile for the DEQ sample dataset, but the 75th percentile of the DEQ dataset may be lower than the Tobacco River's potential because of legacy effects from historic logging. Therefore, the interquartile range from the Swan River reference dataset, which was also applied to large streams in the Grave Creek TMDL (Montana Department of Environmental Quality, 2005), will be applied as the target for streams in the Tobacco TPA with a BFW greater than 35 feet.

Table 5-9. Percentiles of Reference Data and 2008 Tobacco Sample Data for LWD (LWD/mile) used for Target Development

Category	Libby Reference			PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	25th	n	Median	75th
< 20' BFW	57	**359**	183	19	833	272	5	465	533
20-35' BFW	18	**242**	92	42	388	149	10	214	356
> 35' BFW	0	--	--	37	597	295	3	100	103
> 35' BFW (including Tobacco River)	Target value = **104 – 210** LWD/mile based on reference data from the Swan River watershed and Grave Creek TMDL target								

Targets are shown in **bold**

5.4.1.4 Riparian Health

Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of coldwater fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During DEQ assessments conducted in 2008, ground cover, understory shrub cover and overstory vegetation were cataloged at 10 to 20 foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each monitoring reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs. While shrub cover is important for stream health, not all reaches have the potential for dense shrub cover and are instead well armored with rock or have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

At the 2008 assessment sites, there was an average value of 56% understory shrub cover and a median value of 57% understory shrub cover. Based on this median value, a target value of ≥ 57% is established for understory shrub cover in the Tobacco TPA. This target value should be assessed based on the reach average greenline understory shrub cover value. Because not all reaches have the potential for dense shrub cover, for any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian shrub cover and identify if the streambanks in the reach are stabilized instead by rocks, a mature pine forest, and/or wetland vegetation.

5.4.1.5 Sediment Supply and Sources

Anthropogenic Sediment Sources

The presence of anthropogenic sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified anthropogenic sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared since Montana's narrative criteria for

sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources, but the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluation of human induced and natural sediment sources, along with field observations and watershed scale source assessment information obtained using aerial imagery and GIS data layers. Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of anthropogenic sediment impacts must consider both historical sediment loading as well as historical impacts to channel form and stability since the historical impacts still have the potential to contribute toward sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.6**, with additional information in **Appendices D**, **E** and **F**.

5.4.1.6 Biological Indices

Macroinvertebrates

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

The two macroinvertebrate assessment tools used by DEQ are the Multi-Metric Index (MMI) and the Observed/Expected model (O/E). The rationale and methodology for both indices are presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols. Samples collected in 2006 were collected by the USFS and were paired samples collected at the same location by two different protocols (i.e., Kick and Surber); although DEQ samples were primarily collected by the Kick method, USFS samples collected by the Surber protocol are presented in the data summaries because they contain macroinvertebrates from multiple riffles and may be more representative of reach conditions.

The MMI is organized based on different bioregions within Montana (i.e., Mountain, Low Valley, and Plains), and the Tobacco River watershed falls exclusively within the Mountain MMI region, for which the macroinvertebrate community shift point that indicates impairment is an MMI score less than 63. This value is established as a sediment target in the Tobacco TPA. The O/E model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled and is expressed as a ratio of the Observed/Expected taxa (O/E value). The O/E community shift point that indicates impairment for all Montana streams is any O/E value < 0.80. Therefore, an O/E score of ≥ 0.80 is established as a sediment target in the Tobacco TPA. For both metrics, an index score greater than the threshold value is desirable, and the result of each sampling event is evaluated separately. Because index scores may be affected by other pollutants or forms of pollution such as habitat disturbance, they will be evaluated in consideration of more direct indicators of excess sediment. Additionally, because the macroinvertebrate sample frequency and spatial coverage is typically low for each watershed and because of the extent of research showing the harm of excess sediment to aquatic life, meeting both biological targets does not necessarily indicate a waterbody is

fully supporting its aquatic life beneficial use and measures that indicate an imbalance in sediment supply and/or transport capacity will also be used for TMDL development determinations.

Because the indices evaluate different aspects of the macroinvertebrate community, the index score for a single sample may meet the target value for one metric but not the other. In these situations, the sample size should be evaluated because an inadequate sample size (i.e., < 300 individuals) can affect the index score. If the sample size is adequate, the index score farthest away from the target/community shift point should be given the most weight (Feldman, 2006). For example, if a sample has an MMI score of 66, which is slightly above the target value, and an O/E score of 0.65, which is well below the target value, the O/E score is given more weight, indicating impairment of the macroinvertebrate community. Additionally, the percent burrowing taxa, which tend to be elevated in macroinvertebrate samples impaired by sediment, will also be evaluated for situations where the metrics do not agree.

5.4.2 Existing Condition and Comparison to Water Quality Targets

This section includes a comparison of existing data to water quality targets along with a TMDL development determination for each 303(d) listed waterbody. Note: Data for the reach on Clarence Creek are not presented in this section because it is a review of data for waterbodies on the 303(d) list for sediment as well as for Sinclair Creek. This review is not performed for Grave Creek since the sediment TMDL has already been written for Grave Creek (Montana Department of Environmental Quality, 2005).

5.4.2.1 Deep Creek

Deep Creek (MT76D004_080) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, Deep Creek is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant form of pollution commonly linked to sediment impairment. Deep Creek flows 15.4 miles from the headwaters to the confluence of Fortine Creek.

Deep Creek was listed for sediment impairment in 2006 based on heavy sedimentation in pools, bank erosion, accelerated mass wasting, and active channel downcutting and lateral movement attributed to road density in sensitive areas of the watershed, overgrazing of riparian vegetation, and other habitat disturbances associated with land management practices on both public and private lands.

Physical Condition and Sediment Sources

In 2003, DEQ performed a qualitative assessment of Deep Creek at a site near the mouth (**Figure 5-1**). This data was used to support the current 303(d) listing. The information generated from this assessment is summarized below:

The channel is actively downcutting and there is excessive lateral cutting with point bars present on almost all bends. With the exception of near the lumber mill, there is limited woody vegetation, which is likely associated with grazing practices. Much of the reach is heavily overgrazed and the riparian function rating is “not sustainable.” Herbaceous species currently dominate the riparian zone but the potential for regeneration of woody vegetation is high. The substrate is dominated by gravels and sands, and there are heavy sediment deposits in pools, particularly upstream of Highway 93. Spawning habitat is greatly reduced by sediment deposition and there is very little woody debris present. A beaver complex around the timber mill is acting as sediment trap but upstream impacts make sediment load excessive.

File photos showed a degraded riparian condition with grazing to the streambank, very little woody vegetation in the riparian zone, heavy bedload deposition, eroding banks, and an overwidened channel.

In 2008, DEQ performed sediment and habitat assessments at two monitoring sites on Deep Creek (**Figure 5-1**). The uppermost site (DEP 9-2) was located just upstream of the forest boundary on USFS land and parallels Deep Creek Road. At the site, there were a couple very large (50 – 100 feet high) eroding banks that were limiting channel movement and attributed to the road. Man made rock gabion structures were observed at the toe of the largest eroding banks, which caused scouring and additional bank erosion near the structures as well as on the opposite side of the stream. Stream channel measurements at the site resemble Rosgen types F4b, C4b, B3, and E3b in various cells of the sample reach depending on entrenchment, width/depth ratio, and sediment particle size, but the stream is likely a B channel type that is in disequilibrium. The stream showed evidence of downcutting, undercutting, and lateral movement due to excessive sediment input from the eroding banks and human alteration. Within the sample reach, boulders dominate the substrate and the channel is steep and composed of almost all riffle/run channel forms. The reach has minimal pools, and no spawning habitat was noted due to large cobble substrate.

The most downstream site (DEP 13-2) was located on private property between Deep Creek Road and the former Plum Creek mill near Fortine. The lower reach had no apparent current human impacts. The reach is a Rosgen C4 channel type consisting of a meandering channel through a flat valley with minimal riffle development, some point bar development and long runs. The reach contained many lateral scour and LWD formed pools. Beaver activity is evident downstream of the reach and evidence of recent historical beaver activity is evident within the sampled reach. Bank material includes cobble/gravel deposited over a layer of fines.

In addition to these two monitoring sites, streambank erosion and a qualitative assessment of human impacts was evaluated at one additional site along Deep Creek (DEP 7-1). Site DEP 7-1 was located in the headwaters on public land. No bank erosion was observed within this reach. Some clear cuts were observed near the site but no impacts to the stream were noted. The site is a cascading step-pool system with a steep gradient and lots of woody debris that form dams. The substrate is predominantly large cobble. Several small trout were observed during sampling. The sample site appeared to be meeting its potential and was noted as a good example of reference reach for high elevation tributaries.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Deep Creek are summarized in **Table 5-10**. The macroinvertebrate bioassessment data for Deep Creek is located in **Table 5-11**. All bolded cells represent conditions where target values are not met.

Table 5-10. Existing Sediment-Related Data for Deep Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
DEP 13-2	2008	19.4	C4	C4	14	**11**	6	4	14.4	4.7	1.6	90	533	**34**
DEP 9-2	2008	19.9	B3/F4	B3/C3b	6	3	1	ND	11.9	1.8	1.0	84	**333**	**54**

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

Table 5-11. Macroinvertebrate Bioassessment Data for Deep Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Deep Creek	FORTINE05	4 mi u/s from mouth	8/15/06	Surber	72.98	1.04

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

Summary and TMDL Development Determination

The percent fine sediment < 2mm exceeded the target at the lowermost reach (13-2). Understory shrub cover did not meet the target value at both sites, however, the lower site had a high number of wetland herbaceous species and the upper site also had good groundcover acting to stabilize streambanks. The upper site had slightly less LWD than the target value but there were numerous LWD aggregates within the reach that formed dams, retained sediment, and caused channel braiding.

The macroinvertebrate data collected in Deep Creek during 2006 met all applicable target values. It is important to note that the macroinvertebrate sampling site is on USFS land and upstream of the sections of the creek where accelerated bank erosion and excess sediment deposition within the channel were observed.

Altogether, the data collected by DEQ in 2008 suggests some minor level of human-caused negative impact to the coldwater fishery and aquatic life beneficial use. However, due to private property and stream access issues in the lower Deep Creek, the data collected by DEQ in 2008 were spatially limited and not necessarily representative of Deep Creek. Aerial photos and qualitative assessments in 2008 show that grazing practices within riparian areas have largely improved but bank erosion problems remain as originally observed in 2003 and there are still some sections near the mouth with poor riparian buffers. In addition, sediment source assessment information, located in **Section 5.6**, identify potentially significant and controllable human caused sources of sediment throughout the lower watershed. These observations are consistent with the 2003 DEQ data collection that led to a sediment impairment listing for Deep Creek. As a result, sediment TMDL will be prepared for the Deep Creek.

5.4.2.2 Edna Creek

Edna Creek (MT76D004_030) is listed for sedimentation/siltation on the 2010 303(d) List. The Edna Creek watershed falls completely within Northern Rockies ecoregion and the streamflows for approximately 10 miles to its confluence with Fortine Creek. Edna Creek was originally listed in 1992

because of siltation associated with historic riparian harvest and logging, roads, agriculture, and removal of woody debris from the channel.

Physical Condition and Sediment Sources

Various publications from the late 1990s and early 2000 identify sediment impacts to Edna Creek resulting from insufficient BMPs for roads and road network structures, lack of riparian protections, and stream crossings (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1998; River Design Group, 2004; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2000; U.S. Department of Agriculture, Forest Service, 2002). The most notable observed effects were the quantity and quality of pools, frequency of LWD, and the amount and size of sediment in the channel (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1998). A 2002 KNF publication rated the watershed's overall condition as "high concern" based on a combination of sensitivity and disturbance factors and included the road and sensitivity statistics presented below (U.S. Department of Agriculture, Forest Service, 2002).

Total road density rated as high (> 3.5 mi/mi^2), sensitive land type road density rated as high (> 3.0 mi/mi^2 of sensitive land types within watershed), 1 road crossing/mile of road, 4.3 road crossings for mi^2 of watershed (> 3 considered high), 24% effective clear cut area and rated as moderate (15-30% moderate), 54% total disturbance from roads and harvest (> 40% considered high), 8% detrimental soil disturbance. Riparian road density rated high (> 3.0 mi. road/mi^2 of riparian area considered high), # of road crossings/mile of stream rated moderate at 1.8 crossing/mile of stream, 65% intact riparian rated as high potential for disturbance (< 70% rated as high).

In 2003, DEQ performed stream reach assessments at two sites within the Edna Creek watershed (**Figure 5-1**). Pebble counts were performed as well as qualitative assessments of channel conditions, riparian vegetation, and sediment sources. At the upper site (K01EDNAC01), the crew noted lots of gravels and sand and 30-35% embeddedness. At the lower site (K01EDNAC02), embeddedness was 65-70% and although small pools were abundant, pools and spawning substrate were filled with gravel, sand, and silt. LWD was abundant. There was evidence of large tracts of historic timber harvest near the headwaters and a small amount of existing harvest activity. Extensive road crossings were noted as potential sediment sources.

In 2008, DEQ performed a sediment and habitat assessment at one site on Edna Creek (ENA 10-2) and performed an assessment of bank erosion and human impacts to the stream at three other sites. The full assessment site was located just above Forest Service Road 3588, and no human impacts were noted within the reach other than the road crossing downstream of the reach. The stream channel in this reach is a B4c/C4 Rosgen channel type that also resembles an F4 channel type in areas due to various cells within the reach being entrenched. Some historic beaver activity is present and some areas appear to be over widened.

The uppermost bank erosion assessment site (ENA 7-2) was a step-pool system with a significant amount of large woody debris, and the site had no apparent human impacts. The next downstreambank erosion assessment site (ENA 8-1) also had no visible sign of human impact. This reach was also a steep step-pool system and though the road paralleled most of the reach it was 50 – 100 feet off the stream and had no apparent influence. The lowermost bank erosion assessment site (ENA 11-1) was located approximately 0.7 miles upstream of the confluence with Fortine Creek. The site was observed to be heavily impacted by agriculture and the surrounding land is actively hayed. Surveyors noted high amounts of fine sediment deposited within the reach and few stretches of gravel. Though elevated fines

were observed, this may be a natural condition given that the reach was a low gradient E stream type and the existence of beaver dams acting to reduce flushing flows. The site had many multi-channel segments, suggesting current and historic beaver activity as well as historically eroding streambanks. Just downstream of the assessment site, the stream appeared to be in a state of active channel migration, which is assumed to be from beaver activity. Riparian buffers were essentially nonexistent throughout the reach, although there was a dense mat of reed canary grass. Aerial imagery of this site shows old meander scars within the adjacent hay meadows suggesting that the reach was channelized historically. Many of the mid-channel clumps of willow and bank material may be the channel attempting to dissipate its energy and regain its sinuosity. In summary, riparian harvest and the removal of woody debris from the active channel and streambanks as well as channelization has destabilized the lower reaches of Edna Creek.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Edna Creek (ENA) are summarized in **Table 5-12**. The macroinvertebrate bioassessment data for Edna Creek is located in **Table 5-13**. All bolded cells represent conditions where target values are not met.

Table 5-12. Existing Sediment-Related Data for Edna Creek relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
ENA 10-2	2008	22.3	B4c/F4	B4c/C4	14	**9**	3	**14**	**21.5**	1.5	1.2	90	702	90
K01EDNAC02	2003	--	--	--	**41**	**33**	--	**--**	**--**	--	--	--	--	--
K01EDNAC01	2003	--	--	--	**49**	**31**	--	**--**	**--**	--	--	--	--	--

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

Table 5-13. Macroinvertebrate Bioassessment Data for Edna Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Edna Creek	K01EDNAC02	Near mouth and u/s of FS 3588 bridge	8/13/03	Kick	76.13	0.93
Edna Creek	K01EDNAC01	Near headwaters and 0.9 mi d/s from FS 3581	8/13/03	Kick	85.12	1.09
Edna Creek	FORTINE06	Near mouth	8/21/06	Surber	72.28	0.97

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

Summary and TMDL Development Determination

Both reaches assessed in 2003 failed to meet the pebble count fine sediment targets. During the 2008 stream assessment, fine sediment values were much less than in 2003 but ENA 10-2 failed to meet the target for fine sediment < 2mm via riffle pebble count and the target for pool tail grid toss. Half of the cells within the reach were not meeting the potential C4 stream type and had an F4 stream type, suggesting that the stream is entrenched and/or downcut. Likely as a result of overwidening in sections, the reach had a W/D ratio slightly larger than the target value. Due to the large substrate within the

banks, bank erosion did not appear to be accelerated by these entrenched areas. The most downstream reach had some slowly eroding banks attributed to cropland but bank erosion along all other reaches was attributed to natural sources.

Macroinvertebrate data met threshold values at all sites. Although the biological indices indicate sediment may not be impairing macroinvertebrates, elevated levels of fine sediment in riffles and pool tails indicate that the sediment supply is overwhelming the transport capacity of the system and suggests the aquatic life and coldwater fish beneficial use is continuing to be negatively affected by human sources. B channels tend to be quite resilient, as noted in the 2002 KNF report, but the Edna Creek watershed is highly sensitive to disturbance. Particularly in the entrenched sections where the stream is an F channel, Edna Creek may still be attempting to regain some equilibrium of channel form, function, and sediment transport. During the 2008 assessment, numerous well-maintained BMPs were observed throughout the watershed including: waterbars at road crossings, appropriate streamside management zones (SMZ) applied to logged areas, and the existence of a new, appropriately-sized culvert. However, it appears that Edna Creek is still recovering from intense historic land management within the watershed, and it is important that recent BMPs continue to be maintained and that additional BMPs are implemented. The primary anthropogenic sources of sediment within the watershed include unpaved roads, logging, near-stream agriculture, and riparian vegetation removal. Because of the existing 303(d) listing, sensitivity of the Edna Creek watershed to disturbance, and recent data suggesting sediment-related impacts to beneficial uses, a sediment TMDL will be prepared for Edna Creek.

5.4.2.3 Fortine Creek

Fortine Creek (MT76D004_020) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, Fortine Creek is also listed for alteration in streamside or littoral vegetative covers and flow alteration, which is a form of pollution commonly linked to sediment impairment. Fortine Creek was originally listed in 1990 based on FWP data regarding sediment loading and channel siltation, and probable sources were cited as grazing, logging, and land development. The Fortine Creek watershed falls completely within Northern Rockies ecoregion and the streamflows for approximately 30 miles to its confluence with Grave Creek, forming the headwaters of the Tobacco River.

Physical Condition and Sediment Sources

In the early 1900s, Fortine Creek was used as a conduit for timber harvested within the watershed, and log drives, in conjunction with harvesting and channelization from roads and the railroad, have contributed to long lasting changes to channel sinuosity, shifts in stream energy, channel entrenchment, loss of floodplain access, and bank erosion (River Design Group, 2004; U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 2004).

In 2003, DEQ performed stream reach assessments at three sites within the Fortine Creek watershed (**Figure 5-1**). Pebble counts were performed as well as qualitative assessments of channel conditions, riparian vegetation, and sediment sources. The uppermost reach (K01FORTC010) was located near the headwaters on USFS land and moderate sediment deposition was noted in riffle margins with moderate to heavy deposition in the pools. Timber harvest was common but mostly out of the riparian area. Portions of the reach were heavily grazed and observed to be contributing to a lack of woody vegetation in the riparian and increased bank erosion. Both of the downstream sites (K01FORTC020 and K01FORTC020) contained a mixture of unstable areas with excessive bank erosion and stable forested sections with well armored streambanks. Moderate to high sediment deposition was observed in pools and riffles were affected by sand deposition. Some natural erosion of ancient lake bed sediment was

observed and anthropogenic sediment sources were primarily associated with grazing and channelization and habitat alterations associated with the railroad.

Sediment and habitat assessments were performed at eleven sites on Fortine Creek in 2008 (**Figure 5-1**). Of the eleven sites visited in 2008, five were full assessment sites and six were bank erosion-only sites. The uppermost full assessment site (FTN 4-3) was located on USFS land approximately 4.5 miles upstream of the confluence of Swamp Creek. The reach assessed was just upstream from the entrance to the railroad tunnel where the stream is not encroached upon by either the railroad or the Fortine Creek road. Severe grazing impacts were noted throughout the upper end of the assessment reach. Riparian vegetation in this area was trampled and high fines were observed within the stream channel. The stream throughout the reach resembled a Rosgen C4 stream type. The sample reach meandered though a meadow and had a very low gradient, few riffles, long scour pools, and minimal woody debris. Evidence of beaver activity was noted. Bank erosion at this site was predominately natural, except for one large eroding bank associated with cattle access to the stream.

The next downstream full assessment site (FTN 6-1) was located on state land approximately 2 miles upstream of the confluence with Swamp Creek. At this site, Fortine Creek was on the east side of the railroad and the upper and lowermost portions of the sample reach abutted the railroad. The stream was channelized in these areas and riprap was placed along the channel margins. In addition to the railroad impacts, some historic riparian logging activity was observed at the site. The reach is a B3c/B4c channel type which resembles an F3 in areas due to encroachment and channelization from the railroad, and subsequent entrenchment of the channel. The middle of the assessment reach pulled away from the railroad and appeared more natural in its channel dimension, pattern, and profile. Within the middle of the assessment reach, the stream was meeting its potential Rosgen stream type of a B3. Some beaver activity was noted in the upper and lower segments flanking the railroad. Bank erosion at this site was affected by the channelization and shifts in stream energy.

The next downstream site (FTN 9-3) was located on USFS land approximately 0.3 miles below the Swamp Creek Road crossing on Fortine Creek. At this site the only human impact noted included observations of historic riparian logging. The reach is a Rosgen B4c\C4 stream type, with a slow and meandering channel pattern. The reach consisted of long pools and short sporadic riffles. Surveyors noted that the stream was overwidened in places where the channel appeared to be aggrading. Limited spawning habitat was noted due to large substrate, and the surveyors noted a fine coating of sediment on the channel substrate. Bank erosion at this site was minimal.

The next most downstream assessment site (FTN 12-7) was located on private land just downstream of the Loon Lake Road crossing at Fortine Creek, near Trego, Montana. Land use within the reach was predominantly agricultural, including cattle grazing and hay production. The site was severely affected by near-stream grazing and had a heavily browsed riparian area and extensive bank erosion. The survey crew noted some apparent restoration attempts observed near the upper end of the assessment reach including riparian fencing and willow planting, however, an attempt to fence out cattle from the stream in this area was unsuccessful. The stream at this site was a Rosgen B4c\C4 stream type. The channel was overwidened in places due to near-stream grazing, cattle access to the stream, and bank trampling. The large substrate was embedded in a layer of silt and excessive fines were observed throughout the reach. Alders, willows and other wetland vegetation exist where grazing impacts were minimal.

The most downstream full assessment site (FTN 13-1) was located on state land approximately 0.4 miles upstream of the Fortine and Deep Creek confluence, near Fortine, Montana. The assessment reach was

laid out within a meandering section of Fortine Creek that was situated away from the railroad and heavily forested on both sides of the stream. The stream channel was a Rosgen B4c/C4 that resembled an F channel type due to severe entrenchment. Within the reach, there were multiple compound pools with infrequent small riffles. Bank erosion was minimal, however, massive bank failure and erosion was observed on many outside meander bends upstream of the assessment reach. At these locations, the stream appeared to be severely entrenched and/or downcut. The entrenched nature of the reach and nearby areas are believed to be remnants of past logging and log drive practices that were implemented through the turn of the twentieth century (KNF 1998).

In addition to these five monitoring sites, streambank erosion and a qualitative assessment of human impacts was evaluated at six additional sites along Fortine Creek. Several of the sites had portions with adequate riparian buffers or recently installed riparian fencing to reduce grazing impacts, but channel entrenchment and bank erosion were observed throughout the sites and attributed to historic logging in the riparian zone, railroad and road encroachment, channelization, and near-stream grazing. In some cases, only historic impacts were noted and these reaches appeared to be in an active state of recovery from past impacts.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Fortine Creek (FTN) are summarized in **Table 5-14**. The macroinvertebrate bioassessment data for Fortine Creek is located in **Table 5-15**. All bolded cells represent conditions where target values are not met.

Table 5-14. Existing Sediment-Related Data for Fortine Creek Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
FTN 13-1	2008	34.5	B4c/F4	B4c	12	8	7	**9**	25.3	1.5	1.7	58	391	77
FTN 12-7	2008	62.5	B4c/C4	B4c/C4	13	**9**	**13**	**18**	**51.6**	1.7	**1.5**	63	**100**	**33**
FTN 9-3	2008	29.5	B4c/C4	B4c/C4	8	6	1	3	20.2	1.8	1.7	**37**	**100**	**30**
FTN 6-1	2008	21.2	B4c/F4	B3c/B4c	9	**5**	**12**	**11**	**24.0**	1.5	1.0	84	**227**	91
FTN 4-3	2008	22.3	C4	C4	13	8	5	5	17.3	3.0	1.7	53	**132**	61
K01FORTC010	2003	--	--	--	**19**	**13**	--	**--**	**--**	--	--	--	--	--
K01FORTC020	2003	--	--	--	**19**	**19**	--	**--**	**--**	--	--	--	--	--
K01FORTC030	2003	--	--	--	**19**	**15**	--	**--**	**--**	--	--	--	--	--

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

Table 5-15. Macroinvertebrate Bioassessment Data for Fortine Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Fortine Creek	K01FORTC20	0.25 east of FS Rd 3651	8/10/03	Kick	65.05	1.34
Fortine Creek	K01FORTC10	1 mi d/s of upper W Fortine Ck Rd crossing	8/10/03	Kick	75.49	1.10
Fortine Creek	K01FORTC30	0.3 mi u/s of mouth	8/11/03	Kick	65.61	**0.76**
Fortine Creek	FORTINE07	0.3 mi u/s of Swamp Creek	8/17/06	Surber	**53.49**	**0.49**

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

Summary and TMDL Development Determination

All three sites assessed in 2003 had similar fine sediment values and failed to meet the pebble count targets. During the 2008 assessment, percent fine sediment data as compared to targets show mixed results. All reaches assessed met the < 6.35mm pebble count riffle target, but pebble count fine sediment < 2mm as well as riffle and pool spawning habitat grid toss targets were exceeded at various locations throughout the watershed. Reach FTN 12-7, which was observed as having severe grazing impacts and bank erosion, was one of two reaches that failed to meet the W/D ratio target and the only reach failing to meet the residual pool depth target. The average bankfull width for this site was nearly 63 feet with a maximum of 93 feet measured at the most overwidened cross-section. Likely as a result of riparian grazing and historic logging, several reaches failed to meet the target for LWD and greenline shrub cover. Examination of greenline assessment forms indicate FTN 9-3 was limited in shrub cover and had some invasive weed issues but overall had fairly healthy riparian vegetation and a buffer greater than 200 feet throughout most of the reach. The upper section of FTN 12-7 had evidence of tree plantings, but overall the riparian vegetation was well below its potential due to severe overgrazing in much of the reach. This supports the listing for alteration in streamside or littoral vegetative covers and indicates an imbalance in habitat factors important for upland and in stream sediment retention and fish cover. Bank erosion at five of the reaches was predominantly related to natural sources, and bank erosion at the other six reaches was attributed to grazing, historic logging, and encroachment from roads or the railroad.

Of the four macroinvertebrate samples collected in Fortine Creek, one sample collected in 2006 failed to meet both metrics and a sample collected in 2003 did not meet the O/E target. For the sample not meeting the O/E target, the corresponding MMI value is only slightly above the target value (i.e., 63), which indicates more weight should be given to the O/E value. The burrowing taxa at the sites not meeting one or both metrics are elevated relative to sites meeting both metrics, which also indicates excess sediment is impairing macroinvertebrates within Fortine Creek.

The elevated percent of surface fine sediment in riffles and pool tails and high rates of bank erosion associated with human sources indicate an increased sediment supply and a decreased capacity to transport sediment, particularly in the lower watershed. These conditions are contributing to impairment of the macroinvertebrate community and likely limiting fish habitat quality and affecting spawning and rearing success. The primary anthropogenic sources of sediment within the watershed include near-stream grazing, roads, bank erosion, and timber harvest. This information supports the 303(d) listing and a sediment TMDL will be completed for Fortine Creek.

5.4.2.4 Lime Creek

Lime Creek (MT76D004_050) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, Lime Creek is also listed for alteration in streamside or littoral vegetative covers, which is a form of pollution commonly linked to sediment impairment. Lime Creek was originally listed in 1996 based on sedimentation attributed to grazing, logging, and roads. The Lime Creek watershed is situated within the Northern Rockies ecoregion and the streamflows for approximately 4 miles to its confluence with Fortine Creek.

Physical Condition and Sediment Sources

Although limestone geology is prevalent in the upper Fortine Creek watershed and a source of calcium enrichment to its waters, Lime Creek is the only sediment-listed stream in the Tobacco TPA where the entire stream is underlain by limestone geology (**Figure A-3**), which heavily influences the geomorphology of the stream. Sections of Lime Creek are aggrading as a result of calcium carbonate precipitating out of solution, depositing on the bottom, and elevating the base level of the channel (River Design Group, 2004). This phenomenon can reduce the ability of the stream to transport sediment, resulting in increased bank scour and channel instability. Geomorphological conditions of this nature are common in watersheds dominated by re-precipitating calcium carbonate and high rates of deposition. Another product of the increased production and deposition of calcium carbonate is a channel bed dominated by a fine calcium rich substrate. During DEQ field work in 2008, Lime Creek was the only assessed stream where this phenomenon was observed to be a major factor in-channel conditions (**Figure 5-2**).

Figure 5-2. Calcium carbonate precipitate on the channel bottom in Lime Creek upstream of FS Road 3780 (left) and causing a chalky color in the water column at LME 6-1 (right).

In 2003, DEQ performed a pebble count and a qualitative assessment of channel conditions, riparian vegetation, and sediment sources at a site near the mouth (K01LIMEC01) (**Figure 5-1**). The assessor noted severe grazing impacts to the lower 0.5 mile of stream with bank failure, hoof shear, downcutting, and channel overwidening. The thick topsoil was observed to be very erosive where riparian vegetation

was absent, and siltation in the lower 2.5 miles of the stream was noted as a major concern. Riparian timber harvest was observed on private land as well as slash in the channel.

The Kootenai National Forest conducted channel measurements at two reaches in 2004 and 2005. One reach was a B4 channel type with low potential for bank erosion, a moderate sensitivity to disturbance, and a good Pfankuch channel stability rating (Pfankuch, unpublished 1978), and the other reach was a A4/F4b channel type with a high sensitivity to disturbance, a high potential for bank erosion, and a fair Pfankuch channel stability rating (USDA Forest Service, Kootenai National Forest, 1996). The carbonate geology and past management of the riparian zone have contributed to common head cuts and frequent channel changes (River Design Group, 2004). Many of the historic impacts and associated sediment sources within the Lime Creek watershed are in an active state of self restoration.

In 2007, DEQ conducted nutrient sampling on Lime Creek near forest road 3780 and field notes cited evidence of cattle grazing along the entire sample reach, including hummocking and several cattle crossings. A layer of fine sediment was observed on the substrate throughout the reach with “mucky, thick sediment” in pools and at cattle access points. During 2008, DEQ evaluated one full assessment site on Lime Creek (LME 6-1) (**Figure 5-1**). This site was located approximately 2.5 miles upstream of the Lime Creek confluence with Fortine Creek, and just downstream of the forest road 3770 Lime Creek crossing. Within the reach, minimal current human impacts were noted, however the perched road culvert at the upper end of the reach may be causing some elevated erosion on streambanks below the crossing. Some evidence of historic logging was observed at the upper end of the reach. Stream channel measurements suggest that the existing stream type is a E4b channel with a high entrenchment ratio and low width/depth ratio. This stream type is expected given the influence of calcium carbonate noted above. Lots of fines were observed within the channel bed and field notes document calcium carbonate deposits describing the stream bed as having “a chalky appearance from eroded limestone.”

Comparison to Water Quality Targets

The existing data in comparison to the targets for Lime Creek (LME) are summarized in **Table 5-16**. The macroinvertebrate bioassessment data for Lime Creek is located in **Table 5-17.** All bolded cells represent conditions where target values are not met.

Table 5-16. Existing Sediment-Related Data for Lime Creek relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
LME 6-1	2008	7.5	E4b	E4b	**35**	**21**	**17**	ND	6.7	2.9	**0.5**	**74**	465	**53**
K01LIMEC01	2003	--	--	--	**75**	**74**	--	--	--	--	--	--	--	--

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

Table 5-17. Macroinvertebrate Bioassessment Data for Lime Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Lime Creek	K01LIMEC01	0.25 mi u/s of mouth	8/12/03	Kick	**39.18**	**0.70**
Lime Creek	K01LIMEC02	2.5 mi u/s of mouth; just downstream of LME 6-1	7/24/08	Kick	72.57	**0.78**

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

Summary and TMDL Development Determination

The reach assessed in 2003 did not meet the pebble count fine sediment targets, and the 2008 assessment reach (LME 6-1) did not meet either of the fine sediment pebble count targets or the riffle grid toss target. The reach also did not meet the target for residual pool depth and was slightly less than the targets for pool frequency and greenline percent shrub cover. The greenline assessment notes indicate that shrub cover number was reduced below the target because of a section with 30 percent shrub cover but that overall the riparian vegetation was in very good condition with a dense overstory and understory. Given that the carbonate geology is a major driver of fine sediment percentages and channel morphology in Lime Creek, the Tobacco TPA targets (**Table 5-3**) may not be entirely applicable to Lime Creek.

The 2003 macroinvertebrate sample from the site near the mouth did not meet the target value for either metric, indicating impairment. The macroinvertebrate sample collected in 2008 was slightly below the O/E target, but based on the corresponding MMI score being quite a bit above the target, this sample does not indicate impairment.

Due to the limestone geology of Lime Creek, the percentage of fine sediment within the channel bed is likely naturally greater than the target value (i.e., 15% < 6mm) and the potential for pool frequency and residual pool depth may be less than for other sediment-listed streams in the Tobacco TPA. However, based on observed anthropogenic sediment sources including riparian vegetation removal, near-stream grazing, bank erosion, and roads, these sources have also altered channel morphology and increased the fine sediment load. Recent data and field observations suggest Lime Creek is recovering from historic management practices, but because it is still recovering and is a system highly sensitive to disturbance, a sediment TMDL will be developed for Lime Creek.

5.4.2.5 Sinclair Creek

Sinclair Creek (MT76D004_091 and MT76D004_092) was never previously formally assessed by DEQ for beneficial use support and therefore did not appear on the 2010 303(d) List. Due to stakeholder input, high resource value based on occasional use by juvenile bull trout for extended rearing, and the existence of potentially significant controllable sediment sources, Sinclair Creek was added to the list of streams evaluated during this TMDL assessment. Sinclair Creek flows approximately 11 miles from the headwaters to the confluence with the Tobacco River within the Town of Eureka, Montana, but is divided into two waterbody segments with the upper segment contained within the Canadian Rockies and the lower segment within the Northern Rockies ecoregion. The lower segment MT76D004_091, was the focus of this assessment, and extends 7.9 miles from an unnamed tributary to the mouth.

Physical Condition and Sediment Sources

Sediment and habitat assessments were performed at two monitoring sites on Sinclair Creek in 2008. The uppermost full assessment site (SNC 8-2) was located on private property approximately 5 miles

upstream of the mouth. Active grazing lands were noted on both sides of the stream, however, current impacts to the stream were minimized due to the existence of riparian fencing. The reach has a potential Rosgen stream type of a B4c/C4 type channel, but resembles a F4 type channel in areas due to downcutting in the stream channel and low entrenchment ratios. Overall, the stream reach was noted to be in good morphological structure with high numbers of woody debris and quality pools. Riparian vegetation at this reach was composed of older stands of even-aged alder and hawthorn. Grazing impacts to the vegetation were evident but appeared in a state of recovery. A dead bull trout was observed within the reach. Eroding streambanks were prevalent at this site and were located on the outside of meander bends. Impacts from grazing was noted as the primary cause, however as with the riparian vegetation, this erosion seemed to be recovering due to fencing out the cattle.

The lowermost full assessment site (SNC 10-3) was located approximately 0.2 miles upstream of the Sinclair Creek confluence with the Tobacco River, within the town of Eureka. This stream reach was encroached by roads on both sides, and high amounts of fines were observed on the channel bottom. The deposition of fines in this reach is a combination of significant sources of sediment upstream and deposition from culvert backup downstream the reach. Debris such as tires, metal, coolers, and garbage exist throughout the reach. The stream reach is a Rosgen B4c and B5c due to high amounts of fine sediment. The stream reach was observed as having few small riffles and being overwidened in many areas. The stream channel appeared to be aggrading, probably due to backup from the downstream culvert. The riparian vegetation was noted in good health considering extensive human alteration. All eroding banks within this reach were stratified with a layer of sand and rated as slowly eroding. Erosion sources were predominately cited as channelization between the roads but also had some influence from residential developments.

In addition to these two monitoring sites, streambank erosion and a qualitative assessment of human impacts was evaluated at one additional site along Sinclair Creek (SNC 5-1). The reach was located in the headwaters on public land and had no signs of human impact. The reach was a cascading step pool system with lots of LWD and large boulders. The surveyors observed evidence of a large flood that moved very large boulders (> 3 feet) well out into the floodplain. All eroding streambanks observed within the reach were attributed to natural sources.

In June of 2006, Sinclair Creek experienced a significant flood event in response to consecutive days of above average precipitation. The storm generated widespread flooding throughout the watershed and damaged infrastructure including approximately 225 feet of the main Sinclair Creek Road. Post flood surveys were conducted by River Design Group and the U.S. Fish and Wildlife Service in July of 2006. Observations confirmed that the morphology and stability of Sinclair Creek had been compromised as a result of the emergency actions and flood impacts. The post flood survey documented accelerated channel migration, bank erosion, downcutting, loss of floodplain connectivity, and impacts to aquatic habitat (River Design Group, Inc., 2009).

Comparison to Water Quality Targets

The existing data in comparison to the targets for Sinclair Creek (SNC) are summarized in **Table 5-18**. All bolded cells represent conditions where target values are not met. No macroinvertebrate data was available for Sinclair Creek.

Table 5-18. Existing Sediment-Related Data for Sinclair Creek relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
SNC 10-3	2008	21.1	B4c/B5c	B4c	**41**	**28**	**54**	**98**	17.7	1.4	**0.9**	90	253	**15**
SNC 8-2	2008	20.8	C4/F4	B4c/C4	12	**9**	3	2	20.3	**1.6**	**1.1**	90	634	69

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

Summary and TMDL Development Determination

During the 2008 assessments, SNC 10-3 exceeded all pebble count and grid toss targets, with the grid toss in potential pool spawning habitats almost reaching one hundred percent fines < 6mm. The other reach (SNC 8-2) had much lower fine sediment percentages and only slightly exceeded the pebble count target for fines < 2mm. The width/depth values met the target at both sites, but because SNC 8-2 was an entrenched F channel in sections, it did not meet the target for entrenchment ratio. Although channel morphology targets were met in reach SNC 10-3, aggradation was noted and extensive incisement and downcutting was observed above the reach just below the stream's first crossing of HWY 93. Pool frequency and LWD targets were met in both reaches. Both reaches did not meet the residual pool depth target, but the channel bankfull width was close to the 20-foot cutoff and did meet the target for channels < 20 feet wide. Based on field observations, sediment is likely not affecting residual pool depth in reach SNC 8-2, but the aggradation of the stream channel within the SNC 10-3 reach has reduced the residual pool depth, and could be affecting the quality of pool habitat. Some eroding banks appear to be recovering as a result of improvements in grazing practices, but remaining human sources contributing to bank and hillslope erosion include at least two livestock confinement areas bordering the stream and a stream diversion that returns to Sinclair Creek, nearby residential development, at least two major road erosion sources (see example in **Figure 5-3**), and channelization from roads. Understory vegetation targets were not met within reach SNC 10-3, however, it was noted that riparian fencing was having a positive impact on this reach and that vegetation was relatively good considering road encroachment on both sides of the channel.

These results indicate that although some recovery is occurring, current and historic human impacts are negatively effecting sediment production, transport, and deposition within Sinclair Creek. Near-stream grazing in riparian zones, road encroachment, and haying activities have contributed to elevated fines levels, overwidened sections of stream channel, and accelerated bank erosion, which are likely limiting the aquatic life beneficial use. Therefore, a sediment TMDL will be developed for Sinclair Creek.

Figure 5-3. An unpaved road sediment source near Sinclair Creek, shown in dry conditions and during a runoff event

5.4.2.6 Swamp Creek

Swamp Creek (MT76D004_040) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, Swamp Creek is also listed for alteration in streamside or littoral vegetative covers and flow alterations, which is a form of pollution commonly linked to sediment impairment. Swamp Creek was originally listed in 1992 based on turbidity during low flow and sedimentation attributed to roads, riparian harvest, and logging. Swamp Creek extends 11 miles from the headwaters its confluence with Fortine Creek.

Physical Condition and Sediment Sources

In 2003, DEQ performed an assessment 0.1 miles from the mouth (K01SWMPC02) and noted logged areas with channel incision and more lateral erosion but a fair amount of vegetation stabilizing streambanks. Both logged areas and the lower section of the reach had sediment deposition in pools and along riffle margins. Also, mass wasting was observed lower reach sections. Potential sediment sources were cited as culverts, timber harvest (historic and present), and grazing. The Swamp Draft Environmental Impact Statement (U.S. Department of Agriculture, Forest Service, Kootenai National Forest, 1998) noted that basin surveys indicated a lack of adequately sized and spaced pools, insufficient LWD, and poor substrate are all factors limiting aquatic life in Swamp Creek. These factors were attributed to removal of debris dams, upland land management, check dams, and riparian tree harvesting and mortality from mountain pine beetles.

In 2008, sediment and habitat assessments were performed at three locations throughout Swamp Creek from the headwaters to its mouth. Of these three sites, two were full assessment sites and one was a bank erosion only site. The uppermost full assessment site (SWP 5-1) was located just downstream of the Forest Road 3553 crossing on Swamp Creek on USFS land. Human impacts within the reach include

historic riparian logging, minor grazing impacts, and old grade control structures. A new pipe arch bridge exists at the upstream end of the reach, which appears to be causing some localized overwidening. The reach is a Rosgen B4 stream type, with areas resembling an F4b stream type due to entrenchment. The stream in this area has a predominantly large gravel substrate (i.e., D50 = 60mm). At the time of the assessment, streamflow was extremely low as compared to the channel size, and the flow went subsurface at one time within the reach. LWD was significant throughout the entirety of the assessment reach. Some bank erosion at this site was attributed to natural sources but historic riparian logging was cited as the predominant factor. The grade control structure noted in the lower portion of the reach was actually a high stage check dam installed in 1992. During the high runoff of 1995, these structures washed out and now excessive bedload deposition and aggradation is occurring at these sites (River Design Group, 2004). Plunge pool formation formed downstream of the check dams may be a fish barrier at low water.

The lowermost full assessment site (SWP 9-1) was located on USFS land approximately 0.4 miles upstream of the mouth of Swamp Creek. Minimal human influence was observed at this site. The upland forest had been clearcut at the lower end of the reach, but a buffer of at least 100 feet was present. The stream was a Rosgen type B3\C3b within the sample reach. The stream reach is a step-pool system throughout the upper end of the assessment reach, with large cobbles and boulders. Surveyors noted that the amount of woody debris appeared low but could be natural for this system. Bank erosion was very low and attributed to natural sources.

The bank erosion assessment reach (SWP 3-1) was located on USFS land just upstream of Forest Road 3560 Swamp Creek crossing. Historic riparian harvest was the only human impact noted at this site. The site was a step-pool system with high amounts of woody debris. Bank erosion was minimal at this site with a small percentage associated with historic logging but more than 90 percent of eroding banks attributed to natural sources.

A review of the most current aerial imagery for Swamp Creek (2009) identifies 1.5 miles of current human impacts to the stream on private land approximately 3.5 miles upstream of the mouth. Within this relatively flat, unconfined valley, the creek appears to be mostly devoid of riparian vegetation, and it also appears that much of the flow was routed into a straight manmade channel that eliminates much of the water from a large meander bend. DEQ was not able to ground truth this area to more fully evaluate the near stream management practices currently in place. Since DEQ did not have access to this area in 2008 it is assumed that the impacts are leading to significant habitat alterations, particularly channelization and entrenchment stemming from hay production, riparian clearing, and near stream grazing.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the Swamp Creek (SWP) are summarized in **Table 5-19**. The macroinvertebrate bioassessment data for the Swamp Creek is located in T**able 5-20**. All bolded cells represent conditions where target values are not met.

Table 5-19. Existing Sediment-Related Data for Swamp Creek relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
SWP 9-1	2008	35.9	B3/C3b	B3/C3b	6	4	2	ND	23.2	2.1	**1.2**	42	164	**51**
SWP 5-1	2008	24.8	B4/F4b	B4	11	7	5	5	**23.7**	1.6	**0.7**	90	**201**	79
K01SWMPC02	2003	--	--	--	**29**	**24**	--	--	--	--	--	--	--	--

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

Table 5-20. Macroinvertebrate Bioassessment Data for Swamp Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Swamp Creek	K01SWMPC02	0.1 mi upstream from mouth	8/12/03	Kick	67.20	1.30
Swamp Creek	FORTINE08	0.4 mi upstream from mouth; downstream end of SWP 9-1	8/17/06	Surber	**37.60**	**0.26**

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

Summary and TMDL Development Determination

Pebble count fine sediment targets were exceeded in 2003 but all fine sediment targets were met for both full assessment sites in 2008. The width/depth ratio exceeded the target at SWP 5-1, indicating an overwidened channel. Pool frequency indicators were met at both sites, however the residual pool depth indicators were not. Both sites were noted as having predominantly large cobble and boulders, and particularly at site SWP 5-1, aggradation of coarse bedload is likely limiting the pool quality. Although the values were relatively close to the targets, one reach failed to meet the LWD target and the other failed to meet the greenline shrub cover target; a review of field notes for both parameters indicates both values are close to or near the potential for the sites.

Macroinvertebrate data collected in Swamp Creek met both targets values in 2003 but failed to meet both targets in 2006. Although fine sediment values were meeting targets at the 2008 assessment reaches, the burrowing taxa at the 2006 macroinvertebrate site were elevated relative to the 2003 site, indicating excess fine sediment is likely impairing macroinvertebrates. This difference between fine sediment values at the assessment reaches and macroinvertebrate health could be because excess fine sediment was flushed downstream between 2006 and 2008 or because excess fine sediment accumulation is patchy throughout the system.

Recent field observations combined with channel morphology, pool depth, and riparian habitat measures support the 303(d) listing for habitat alteration and also indicate coarse sediment has aggraded sections of Swamp Creek. Although the 2006 macroinvertebrate sample indicates impairment associated with fine sediment, excess coarse sediment can also alter the composition and diversity of macroinvertebrate taxa (Rice, et al., 2001) and decrease fish habitat, food availability, and productivity

(May and Lee, 2004; Sullivan and Watzin, 2010). Riparian grazing roads are contributing sources but the most significant human sources are associated with historic grade control structures and logging practices. Therefore, recent data support the 303(d) listing and a sediment TMDL will be written for Swamp Creek.

5.4.2.7 Therriault Creek

Therriault Creek (MT76D004_070) is listed for sedimentation/siltation on the 2010 303(d) List. Therriault Creek's headwaters originate in the Canadian Rockies ecoregion and the streamflows for approximately 9 miles to its confluence with the Tobacco River. Therriault Creek was originally listed in 1988 based on sedimentation attributed to agriculture, roads, and channel instability resulting from channel straightening and alterations.

Physical Condition and Sediment Sources

A channel and fish habitat survey conducted by FWP and USFS in 1996 noted approximately 4,500 feet of the stream channel was eroding and downcutting due to past alterations and land use activities (River Design Group, 2004). Within this section of stream, located approximately 1.5 miles upstream the US Hwy 93 crossing, it was estimated that 7,000 cubic yards of sediment eroded into the channel in response to straightening and realignment in the early 1900s as well as during subsequent downcutting (River Design Group, 2004). This area was targeted for active restoration in 2004 and 2005 by the KRN with support from the landowner, FWP, the USFWS Partners for Wildlife Program, and the Bonneville Power Administration. The restoration project was aimed at restoring the proper channel form and function and reestablishing 55 acres of drained wetlands adjacent to the stream channel. The project involved 9,200 feet of new channel construction, installation of 70 fish habitat structures and planting of 10,000 native shrubs and trees.

A 2002 KNF publication rated the watershed's overall condition as "high concern" based on a combination of sensitivity and disturbance factors and included the road and sensitivity statistics presented below (U.S. Department of Agriculture, Forest Service, 2002).

> Total road density rated as high (> 3.5 mi/mi^2), sensitive land type road density rated as high (> 3.0 mi/mi^2 of sensitive land types within watershed), 0.9 road crossing/mile of road, 3.7 road crossings for mi^2 of watershed (> 3 considered high), 45% total disturbance from roads and harvest (> 40% considered high), 0% detrimental soil disturbance. Riparian road density rated high (> 3.0 mi. road/mi^2 of riparian area considered high), # of road crossings/mile of stream rated moderate at 2.0 crossing/mile of stream, 53% intact riparian rated as high potential for disturbance (< 70% rated as high).

In 2003, DEQ performed a stream reach assessment at a site 1.5 miles from the mouth (K01THRLC10). The assessor noted the substrate was dominated by fine gravels and sand, and noted some disturbance to fish habitat in the lower portion of the reach and sand deposition as limiting spawning habitat. In addition, the surveyors noted significant sediment sources upstream the site and indications of heavy bedload movement. With the exception of some lateral erosion along farmed areas with limited riparian vegetation, bank erosion was minimal and the riparian vegetation was rated as "sustainable."

In 2008, sediment and habitat assessments were completed at two sites on Therriault Creek. The uppermost site (THR 9-5) was located on private property approximately 4 miles upstream of the confluence with the Tobacco River. Impacts within the reach include historic logging within the riparian area. Current logging was noted in the area though proper BMPs were in place and impacts to the

stream were not observed. The stream reach has a potential Rosgen stream type of E4 with a low width/depth ratio and gravel substrate, but the reach is also slightly entrenched in areas resembling a B4a stream type. The reach has a fairly steep slope, poor spawning habitat and marginal pool formation. A few tall eroding banks were observed but most bank erosion was on outside meander bends. Bank erosion sources were cited as logging and natural.

The lowermost full assessment site (THR 14-1) was located on private property approximately 2.5 miles upstream of the confluence with the Tobacco River. At this location, human sediment sources include an undersized failing culvert and historic riparian logging and grazing. Observers noted that new riparian fencing was in place and in good shape. The stream reach is a Rosgen type C4 channel in the upper portion, and resembles an E4 type in the lower section due to a very low width/depth ratio. Aggradation was observed upstream of the failed culvert. Bank erosion at the site was minimal and predominantly limited to outside meander bends. Bank erosion was mostly attributed to natural sources but human sources included rural residences, grazing, and logging.

Comparison to Water Quality Targets

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

Table 5-21. Existing Sediment-Related Data for Therriault Creek relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
THR 14-1	2008	17.4	C4/E4	B4c/C4	15	**11**	7	3	12.8	2.9	1.5	84	396	**27**
THR 9-5	2008	15.6	B4c/E4	B4c/E4	**19**	8	**13**	7	10.6	2.1	1.2	84	808	60
K01THRLC10	2003	--	--	--	**65**	**49**	--	**--**	**--**	--	--	--	--	--

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

Table 5-22. Macroinvertebrate Bioassessment Data for Therriault Creek

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Therriault Creek	K01THRLC10	1.5 mi upstream from mouth	8/11/03	Kick	71.61	1.08
Therriault Creek	FORTINE03	1.5 mi upstream from mouth	8/14/06	Surber	**49.64**	1.08

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

Summary and TMDL Development Determination

The pebble count in 2003 exceeded both percent fine target values, and although pebble count values were quite a bit less in 2008, site THR 9-5 exceeded the riffle pebble count and grid toss targets for fine sediment < 6mm and THR 14-1 exceeded the riffle pebble count target for fine sediment < 2mm. Both sites met the grid toss fine sediment target for pool spawning habitat. This data suggests that excess fine sediment is accumulating in riffles and potentially impacting the aquatic and fishery beneficial use.

However, because part of each assessment reach is an E channel type, which commonly has higher percentages of fine sediment than B and C channels, it is recommended that the fine sediment targets be re-evaluated in the future to determine if they are attainable for Therriault Creek. Both sites met the channel morphology targets. The riparian shrub target was not met for THR 14-1, but based on a review of site notes and other aspects of the greenline assessment, the low shrub cover value is not a concern because the reach had lots of wetland vegetation stabilizing the streambanks and new riparian fencing in place. All other habitat related targets were met.

Macroinvertebrate data collected in Therriault Creek met both targets values at one site but failed to meet the MMI target value at the other site. Although the corresponding O/E value is well above the target (i.e., 0.80), the burrowing taxa at the site are elevated, indicating fine sediment is likely impairing the macroinvertebrates.

Field observations from 2008 document well-maintained near stream BMPs throughout the lower watershed, and the restoration project completed in 2005 addressed a major sediment source and undoubtedly reduced loading to Therriault Creek. Despite these improvements, field observations and recent data also indicate that Therriault Creek is still recovering from the effects of historic logging and grazing practices. Additional controllable human sediment sources that were identified include roads, residential development, and cropland. Because Therriault Creek is still recovering from historic management practices, significant controllable human sediment sources exist, and because of its sensitivity to disturbance, a sediment TMDL will be prepared for Therriault Creek.

5.4.2.8 Tobacco River

The Tobacco River (MT76D004_010) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, the Tobacco River is also listed for physical substrate habitat alterations. The Tobacco River was originally listed in 1988 based on sedimentation and bank erosion attributed to logging, roads, and agriculture. The Tobacco River extends 14 miles from its formation at the confluence of Grave Creek and Fortine Creek to the mouth, at Lake Koocanusa.

Physical Condition and Sediment Sources

Sediment and habitat assessments were performed at four locations throughout the Tobacco River from its headwaters (confluence of Grave and Fortine Creeks) to the mouth. Of these four locations, two were full assessment reaches and two were bank erosion only assessment reaches. The upper most assessment reach (TOB 1-1) was located on private property just downstream the confluence of Grave Creek and Fortine Creek. This reach was influenced by rural residential development and some minor grazing impacts. The stream reach was a Rosgen C4 stream type, but resembles an F4 in areas due to entrenchment. Aerial imagery shows old channel scars and floodplain deposits within the agriculture area to the south of the assessment reach, suggesting that this portion of the Tobacco River has been channelized, which likely contributed to the entrenchment noted above. The reach assessed was a high energy system, with large substrate, and a minimal number of pools, and poor spawning habitat.

The most downstream assessment site (TOB 2-6) was located just upstream of the Highway 37 bridge on private property. Human impacts within this reach include rural residential encroachment with severely eroded streambanks. Surveyors noted a failing bank erosion and flood control project on one eroding bank. The old railroad grade was on river left of the assessment reach. The bottom of the reach is naturally confined between bedrock on both sides of the river, and the river above the site is relatively unconfined though apparently channelized historically from development in the floodplain. The stream channel is a Rosgen type C4 and F4 in areas due to entrenchment. The river appeared to be aggrading

and overwidened in places. Within the reach, surveyors noted multiple transverse bars with high bedload that appears to be partly from the large eroding banks. Riparian vegetation within the reach had been removed in areas and is attributable to historic agriculture and current residential encroachment within the floodplain.

At the two bank erosion sites, streambank erosion is assessed and a qualitative assessment of human impacts is evaluated. The uppermost bank erosion only site (TOB 1-3) was located just downstream of the Tobacco River's confluence with Therriault Creek. This reach is naturally confined against a hillside on river right, while apparently unconfined on river left. That being said, changes in land use within the floodplain have forced the river into its current which has led to channelization. Aerial imagery reveals old channel scars and floodplain deposits within the agriculture area to the south of the assessment reach supporting the prior assertion, and suggesting that entrenchment and bank erosion could be a problem.

The lowermost bank erosion only site (TOB 2-3) was located with the Town of Eureka. The site was located just upstream of the Dewey Avenue bridge. The reach was very confined, with urban impacts to the north and railroad and lumber yard impacts to the south. Lots of riprap exists along the reach to prevent the stream from migrating into its banks. Though confined, surveyors noted that the reach generally has good riffle development, a fair amount of woody debris, and good point bar development, though poor habitat complexity was noted. Salmon were actively spawning in the reach during this assessment. Several tall actively eroding streambanks were observed as well as some slowly eroding banks with good surface protection from cobbles. Bank erosion as attributed to a combination of urban development, roads, and natural sources.

A Master's thesis completed in 2002 reported on stream morphology, riparian conditions, and late summer instream nutrient levels along the Tobacco River, and provided some recommendations for streambank stabilization at one site located approximately one mile downstream the Town of Eureka (Dunn, 2002). During this assessment, Dunn found many large eroding streambanks that appeared to be the result of anthropogenic activities. Sources included cattle grazing and browse of riparian vegetation, channelization and entrenchment from channel manipulations, riparian clearing and failed bank stabilization projects. Accelerated rates of bank erosion were occurring throughout nearly 11% of the study reach, for a total of 422 meters of erosion along 3960 meters of bank. Dunn concluded that the study site was a significant source of human caused sediment and that the site was prime candidate for bank stabilization and riparian restoration.

Though the TMDL process primarily focuses on those activities that are currently impacting the waterbodies in question, it is also important to make note of historic impacts, as they may be still affecting the dimension, pattern and profile of these rivers and streams. In this regard, the Tobacco River has a long history of impacts. Near the turn of the twentieth century the Eureka Lumber Mill was at its earliest stages of production. At that time, logs were floated down the Tobacco during high water. These floats which occurred early in the spring were used to transport hundreds of thousands of logs downstream to the "Big Mill" in Eureka. Historic accounts state that after the first few years, the banks of the Tobacco River were so severely degraded that dams needed to be constructed along the Tobacco in order to produce enough head to float the logs downstream. In 1919, fifty million board feet of timber were floated down the Tobacco River and logs were backed upstream for over 25 miles. The log floats ended in 1924 when the Eureka Mill closed. During this time period, impacts to the geomorphology and aquatic life of the Tobacco River were extensive, and though these activities ended over 85 years ago, the Tobacco River appears to still be in a recovery mode. Impacts often associated

with these types of activities include: Channel scour that homogenizes bed substrates, entrenchment of the stream channel and reduction of the river's ability to access its floodplain leading to increased bank erosion, reductions in pool habitat and quality, and major impacts to aquatic macroinvertebrate communities. Though many of the impacts noted above have recovered, others, such as entrenchment and bank erosion, are still prevalent throughout the river's length.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the Tobacco River (TOB) are summarized in **Table 5-23**. The macroinvertebrate bioassessment data for the Tobacco River is located in **Table 5-24**. All bolded cells represent conditions where target values are not met.

Table 5-23. Existing Sediment-Related Data for Tobacco River Relative to Targets

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% < 6mm	% < 2mm	Riffle % < 6mm	Pool % < 6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
TOB 2-6	2008	84.7	C4/F4	C4	8	6	1	1	**42.3**	**1.8**	2.6	32	106	62
TOB 1-1	2008	75.5	C4/F4	C4	10	**9**	2	5	31.1	4.0	1.6	16	**90**	**38**

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

Table 5-24. Macroinvertebrate Bioassessment Data for the Tobacco River

Stream Name	Station ID	Location	Collection Date	Collection Method	MMI	O/E
Tobacco River	BKK145	0.3 mi u/s from mouth	8/13/92	Kick	77.40	0.88
Tobacco River	FORTINE02	Near confluence of Fortine and Grave creeks	8/15/06	Surber	68.05	0.89
Tobacco River	FORTINE01	0.5 mi u/s from mouth	8/21/06	Surber	66.41	0.88

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

Summary and TMDL Development Determination

During the 2008 assessments, site TOB 1-1 slightly exceeded the pebble count target for fine sediment < 2mm. Data collected during this effort found that the substrate was predominately cobble sized. The lowermost site (TOB 2-6) did not meet either channel morphology target, which was largely a result of the overwidened sections and entrenched sections. The uppermost site below the confluence of Grave and Fortine Creeks did not meet the targets for LWD or greenline shrub cover. A review of the greenline assessment notes indicates the shrub cover target was not met due to historic grazing, but vegetation is recovering and wetland vegetation was observed in some areas.

Of the three macroinvertebrate samples collected on the Tobacco River, all samples met both target values, indicating the macroinvertebrate communities at those sites are not impaired.

Based on the recent data, several sections of the Tobacco River have recovered from the widespread changes largely associated with historic log drives and have good substrate distribution within riffles,

sufficient LWD, and high quality fish spawning and rearing habitat. However, other stressors such as excessive sediment loads from tributaries and channelization, removal of riparian vegetation, and confinement from transportation networks have slowed the system's recovery and contributed to channel entrenchment, streambank instability and erosion, and a reduction in sediment transport capacity. All of these factors are likely limiting the ability of the Tobacco River to fully support fish and aquatic life. Therefore, this information supports the existing 303(d) listings and a sediment TMDL will be written for the Tobacco River.

5.5 TMDL Development Summary

Based on the comparison of existing conditions to water quality targets, eight sediment TMDLs will be developed in the Tobacco TPA. **Table 5-25** summarizes the sediment TMDL development determinations and corresponds to **Table 1-1**, which contains the TMDL development status for listed waterbody segments in the Tobacco TPA on the 2010 303(d) List.

Table 5-25. Summary of TMDL Development Determinations

Stream Segment	Waterbody #	TMDL Development Determination (Y/N)
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	Y
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	Y
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	Y
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	Y
Sinclair Creek*, confluence of un-named tributary, Lat -114.945 Long 48.908, to mouth (Tobacco River)	MT76D004_091	Y
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	Y
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	Y
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	Y

* Sinclair Creek was not on Montana's 2010 303(d) List

5.6 Source Assessment

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

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

EPA sediment TMDL development guidance for source assessments states that the basic source assessment procedure includes compiling an inventory of all sources of sediment to the waterbody and using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (U.S. Environmental Protection Agency, 1999). Additionally, regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR § 130.2(G)). The source assessments evaluated loading from the primary sediment sources using standard DEQ methods, but the sediment loads presented herein

represent relative loading estimates within each source category, and, as no calibration has been conducted, should not be considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. These estimates of percent reduction provide a basis for setting load or wasteload allocations. As better information becomes available and the linkages between loading and instream conditions improve, the loading estimates presented here can be further refined in the future through adaptive management.

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

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

5.6.1 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2008 at the 18 full assessment reaches discussed in **Section 5.3**, but because the results of the field assessment are extrapolated to the listed-segment watershed scale, an additional 14 reaches were assessed for bank erosion to help obtain a representative dataset of existing loading conditions, causes, and the potential for loading reductions associated with improvements in land management practices. Sediment loading from eroding streambanks was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and evaluating the Near Bank Stress (NBS) (Rosgen, 2006) along monitoring reaches in 2008. BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- irrigation-shifts instream energy
- natural sources
- other

Based on the aerial assessment process (described in **Section 5.3**) in which each assessed stream segment is divided into different reaches, streambank erosion data from each 2008 monitoring site was used to extrapolate to the reach scale. Then, the average value for each unique reach category was applied to unmonitored reaches within the corresponding category to estimate loading associated with bank erosion at the stream segment and watershed scales. The potential for sediment load reduction was estimated as a percent reduction that could be achieved if all eroding streambanks could be

reduced to a moderate BEHI score (i.e., moderate risk of erosion). For assessed streambanks already achieving this rate, no reduction was applied. The most appropriate best management practices (BMPs) will vary by site, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream, and the application of riparian BMPs are anticipated to lower the BEHI scores and result in the estimated reductions. It is acknowledged that a moderate risk of erosion may not be achievable for all eroding banks. This is balanced by the recognition that greater reductions in erosion risk might be achievable for other eroding banks.

For bank erosion, some sources are the result of historical land management activities that are not easily mitigated through changes in current management, and they may be costly to restore and have been irreversibly altered. It is also recognized that it is difficult to capture bank erosion linked to historic channel manipulation or flow modifications from past land management, both of which are concerns throughout the Tobacco watershed given the logging and development history discussed in previous sections of this document. Therefore, although the sediment load associated with bank erosion is presented in separate source categories (e.g., transportation, grazing, cropland), the allocation is presented as a percent reduction expected collectively from human sources. A more detailed description of this assessment can be found in *Streambank Erosion Source Assessment,* which is included as **Appendix E**.

Assessment Summary

Based on the source assessment, streambank erosion contributes an estimated 20,684 tons of sediment per year to the Tobacco River TPA. Sediment loads due to streambank erosion range from 433 tons/year in the Therriault Creek watershed to 10,849 tons per year in the Fortine Creek watershed. For the whole watershed, 74% of the sediment load from streambank erosion is attributed to natural sources (no human impacts), while 26% is attributable to human sources. Significant human related sources of streambank erosion include riparian grazing, riparian clearing, hay production, transportation, and historic logging. **Appendix E** contains additional information about sediment loads from eroding streambanks in the Tobacco River TPA by subwatershed, including all that were assessed. **Table 5-26** provides a summary of the bank erosion loads by each watershed where TMDLs are being developed in this document. **Table 5-26** also includes sediment load reduction information based on the application of best management practices. The load reduction approach and associated assumptions are described in **Appendix E**.

Table 5-26. Bank Erosion Results; Estimated Load Reduction Potential and Resulting Modeled Loads after Application of Best Management Practices

Watershed	Total Bank Erosion Load	Load Reduction Potential (% reduction)	Modeled Load After Application of Best Management Practices (tons/year)
Deep Creek	453	13	396
Edna Creek	452	1	446
Fortine Creek	10,849	7	10,109
Sinclair Creek	1,381	25	1,039
Therriault Creek	433	11	386
Lime Creek	530	8	487
Swamp Creek	1,408	7	1,314
Tobacco River	20,684	8	18,946

Appendix D also provides a comparison of bank erosion loads from the Tobacco TMDL assessment from this project to bank erosion loads from the 2003 Grave Creek TMDL source assessment (Montana

Department of Environmental Quality, 2005). While the result from both source assessments are similar, this points out that loading values can vary based on assessment methodology.

Based on field observations, bank erosion sediment loading in the Tobacco watershed includes a significant percentage of sediment that is larger than the fine sediment category of primary concern regarding most of the target parameters evaluated. This is particularly true in watersheds like Grave Creek where bank erosion in the lower reaches includes a significant portion of cobble size material.

5.6.2 Upland Erosion and Riparian Buffering Capacity

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE). Sediment delivery to the stream was predicted using a sediment delivery ratio, taking into account riparian buffering. The USLE results are useful for source assessment as well as for determining allocations to human-caused upland erosion. This model provided an estimate of existing sediment loading from upland sources and an estimate of potential sediment loading reductions that could be achieved by applying best management practices (BMPs) in the uplands and in the near stream riparian area. Because the plant canopy and type of tillage practices can influence erosion, potential load reductions were calculated by adjusting factors within the model associated with land management and cropping practices (C-factors). Additional potential load reductions were estimated by improving the sediment trapping efficiency of the riparian buffer. Riparian health was classified as poor, fair, or good per listed waterbody for both right and left banks during the aerial stratification process described in **Section 5.3** and the improved condition with BMPs in place was represented as 75 percent of the riparian habitat in good condition and 25 percent in fair condition. Ground cover values and BMP implementation for both scenarios (i.e., existing and potential reductions) were based on literature values, stakeholder input, and field observations. It is acknowledged that ground cover values and BMP implementation are variable within land use categories throughout the watershed and over time, but due to the scale of the model, values for ground cover were assumed to be consistent throughout each land use category and throughout the year. Additionally, it is important to note that a significant portion of the remaining sediment loads after BMPs in areas with agricultural and/or transitional land-uses is also a component of the “natural upland load”, but the assessment methodology did not differentiate between sediment loads with all reasonable BMPs and “natural” loads where there were no human influences.

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

Assessment Summary

Based on the source assessment, upland erosion contributes approximately 2,297 tons per year to the Tobacco River TPA. This includes assessed loading from the Grave Creek watershed to the Tobacco River. The assessment indicates that rangeland grazing and hay production within the near stream riparian buffer are the most significant contributors to accelerated upland erosion. Sediment loads due to upland erosion range from 35 tons/year in the Lime Creek sub-watershed to 1,106 tons/year in the Fortine Creek watershed. Since this assessment was conducted at the watershed scale, it is expected

that larger watersheds will have greater sediment loads. A significant portion of the sediment load due to upland erosion is contributed by natural sources. **Appendix F** contains additional information about sediment loads from upland erosion in the Tobacco River TPA by subwatershed, including all 6th code HUCs in the TPA. In order to facilitate reporting of the upland sediment loading information following the allocation strategy specific to this source category the data from each sub-watershed located in the appendix was further manipulated by:

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

Table 5-27 below reports the final loading information for those watersheds that will have TMDLs developed for them.

Table 5-27. Existing Upland Sediment Loads by Watershed Incorporating both Upland and Riparian Conditions.

Watershed	Watershed Area (acres)	Estimated Existing Upland Sediment Load (tons/year)	Normalized Upland Sediment Load (tons/year/acre)
Deep Creek	11,803	168	0.0138
Edna Creek	14,502	99	0.0067
Fortine Creek	158,448	1,106	0.0070
Sinclair Creek	7,827	76	0.0096
Therriault Creek	12,937	101	0.0078
Lime Creek	6,148	35	0.0057
Swamp Creek	27,986	252	0.0090
Tobacco River	277,067	2,297	0.0083

Appendix F also provides an evaluation of potential load reduction using land cover improvement BMPs along with riparian improvement BMPs. Total potential load reductions and resulting loads after applying the BMP reductions are summarized in **Table 5-28**. This information can be used as a basis for setting TMDL load allocations.

Table 5-28. Estimated Load Reduction Potential and Resulting Modeled Loads after Application of Best Management Practices

Watershed	Estimated Existing Upland Sediment Load (tons/year)	Estimated Load Reduction Potential (% reduction)	Modeled Load After Application of Best Management Practices (tons/year)
Deep Creek	168	16	141
Edna Creek	99	35	64
Fortine Creek	1,106	30	778
Sinclair Creek	76	37	48
Therriault Creek	101	34	67
Lime Creek	35	29	25
Swamp Creek	252	37	160
Tobacco River	2,297	31	1585

5.6.3 Road Sediment Assessment

5.6.3.1 Erosion from Unpaved Roads

Sediment loading from unpaved roads was assessed using GIS, field data collection, and sediment modeling. Each identified unpaved road crossing and near-stream road segment was assigned attributes for road name, surface type, road ownership, stream name, subwatershed, and landscape type (i.e., mountain, foothill, or valley). Fifty crossings and 10 near-stream parallel segments representing the range of conditions within the watershed were field assessed in 2008, and sediment loading was estimated using the Water Erosion Prediction Project Methodology (WEPP:Road). The average sediment contribution from unpaved road crossings and near-stream road segments were extrapolated to all unpaved roads in the watershed based on landscape type. To address sediment from unpaved roads in the TMDLs and allocations that follow in **Section 5.7**, the WEPP:Roads analysis was also run using BMPs to reduce the road contributing length to 200 feet. The 200-foot BMP scenario is used in this document as a general approximation of achievable modeled loading reduction to help develop the road crossing allocations. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. Other potential BMPs include the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting. A more detailed description of this assessment can be found in **Appendix G**.

Assessment Summary

Based on the source assessment, unpaved roads are contributing 98 tons of sediment per year to the Tobacco River watershed. This includes 78 tons from unpaved road crossings and 9 tons per year from parallel unpaved road segments for the Tobacco TMDL planning area; plus an additional 11 tons per year from unpaved road crossings and parallel segments in the Grave Creek watershed. Sediment loads range from < 1 ton/year in the Sinclair Creek watershed to 72.4 tons/year in the Fortine Creek watershed. Factors influencing sediment loads from unpaved roads at the watershed scale include the overall road density within the watershed, watershed size, and the configuration of the road network, along with factors related to road construction and maintenance. **Table 5-29** contains annual sediment loads from unpaved roads (crossings & parallel segments) from the watersheds where TMDLs are developed within this document. **Table 5-29** also includes the percent load reduction by watershed based on the contributing road length BMP scenario which is further defined within **Appendix G**.

When evaluated by ownership for the Tobacco River watershed, the load per crossing after extrapolation was about the same for federal and private crossings. However, because of the higher number of federal crossings, the total load breakdown was about 51 tons/year for federal crossings and 23 tons/year for private crossings. The resulting reduction in sediment loading, when extrapolated by ownership and landscape type, was also similar for road crossing ownership, with a resulting 56% reduction for federal roads and a 58% reduction for private roads. Only one state road crossing was evaluated and therefore state roads are not included in this comparison.

Table 5-29. Annual Sediment Load (tons/year) from Unpaved Roads (Crossings + Parallel Segments) within the Tobacco River Watershed.

Watershed	Total Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
Deep Creek	**2.4**	**50%**	**1.2**
Edna Creek	**9.3**	**57%**	**4.0**
Fortine Creek	**74.1**	**56%**	**32.6**
Lime Creek	**3.9**	**56%**	**1.7**
Sinclair Creek	**0.7**	**57%**	**0.3**
Swamp Creek	**9.1**	**57%**	**3.9**
Therriault Creek	**2.9**	**52%**	**1.4**
Tobacco River Watershed	**98**	**57%**	**42.1**

5.6.3.2 Road Sand Contribution and Assessment Summary

An estimate of road sand contribution from paved road crossings and paved parallel segments is provided in **Appendix G**. The final load determination is based on state and county application rates and an assumed delivery percentage based on similar analyses from previous TMDL documents. The estimated road sand load throughout the watershed was 16 tons/year prior to 2008 and 11 tons/year after 2008. A reduction analysis for this 11 tons/year is not pursued for allocation purposes for the reasons identified below.

- Road sanding plays an important driving safety role
- The sediment load is significantly low in comparison to loads from unpaved roads
- Significant application rate reductions have already been achieved for state roadways by the transition from road sand to road salt.

5.6.3.3 Culvert Failure and Fish Passage Analysis

Undersized or improperly installed culverts may be a chronic source of sediment to streams or a large acute source during failure, and they may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for a subset of culverts. The flow capacity culvert analysis was performed on 47 culverts and incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g., 2, 5, 10, 25, 50, and 100 year) and measurements for each culvert to estimate its capacity and amount of fill material.

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

Fish passage assessments were performed on 8 culverts. The assessment was based on the methodology defined in **Appendix G**, which is geared toward assessing passage for juvenile salmonids.

Considerations for the assessment include streamflow, the culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e., culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish passage barriers and those that need a more in-depth analysis. Culverts with fish passage concerns may have elevated road failure concerns since fish passage is often linked to undersized culvert design.

Assessment Summary
More than half of culverts (57%) were estimated to pass the Q100 event. However, there were 18 culverts (38%) that did not pass the Q25 design flow. For the federal crossings, 69% passed the Q25 and 66% passed the Q100, whereas only 36% of the private crossings passed the Q25 and only 27% passed the Q100. Many of the private crossings did not even pass the 2, 5 or 10 year flow events, indicating a significant culvert failure risk for this category of culverts. On the other hand, it appears that the Forest Service (federal) crossings are being managed in a manner consistent with the Inland Native Fish Strategy (U.S. Department of Agriculture, Forest Service, 1995a) recommendation that as old culverts are replaced, new culverts should be designed to pass the 100-year flow event.

For the fish passage assessment, 4 out of 8 culverts were determined to pose a significant passage risk to juvenile fish at all flows and 4 were determined to need additional analysis.

5.6.4 Point Sources

As of January 1, 2011, permitted point sources within the Tobacco River watershed consist of:

- Eureka Sewage Treatment Facility (MTG580032),
- Timberline Ready Mix (MTR300259), and
- Six general permits for construction stormwater

5.6.4.1 Eureka Sewage Treatment Facility (MTG580032)

The Eureka Sewage Treatment Facility is a 3-celled aerated wastewater treatment lagoon system with a design capacity of 0.35 million gallons per day (MGD). The facility is authorized under the General Permit for Domestic Sewage Treatment Lagoons (MTG580000), which has a 7-day average total suspended solids (TSS) concentration limit of 135 mg/L and a 30-day average TSS concentration limit of 100 mg/L. Like most wastewater discharge, the suspended solids in the effluent are likely predominantly organic matter and not sediment. According to the permit file, the facility does batch discharges and conducts monitoring prior to discharging. Based on Discharge Monitoring Reports submitted by the facility, 29 TSS samples were collected from 2001 through January 2011 and none exceeded 100 mg/L. The highest concentration was 98 mg/L in 2002 but all other samples were equal or less than 25 mg/L. A conservative calculation of the existing load was made by assuming an average daily discharge of 0.25 mgd, which is the maximum measured discharge in the permit file, at a TSS concentration of 25 mg/L. This would result in an annual load of 9.5 tons.

The maximum allowable permit values can be used to evaluate impact to the Tobacco River by evaluating the potential increase in TSS loading to Tobacco River from the Eureka discharge. Based on unpublished water quality chemistry and flow data collected by DEQ in 2008, a typical low flow for the Tobacco River is about 50 cfs, and a typical TSS value during low flow is about 1 mg/l or less. The Eureka facility design capacity discharge of 0.35 MGD is approximately 0.5 cfs. If the Eureka facility was discharging with a TSS concentration of 135 mg/l into the Tobacco River when the Tobacco River was flowing at 50 cfs, the result would be an increase in TSS concentration in the Tobacco River from 1 mg/l to 2.3 mg/l. Although this represents more than a doubling of the TSS concentration, 2.3 mg/l

represents an acceptably low level that is not expected to cause harm to aquatic life (Newcombe and Jensen, 1996) nor is it expected to result in aesthetic concerns.

5.6.4.2 Timberline Ready Mix (MTR300259)

The Timberline Ready Mix facility is authorized under the General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities (MTR300000). The permit (MTR300259) includes a Storm Water Pollution Prevention Plan (SWPPP) and requires biannual reporting of discharge monitoring data. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in stormwater discharges. DEQ conducted an inspection of the 12.3 acre site in May 2010 and concluded the SWPPP was being followed. According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general storm water permit, the benchmark value for TSS is 100 mg/l. The facility is designed to capture a minimum of a 2-year one hour storm as part of their SWPPP. There has been no measurable offsite runoff according to the facility operator. Therefore, the existing annual sediment load is likely zero tons or very close to no loading during most years with normal or average precipitation events.

To provide a numeric estimate of the potential yearly sediment load to the Tobacco River from the Timberline Ready Mix, the Soil Conservation Service curve number (CN) methodology (U.S. Department of Agriculture, Soil Conservation Service,1972) was used to relate precipitation events to runoff. Because infiltration capacity varies as a function of landcover condition and soil type, the CN equation presents a way to relate precipitation to rainfall excess or runoff. Precipitation-runoff estimates for this calculation assume that no run-on from upgradient contributing areas occurs and also do not account for rain-on-snow or other precipitation events which may increase water availability. Necessary model parameters were derived from information in the site permit, and a composite curve number of 61 was used in the analysis based on the various landcover types at the site (e.g., paved areas/buildings, gravel, and grass/rangeland) and hydrologic B soil (which was verified in STATSGO). No efforts were made to validate any of the information presented in the permit file.

Based on application of the CN procedure, site runoff does not occur until 1.26 inches of precipitation is received for a given precipitation event. Based on the lack of site runoff (and no resulting Discharge Monitoring Report data), this seems like a reasonable estimate. Runoff volumes were modified to reflect the 200 ft^3 swale mentioned in the permit file. As shown in **Table 5-30**, site runoff was determined for precipitation depth intervals ranging from 1.26 - 3 inches. For intermediate values, the equation of the line can be used by as follows to determine the runoff volume:

Runoff volume (cfs) = $-0.011x^3 + 0.1482x^2 – 0.318x + 0.1873$
x = Precipitation (inches)

As shown in the equation below, the potential daily load was calculated based on the computed site runoff volumes and the site runoff target concentration. The target concentration is based on the 100 mg TSS/L benchmark value provided in the general permit. Because runoff should not be generated from the site until 1.26 inches of precipitation, the load estimate is set = 0 until precipitation equals 1.26 inches or more for a given event. In a review of precipitation data for the Eureka Ranger Station, only about 9 days with precipitation greater than 1.26 inches have been recorded since 1960, with no daily precipitation greater than 2 inches. The potential loads at different precipitation events are included in **Table 5-30** and **Figure 5-4**. A conservatively high yearly load estimate can be based on two 2-inch precipitation events per year, which would result in a load of about 60 lbs or 0.03 tons. This is a very

small load that would rarely occur, if ever, as long as the BMPs identified in the permit are maintained consistent with this analysis.
Daily Load Estimate = Target Concentration (mg/L) * Runoff Volume (cfs) * 5.4 conversion factor

Table 5-30. Estimated Timberline Ready Mix site runoff for precipitation up to 3 inches

Precipitation (in)	Runoff Volume (cfs)	Load (lbs/day)
<1.26	0	0.00
1.50	0.002	3.54
1.75	0.016	13.94
2.00	0.039	30.47
2.25	0.068	52.49
2.50	0.104	79.45
2.75	0.146	110.89
3.00	0.194	146.37

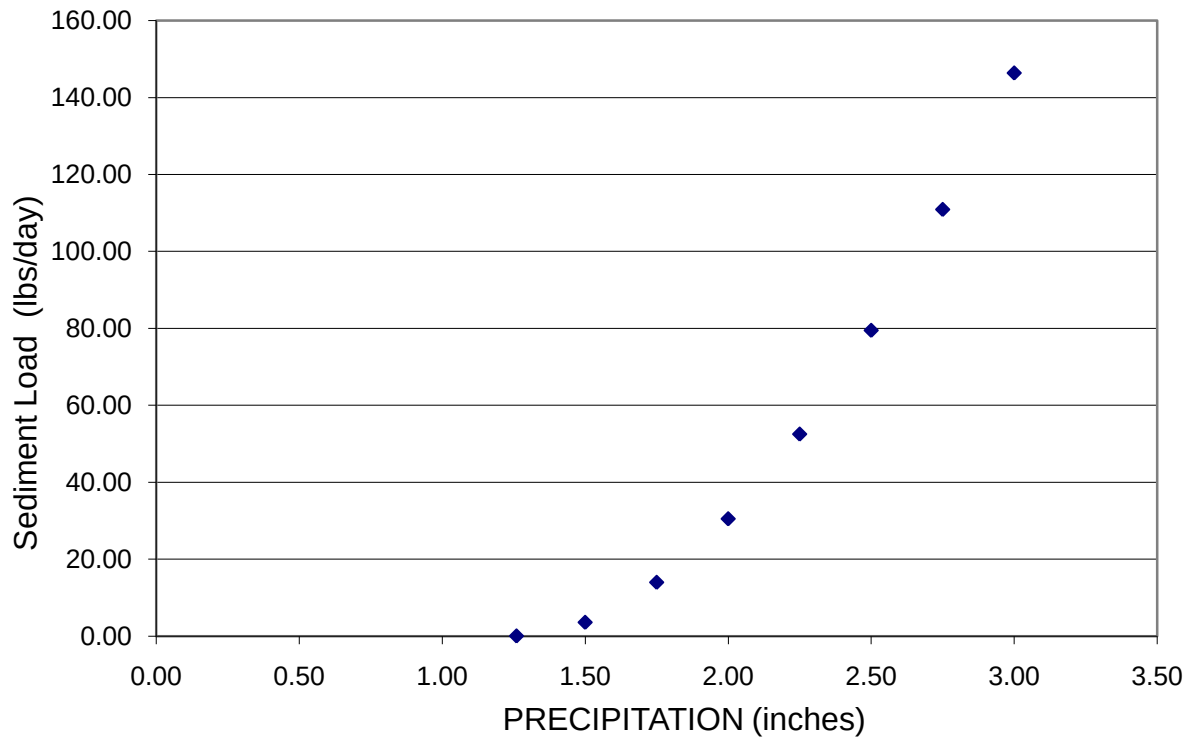

Figure 5-4. Sediment load as TSS with different amounts of precipitation

5.6.4.3 Construction Storm Water Permits

All construction storm water permits were authorized under General Permit MTR100000. As of January 1, 2011 there were six of these permits within the Tobacco TMDL planning area. One of the permits is for a construction project in the Sinclair Creek watershed and the remaining five permits are for construction projects within the Tobacco River watershed in the vicinity of Eureka. Because TMDLs are allocated to the watershed scale, all permitted construction project loading within the Tobacco River watershed will be evaluated cumulatively to facilitate development of a composite wasteload allocation. Collectively, these areas of severe ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained.

Each permittee is required to develop a SWPPP that identifies the stormwater BMPs that will be in place during construction. Prior to permit termination, disturbed areas are required to have a vegetative density equal to or greater than 70 percent of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required, and although Montana storm water regulations provide the authority to require stormwater monitoring, water quality sampling is typically not required (Heckenberger, Brian, personal communication 2009).

To assess the disturbed acreage associated with construction storm water permits, each permit file was evaluated. The construction project in the Sinclair Creek watershed was anticipated to disturb 3 acres and the other permitted projects were anticipated to disturb approximately 64 acres. Most of the disturbance (i.e., 40 acres) is associated with a golf course (MTR102204) in the Indian Creek drainage (Indian Creek flows into the Tobacco River). The permit applicant noted that no site runoff was anticipated because of swales and detention ponds on-site. BMPs at other sites include settling basins, straw bales, silt fences, and re-vegetating with a NRCS seed mix.

Two approaches were used to estimate sediment loading from permitted construction sites. The first approach provides an estimate of the sediment loads if inadequate BMPs were in place. The second approach then provides an estimate of the sediment loads with BMPs in place, consistent with storm water construction permit expectations. Loads from both approaches were derived using the output from the upland erosion assessment (**Section 5.3.2** and **Appendix F**). Construction sites have the potential to have C-factors ranging from 0.3 to 1 (Toy and Foster, 1998; Pudasaini, et al., 2004; Sinha and Labi, 2007), with variability associated with soil type and slope, stage of construction, and level of BMP implementation. To estimate impacts from a site with inadequate BMPs, the existing annual erosion rate normalized per acre for the Tobacco River watershed for cultivated crops was tripled to represent construction sites with some ground cover but inadequate BMP implementation (i.e., approximate C-factor = 0.72), resulting in an erosion rate of 0.06 tons/acre/year. This value is then multiplied by the disturbed acreage associated with construction storm water permits, resulting in 0.18 tons/year (0.06 * 3 acres = 0.18) for the Sinclair Creek watershed and about 4.0 tons for the Tobacco River watershed (0.06 * 64 acres = 3.8).

To estimate impacts from these same sites with BMPs in place, the loading rate associated with implementation of upland and riparian BMPs from the cultivated crops category used in **Appendix F** was used as an equivalent condition. This loading rate is equal to 0.013 tons/acre/year and equates to a C-factor of 0.013, representing approximately 80 percent groundcover. This loading rate is then multiplied by the disturbed acreage resulting in a load of 0.04 tons/year for the Sinclair Creek watershed and 0.83 tons/year for the Tobacco River watershed. These lower values represent the estimated existing loads from permitted construction sites based on the assumption that appropriate BMPs are in place and being properly maintained. The above analysis resulted in an approximate 80% reduction in sediment loading with BMPs, and thus provides an example of how BMPs required under storm water permits can result in significantly reduced sediment loading to a waterbody.

5.6.5 Source Assessment Summary

The estimated annual sediment load from all identified sources throughout the Tobacco River Watershed is 23,101 tons. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, due to the uncalibrated nature of the source assessment work and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate

source impacts within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus waters quality restoration activities in the Tobacco TMDL planning area by indicating the relative contribution of different subwatersheds or landcover types for that source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendices E**, **F**, and **G**).

5.7 SEDIMENT TMDLS AND ALLOCATIONS

This section is organized by the following topics:

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

5.7.1 Application of Percent Reduction and Yearly Load Approaches

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

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

5.7.2 Development of Sediment Allocations by Source Categories

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

of the sources deliver sediment to tributaries that then deliver this sediment load to the impaired waterbodies.

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

The following subsections discuss specific allocation details and rationale for each sediment source category.

5.7.2.1 Streambank Erosion

Sediment loads associated with bank erosion were identified by separate source categories (e.g., transportation, grazing, natural) in **Appendix E**. Because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding impacts from historical land management activity, all human caused sources of bank erosion were combined for the purpose of determining the potential sediment load reductions. The reduction approach applied in **Appendix E** assumed that, on average, the application of BMPs along streams could reduce human caused bank erosion by 33%. Because this reduction is only applied to the human caused portion of bank erosion, estimated at 26% for the Tobacco watershed, the percent reductions in total bank erosion loading is significantly lower for each stream of interest depending on the extent of human-caused versus natural (or non-human caused) streambank loading within each watershed.

Streambank stability and erosion rates are largely a factor of the health of vegetation near the stream, and the reduction in bank erosion risk and sediment loading is expected to be achieved by applying BMPs within the riparian zone. These riparian protection BMPs are further defined and discussed within **Section 6**.

5.7.2.2 Upland Erosion

Allocations for upland sediment sources were derived by modeling the reduction in sediment loads that can occur via upland erosion prevention BMPs such as increasing ground cover, and combining these reductions with reduced sediment transport that could be achieved via BMPs to improve riparian and stream buffering conditions. No reductions were allocated to natural sources, which are a significant portion of all upland land use categories, especially the “forest” category.

The load reductions from “agriculture,” “range” and “other” land use categories include a combination of increased application of upland erosion prevention and riparian health improvement BMPs. No reduction from upland erosion prevention BMPs is applied the “forest” land use category based on the assumption that logging or silviculture activities will continue on public and private forest land within the watershed, and these activities will be in adherence to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) law (77-5-301 through 307 MCA). A percent reduction is applied to the “forest” category based on riparian and stream buffering improvements over time since grazing and historical riparian harvest have impacted riparian health and stream buffering capacity in many locations. Because of the application of SMZ law

in recent years, most of the action necessary to eventually meet the "forest" portion of the upland erosion allocation has been implemented.

The allocation to upland sources includes application of BMPs to present land use activities as well as recovery from past land use influences such as riparian harvest. For all upland sources, the largest percent reduction is achieved via riparian improvements. Upland erosion and riparian improvement BMPs are further defined and discussed in **Section 6**.

5.7.2.3 Roads

Roads allocations are addressed by different sediment loading categories including erosion from unpaved crossings and unpaved parallel segments, road sand application, and road culvert or road crossing failure from flood events.

5.7.2.3.1 Unpaved Roads (Crossings and Parallel Segments)

The percent reduction allocation for unpaved roads is derived from modeling the reduction in road contributing length for those roads where the contributing erosion length was greater than 200 feet. The 200-foot BMP scenario is used in this document as a general approximation of achievable modeled loading reduction to help develop the road crossing allocations; at some locations a shorter contributing length can be obtained via BMP application, and at other locations it may not be feasible. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading and to eliminate the discrete conveyance of sediment loads to streams from the lack of erosion prevention BMPs. Other potential BMPs include the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting. A more detailed description of the road assessment and reduction analysis can in **Appendix G**.

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

Although the **Appendix G** analysis evaluated roads by ownership (private, federal, state), allocations were not apportioned between ownership given the similarities in percent reductions. For example, when extrapolated by ownership and landscape type, the resulting reduction in sediment based on the 200-foot BMP application resulted in a 56% reduction for federal roads and a 58% reduction for private roads. Only one state road crossing was evaluated and therefore state roads are not included in this comparison. Nevertheless, road owners within any ownership category can demonstrate that they are meeting the allocation via application, documentation, and maintenance of the appropriate BMPs at road crossings and parallel segments.

5.7.2.3.2 Road Sanding

An estimate of road sand contribution from paved road crossings and paved parallel segments is provided in **Appendix G**. A reduction analysis is not pursued for allocation purposes for the reasons identified below.

- Road sanding plays an important driving safety role

- The sediment load is significantly low in comparison to loads from unpaved roads
- Significant application rate reductions have already been achieved for state roadways by the transition from road sand to road salt.

The resulting road sand load estimate of 11 tons/year is applied to the Tobacco River versus the individual tributaries because of the small load and variable application of the road sand throughout the watershed. In essence, the load allocation for the Tobacco River and any tributaries with road sanding is no increased loading unless the increase represents an important safety precaution and any new paved road design incorporates sediment delivery BMPs where practical.

5.7.2.3.3 Road Crossing Culverts

Though culvert failure represents a potential load of sediment to streams, a yearly load was not estimated due to its sporadic nature and uncertainty regarding estimating the timing of such failures. A common BMP for culverts is designing them to accommodate the 25-year storm event; this design capacity is specified as a minimum in both the Montana stream permitting guidance for conservation district supervisors and others, and Forestry BMPs for Montana (Montana State University, Extension Service, 2001), and it is typically the minimum used by the USFS. However, other considerations such as fish passage, the potential for large debris loads, and the level of development and road density upstream of the culvert or within the watershed of interest should also be taken into consideration during culvert installation and replacement, and may necessitate the need for a larger culvert. For instance, the USFS typically designs culverts to pass the 100-year event and be suitable for fish and aquatic organism passage on fish bearing streams (U.S. Department of Agriculture, Forest Service, 1995a).

The individual or cumulative impacts from historic culvert failures may be contributing to the existing water quality impairment conditions, and future failures could lead to sediment impairment problems not identified or quantified during the 2008 assessment work. Therefore, a watershed scale load allocation is developed for culverts at road crossings. The culvert allocation is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. At a minimum, culverts should meet the 25-year event. Meeting the 100-year event is recommended for fish-bearing streams or those watersheds with a high road density, an existing high number of undersized culverts (e.g., those that cannot pass a 25-year or smaller event), or high level of road and impervious surface development upstream. Furthermore, new crossings and culvert replacements must be completed in a manner that allows for fish passage on fish bearing streams unless the Montana Fish Wildlife and Parks and/or the US Fish and Wildlife Service determines that prevention of fish passage is desirable for native species protection.

Upgrading culverts to meet this allocation is an important sediment reduction and water quality improvement goal because a large flow event could lead to significant sediment loading based on the large percentage of culverts that cannot pass a 25-year event per the **Appendix G** analysis. In fact, many culverts throughout the watershed do not appear large enough to even pass flows as common as 2-year, 5-year and 10-year events, particularly for the privately owned crossings.

5.7.2.4 Permitted Point Sources

There are several Montana Pollutant Discharge Elimination System (MPDES) permitted point sources that can contribute sediment loading to streams in the Tobacco watershed. These include a wastewater treatment lagoon permit for the Eureka Sewage Treatment Facility (permit number MTG580032) that

discharges into the Tobacco River; an industrial storm water permit for Timberline Ready Mix (permit number MTR300259) that is within the Tobacco River watershed near Eureka; and 6 general permits for construction storm water as of January 1, 2011; including one large acreage within Sinclair Creek watershed and the remaining five within the Tobacco River watershed near Eureka. The following subsections define the rationale used to develop the wasteload allocations (WLAs) for these permits.

5.7.2.4.1 Eureka Sewage Treatment Facility

One option for developing the WLA for the Eureka Sewage Treatment facility (**WLA_{EUREKA}**) is to base the WLA on the current load limit in its permit. This can be calculated using the facility's existing nondegradation permit limit (Montana Department of Environmental Quality, Permitting and Compliance Division,1999) which is based on a discharge of 0.225 mgd (0.35 cfs) and a 30-day average TSS permit concentration limit of 100 mg/L. This equates to 188 lbs/day, or 34.2 tons/year. The potential impact from the permitted discharge was evaluated in **Section 5.6** where it was determined that a higher load than this permit load would not cause a negative impact on Tobacco River water quality.

Therefore, the 34.2 tons/year load based on the existing permit is an acceptable value to use as the **WLA_{EUREKA}** and it only applies to the Tobacco River TMDL.

5.7.2.4.2 Timberline Ready Mix Industrial Storm Water Permit

The permit for Timberline Ready Mix is an industrial storm water permit, and thus, the facility does not have a regular discharge. The WLA for Timberline Ready Mix is developed using a loading analysis based on existing BMPs, land cover, precipitation, and runoff modeling that was performed as part of the facility's source assessment in **Section 5.6.4**. The analysis resulted in conservatively high load estimate of 0.03 tons/year (60 lbs/year). This is an acceptable loading level that will be used to represent the numeric wasteload allocation (**WLA_{TRM}**) for the Timberline Ready Mix facility.

The WLA_{TRM} only applies to the Tobacco River TMDL. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add an additional permit load limit requirement; instead it is assumed that the **WLA_{TRM}** will be met by adherence to the permit requirements, which include a SWPPP with numerous BMPs. Because of the very small load from this site, it is assumed that future industrial facilities located anywhere in the Tobacco River watershed will have insignificant loading to any impaired stream as long as similarly protective BMPs are incorporated into each storm water permit.

5.7.2.4.3 Construction Storm Water Permits

The loading estimate (**Section 5.6.4.3**) for permitted construction stormwater sources is based on the upland erosion assessment with appropriate BMPs in place. For the Sinclair Creek watershed, the construction load estimate was 0.04 tons/year based on one permitted site with 3 acres of disturbance. For the Tobacco River watershed, the construction load estimate was 0.83 tons/year based on 6 permitted sites with 64 acres of disturbance. These values are used to develop the construction stormwater WLAs.

Individual WLAs are not provided for each construction site; instead composite construction stormwater WLAs are provided for each stream consistent with EPA guidance (U.S. Environmental Protection Agency, 2008). Since the current number of permits and amount of disturbed acreage represents a snapshot in time, the composite WLA is based on a conservative approach of assuming an increase in permitted construction sites and associated disturbed acreage with BMPs in place; up to 50 acres of disturbance in the Sinclair Creek watershed and up to 400 acres of disturbance in the Tobacco River

watershed. This results in a composite WLA equal to 0.7 tons/year for the Sinclair Creek watershed, and a composite WLA equal to 5.3 tons/year for the Tobacco River watershed. These WLAs are intended to address existing and future permits. The WLA is provided because it is a requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the WLA will be met by adherence to the General Permit requirements (MTR100000), which include a SWPPP with numerous BMPs and site stabilization before a permit can be terminated. If disturbed acreages exceed the amount used to calculate the WLA, the intent of the allocation may be met by adhering to permit requirements, including SWPPP development and implementation.

The Tobacco River composite WLA can be further apportioned among the impaired streams with sediment TMDLs, providing allowance for future growth in construction permits throughout the watershed as long as the each site owner develops and follows a SWPPP consistent with General Permit requirements. It is estimated that at any one time construction within most drainages would have a small load consistent with the Sinclair Creek construction stormwater composite WLA.

5.7.3 Allocations and TMDLs for Each Stream

The following subsections present of the existing quantified sediment loads, allocations and TMDL for each waterbody.

5.7.3.1 Deep Creek

Deep Creek was listed as impaired due to sedimentation/siltation on the 2010 303(d) List. Sediment sources assessed and quantified within the Deep Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment to Deep Creek identified during this assessment include roads/transportation, grazing, cropping, silviculture and “other,” which refers to channel obstructions from historic mining.

The current annual sediment load from the assessed sources is estimated at 623 tons/year (**Table 5-31**). By applying BMPs, this sediment load to the Deep Creek watershed could be reduced to 538 tons/year. To achieve this reduction, a 50% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. A 13% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 16% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Deep Creek is expressed as a 14% reduction in the total average annual sediment load.

Deep Creek also has a habitat alteration type of impairment specifically defined as an *alteration in streamside or littoral vegetative covers*. This impairment cause is not a pollutant and does not require TMDL development. The solutions to this habitat problem are included within the water quality protection and improvement activities that must be pursued to meet the Deep Creek sediment TMDL and associated allocations. Therefore, the Deep Creek sediment TMDL addresses both the sediment impairment as well as this habitat alteration impairment.

Table 5-31. Quantified Sediment Loads, Allocations and TMDL for Deep Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**2**	**1**	**50%**
Streambank Erosion	Human Caused	174	117	33%
	Natural Background	279	279	0%
	Total	**453**	**396**	**13%**
Upland Sediment Sources	Forest	133	115	14%
	Range	23	19	14%
	Agriculture	7	4	44%
	Total	**168**	**141**	**16%**
Total Sediment Load		**623**	**538**	**TMDL = 14% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4**.
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.2 Edna Creek

Edna Creek was listed as impaired due to sedimentation/siltation on the 2010 303(d) List. Sediment sources assessed and quantified within the Edna Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, riparian clearing, and hay production.

The current annual sediment load from the assessed sources is estimated at 560 tons/year (**Table 5-32**). By applying BMPs, this sediment load to the Edna Creek watershed could be reduced to 514 tons/year. To achieve this reduction, a 57% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. A 1% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 35% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Edna Creek is expressed as an 8% reduction in the total average annual sediment load.

Table 5-32. Quantified Sediment Loads, Allocations and TMDL for Edna Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**9**	**4**	**57%**
Streambank Erosion	Human Caused	19	13	33%
	Natural Background	433	433	0%
	Total	**452**	**446**	**1%**
Upland Sediment Sources	Forest	71	46	34%
	Range	25	17	34%
	Agriculture	1.1	0.5	57%
	Total	**99**	**64**	**35%**
Total Sediment Load		**560**	**514**	**TMDL = 8% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4**.
Sediment loads greater than 1 ton were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.3 Fortine Creek

Fortine Creek was listed as impaired due to sedimentation/siltation on the 2010 303(d) List. Sediment sources assessed and quantified within the Fortine Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, and hay production.

The current annual sediment load from the assessed sources is estimated at 12,029 tons/year (**Table 5-33**). By applying BMPs, this sediment load to the Fortine Creek watershed could be reduced to 10,920 tons/year. To achieve this reduction, a 56% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. A 7% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 30% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Fortine Creek is expressed as a 9% reduction in the total average annual sediment load.

Fortine Creek also has a habitat alteration type of impairment specifically defined as an *alteration in streamside or littoral vegetative covers*. This impairment cause is not a pollutant and does not require TMDL development. The solutions to this habitat problem are included within the water quality protection and improvement activities that must be pursued to meet the Fortine Creek sediment TMDL and associated allocations. Therefore, the Fortine Creek sediment TMDL addresses both the sediment impairment as well as this habitat alteration impairment.

Table 5-33. Quantified Sediment Loads, Allocations and TMDL for Fortine Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**74**	**33**	**56%**
Streambank Erosion	Human Caused	2,243	1,503	33%
	Natural Background	8,606	8,606	0%
	Total	**10,849**	**10,109**	**7%**
Upland Sediment Sources	Forest	803	576	28%
	Range	265	183	31%
	Agriculture	33	16	52%
	Other	5	3	40%
	Total	**1,106**	**778**	**30%**
Total Sediment Load		**12,029**	**10,920**	**TMDL = 9% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4**.
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.4 Lime Creek

Lime Creek was listed as impaired due to sedimentation/siltation on the 2010 303(d) List. Sediment sources assessed and quantified within the Lime Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, and riparian vegetation removal.

The current annual sediment load from the assessed sources is estimated at 569 tons/year (**Table 5-34**). By applying BMPs, this sediment load to the Lime Creek watershed could be reduced to 514 tons/year. To achieve this reduction, a 56% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. An 8% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 29% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Lime Creek is expressed as a 10% reduction in the total average annual sediment load.

Lime Creek also has a habitat alteration type of impairment specifically defined as an *alteration in streamside or littoral vegetative covers*. This impairment cause is not a pollutant and does not require TMDL development. The solutions to this habitat problem are included within the water quality protection and improvement activities that must be pursued to meet the Lime Creek sediment TMDL and associated allocations. Therefore, the Lime Creek sediment TMDL addresses both the sediment impairment as well as this habitat alteration impairment.

Table 5-34. Quantified Sediment Loads, Allocations and TMDL for Lime Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**4**	**2**	**56%**
Streambank Erosion	Human Caused	130	87	33%
	Natural Background	400	400	0%
	Total	**530**	**487**	**8%**
Upland Sediment Sources	Forest	33	23	30%
	Range	2.1	1.5	30%
	Total	**35**	**25**	**29%**
Total Sediment Load		**569**	**514**	**TMDL = 10% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4.**
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.5 Sinclair Creek

Sinclair Creek was not on 2010 303(d) List, but it was added to the scope of this project based on stakeholder concerns. The source assessment indicates excess sediment associated with human sources is likely impairing beneficial use support and a TMDL is presented here. Sediment sources assessed and quantified within the Sinclair Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, grazing, and construction.

The current annual sediment load from the assessed sources is estimated at 1,459 tons/year (**Table 5-35**). By applying BMPs, this sediment load to the Sinclair Creek watershed could be reduced to 1,088 tons/year. To achieve this reduction, a 57% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. A 25% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. No reduction is applied to the construction activity based on the assumption that erosion prevention requirements within the construction permit are being met and will continue to be met. Instead, the construction WLA includes an increase in loading in recognition of potential future growth along with continued application of required storm water permit BMPs. Sediment loading sources linked to upland or hillslope erosion are allocated a 37% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Sinclair Creek is expressed as a 25% reduction in the total average annual sediment load.

Table 5-35. Quantified Sediment Loads, Allocations and TMDL for Sinclair Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Sediment Load BMPs (Tons/Year)**	Sediment Load and Wasteload Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**0.7**	**0.3**	**57%**
Streambank Erosion	Human Caused	1,037	695	33%
	Natural Background	344	344	0%
	Total	**1,381**	**1,039**	**25%**
Upland Sediment Sources	Forest	64	41	35%
	Range	7	5	35%
	Agriculture	4	2	58%
	Total	**76**	**48**	**37%**
Point Sources	**Construction Storm Water Permits**	**0.04**	**0.7**	**0%**
Total Sediment Load		**1,459**	**1,088**	**TMDL = 25% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts and road sanding also apply as defined within **Section 5.7.2.3**.
Sediment loads greater than 1 ton were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.6 Swamp Creek

Swamp Creek was listed as impaired due to sedimentation/siltation on the 2010 303(d) List. Sediment sources assessed and quantified within the Swamp Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, silviculture, channel modifications, and removal of riparian vegetation.

The current annual sediment load from the assessed sources is estimated at 1,669 tons/year (**Table 5-36**). By applying BMPs, this sediment load to the Swamp Creek watershed could be reduced to 1,477 tons/year. To achieve this reduction, a 57% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. A 7% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 37% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Swamp Creek is expressed as a 12% reduction in the total average annual sediment load.

Swamp Creek also has a habitat alteration type of impairment specifically defined as an *alteration in streamside or littoral vegetative covers*. This impairment cause is not a pollutant and does not require TMDL development. The solutions to this habitat problem are included within the water quality protection and improvement activities that must be pursued to meet the Swamp Creek sediment TMDL

and associated allocations. Therefore, the Swamp Creek sediment TMDL addresses both the sediment impairment as well as this habitat alteration impairment.

Table 5-36. Quantified Sediment Loads, Allocations and TMDL for Swamp Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**9**	**4**	**57%**
Streambank Erosion	Human Caused	285	191	33%
	Natural Background	1,123	1,123	0%
	Total	**1,408**	**1,314**	**7%**
Upland Sediment Sources	Forest	149	94.5	37%
	Range	103	65	37%
	Total	**252**	**159**	**37%**
Total Sediment Load		**1,669**	**1,477**	**TMDL = 12% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4**.
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.7 Therriault Creek

Therriault Creek was listed as impaired due to sedimentation on the 2010 303(d) List. Sediment sources assessed and quantified within the Therriault Creek watershed include roads, streambank erosion, and upland erosion. Human sources of sediment identified during this assessment include roads/transportation, historic silviculture and grazing, and channel modification.

The current annual sediment load from the assessed sources is estimated at 537 tons/year (**Table 5-37**). By applying BMPs, this sediment load to the Therriault Creek watershed could be reduced to 454 tons/year. To achieve this reduction, a 52% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. An 11% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 34% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

The sediment TMDL for Therriault Creek is expressed as a 16% reduction in the total average annual sediment load.

Table 5-37. Quantified Sediment Loads, Allocations and TMDL for Therriault Creek*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**3**	**1**	**52%**
Streambank Erosion	Human Caused	141	95	33%
	Natural Background	290	290	0%
	Total	**433**	**385**	**11%**
Upland Sediment Sources	Forest	88	59	33%
	Range	5	4	33%
	Agriculture	8	3	57%
	Total	**101**	**67**	**34%**
Total Sediment Load		**537**	**453**	**TMDL = 16% Load Reduction**

* In addition to the quantified allocations, allocations developed at the watershed scale for culverts, road sanding, and storm water permits also apply as defined within **Sections 5.7.2.3** and **5.7.3.4**.
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

5.7.3.8 Tobacco River

The Tobacco River was listed as impaired due to sedimentation on the 2010 303(d) List. Sediment sources assessed and quantified within the Tobacco River watershed include roads, streambank erosion, upland erosion and permitted point sources. The assessment results represent the cumulative total loading and associated reductions for the complete watershed, including Grave Creek loading contributions to the Tobacco River. Human sources of sediment identified during this assessment include roads/transportation, channel modifications, historic log drives, riparian vegetation removal, and permitted point sources.

The current annual sediment load from the assessed sources is estimated at 23,097 tons/year (**Table 5-38**). By applying BMPs, this sediment load to the Tobacco River watershed could be reduced to 20,631 tons/year. To achieve this reduction, a 57% sediment load reduction is allocated to unpaved roads. This reduction can be accomplished via application of appropriate road BMPs. An 8% reduction is allocated to streambank erosion, which equates to a 33% reduction in the human caused portion of the streambank erosion achieved primarily through improved riparian conditions along streams. Sediment loading sources linked to upland or hillslope erosion are allocated a 31% reduction. Upland erosion reductions are primarily achieved through the application of riparian BMPs or similar buffers to reduce the transport of eroded material to streams, although some reductions can also be achieved via erosion prevention BMPs in upland areas.

WLAs are provided for Eureka Sewage Treatment facility, Timberline Ready Mix, and construction storm water permits. The industrial stormwater facility (Timberline) has no reduction applied based on the assumption that erosion prevention requirements within its storm water permit are being met and will continue to be met. A composite construction stormwater wasteload allocation applies to multiple sites but none of them are allocated a reduction in loading also based on the assumption that erosion prevention requirements within the construction permits are being met and will continue to be met. Instead, the construction WLA includes an increase in loading in recognition of potential future growth

along with continued application of required storm water permit BMPs. The WLA for the Waste Water Treatment Plant is based on existing permit limits.

The sediment TMDL for the Tobacco River is expressed as an 11% reduction in the total average annual sediment load.

The Tobacco River Creek also has a *physical substrate habitat alterations* impairment. This impairment cause is not a pollutant and does not require TMDL development. The solutions to this habitat problem are included within the water quality protection and improvement activities that must be pursued to meet the Tobacco River sediment TMDL and associated allocations. Therefore, the Tobacco River sediment TMDL addresses both the sediment impairment as well as this habitat alteration impairment.

Table 5-38. Quantified Sediment Loads, Allocations and TMDL for Tobacco River*

Sediment Sources		Current Estimated Load (Tons/Year)**	Potential Estimated Load BMPs (Tons/Year)**	Sediment Load and Wasteload Allocations (% reduction)**
Roads	**Unpaved Roads Total**	**98**	**42**	**57%**
Roads	**Road Sand**	**11**	**11**	**0%**
Streambank Erosion	Human Caused	5,282	3,544	33%
	Natural Background	15,402	15,402	0%
	Total	**20,684**	**18,946**	**8%**
Upland Sediment Sources	Forest	1,717	1,215	29%
	Range	439	303	31%
	Agriculture	124	55	56%
	Other	17	12	29%
	Total	**2,297**	**1,585**	**31%**
Point Sources	**Eureka Sewage Treatment**	**10**	**34**	**0%**
	Timberline Ready Mix	**0**	**0.03**	**0%**
	Construction Storm Water Permits	**0.8**	**5**	**0%**
Total Sediment Load		**23,101**	**20,623**	**TMDL = 11% Load Reduction**

* In addition to the quantified allocations, an allocation developed at the watershed scale for culvert also applies as defined within **Sections 5.7.2.3**.
Sediment loads were rounded to the nearest whole number, and therefore they do not exactly match the numbers presented in the appendices and within **Section 5.6. The percent reduction values are intended to match the values presented in **Section 5.6** and related appendices.

Grave Creek Loads and TMDL Linkages

Grave Creek flows into Fortine Creek to form the Tobacco River. Therefore, Grave Creek sediment loading information is applicable to the Tobacco River sediment source assessment and subsequent development of the Tobacco River sediment TMDL and allocations. The sediment source assessment methods defined within Appendices E, F, and G generally differ from the methods that were used for development of the 2005 Grave Creek sediment TMDL (Montana Department of Environmental Quality, 2005). On the other hand, the 2011 Tobacco River TMDL and 2005 Grave Creek TMDL load allocations are developed using similar percent reduction approaches; both being based on the application of sediment load reduction practices and associated BMPs. The resulting allocations from the Grave Creek watershed to the Tobacco River, as defined by this document, do not supersede sediment allocations

applicable to Grave Creek as defined by the Grave Creek TMDL. Each allocation scenario within each document must be addressed to ensure compliance with the applicable water quality standards for the Tobacco River as well as Grave Creek. Below are comparisons of the source assessment methods and allocation approaches for the 2011 Tobacco River sediment TMDL and for the 2005 Grave Creek sediment TMDL.

- Streambank Erosion
  Streambank erosion loading for the Grave Creek watershed was evaluated for both TMDL documents using a similar BEHI method. The 2005 Grave Creek TMDL sediment load results are based on significantly more data collected along Grave Creek, whereas the 2011 Tobacco River TMDL sediment load results are based almost completely on extrapolation from other assessed streams throughout the Tobacco TPA. The allocation approach for each TMDL is based on an assessment of achievable reductions in human controlled impacts, and meeting the allocation in each document is based on applying appropriate erosion prevention BMPs mostly linked to improved riparian health along streambanks. A more detailed comparison of the bank erosion assessments and associated allocations is provided within **Section 5 of Appendix E**.

- Upland Erosion
  Grave Creek upland erosion loading and percent reduction scenarios for the 2011 Tobacco River TMDL are defined within **Appendix F**. Although the 2005 Grave Creek TMDL does not include an equivalent upland erosion loading analysis, the 2005 Grave Creek TMDL does include a load allocation that applies to forestry management activity consistent with the forest landscape allocation within the 2011 Tobacco River TMDL. The allocation within each document allows for limited upland erosion sediment loading from forest management activity based on the assumption of continued application of all appropriate forest practices BMPs.

- Roads
  Road source assessment loading and percent reduction scenarios for the 2011 Tobacco River TMDL are provided within **Appendix G**. The road loading results from the Tobacco TPA watersheds were used to extrapolate a load for unpaved crossings within the Grave Creek watershed as described within **Section 3.3** of **Appendix G**. This was necessary because the 2005 Grave Creek TMDL roads assessment was based on a completely different modeling method that is not comparable to the method used for the 2011 Tobacco River TMDL roads assessment.

  The 2005 Grave Creek TMDL road allocation includes a reduction in culvert failure risk consistent with the 2011 Tobacco TMDL culvert failure allocation. The 2005 Grave Creek TMDL road crossing allocation is no increase in road erosion loading (0% reduction) based on application of appropriate road BMPs. The 2011 Tobacco TMDL applies a seemingly more stringent 57% load reduction to unpaved crossings within the Grave Creek watershed. For the 2011 Tobacco River TMDL, existing BMP applications in the Grave Creek watershed were assumed consistent with the remainder of the Tobacco TPA where it was estimated that the application of BMPs could result in a 57% load reduction. For the Grave Creek TMDL, it was assumed that road crossing BMPs were mostly in place; although it is pointed out that road BMPs should be maintained or improved where BMPs are lacking. In reality, meeting the road load allocation for each TMDL is based on application of appropriate road crossing BMPs at all locations.

- Permitted Point Sources
  Permitted point sources were not identified with the Grave Creek watershed and thus were not incorporated into the Grave Creek TMDL.

- Mass Wasting
  Sediment loading from mass wasting was not evaluated as a unique loading source for the Tobacco TPA TMDL source assessment. Mass wasting was evaluated for the Grave Creek TMDL and was identified as a significant source of sediment loading. The allocation for Grave Creek allowed for no future sediment loading from mass wasting linked to a lack of BMPs for human related activities. This document addresses mass wasting prevention as follows:
  - The bank erosion sediment assessment should capture mass wasting loading adjacent to or along streambanks, and the bank erosion allocation approach incorporates BMPs to avoid mass wasting near streams via riparian protection improvement assumptions.
  - The upland sediment erosion model and assumptions linked to continued application of forestry BMPs is consistent with mass wasting prevention.
  - The roads allocations include BMPs at crossings and culvert upgrades that should reduce mass wasting potential.

5.7.4 Meeting the Intent of TMDL Allocations

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

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

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

5.8 SEASONALITY AND MARGIN OF SAFETY

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

5.8.1 Seasonality

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

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

5.8.2 Margin of Safety

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

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets.
- TMDL development was pursued for all streams evaluated, even though some streams were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness, and recognizes that sediment source reduction capabilities exist throughout the watershed.
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations.

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

5.9 TMDL Development Uncertainties and Adaptive Management

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

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

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

5.9.1 Sediment and Habitat Data Collection and Target Development

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

<u>Data Collection</u>

The stream sampling approach used to characterize water quality is described within **Appendix D**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for the purpose of sediment TMDL development (Montana Department of Environmental Quality, 2010). This procedure defines specific

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

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

Target Development

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

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

Because sediment target values are based on statistical data percentiles, DEQ recognizes that it may be impossible to meet all targets for some streams even under normal levels of disturbance. This does not appear to be a major concern throughout the Tobacco TPA since most streams are close to satisfying the majority of the target values. On the other hand, some target values may underestimate the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluation during adaptive management. This also does not appear to be a major concern because the current levels of human disturbances are not extremely high based on overall percent loading reductions. Furthermore, it appears that much of the watershed has recovered from historical practices that negatively affected water quality and stream habitat. It is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

5.9.9.2 Source Assessments and Load Reduction Analyses

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

Bank Erosion

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

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

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

Upland Erosion

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

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

Roads

The most significant road sediment load was linked to unpaved road crossings. As described in **Appendix G**, the road crossings sediment load was estimated via a standardized simple yearly model developed by the U.S. Forest Service. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 50 sites were randomly selected for evaluation, representing about 4% of the total population of roads. The results from these 50 sites were extrapolated to the whole population of roads stratified by landscape type. The reduction potential for all roads was also based on data collected from the 50 sites taking into consideration existing BMP conditions. This approach introduces uncertainty based on how well the 50 sites and associated BMPs represent the whole population. The average reduction of 57% used for road allocations appears to be a reasonable representation of the overall achievable sediment load reduction since this result is consistent with findings from similar TMDL evaluations in other watersheds within western Montana (Montana Department of Environmental Quality, 2008; Montana Department of Environmental Quality, 2011; Montana Department of Environmental Quality, 2009). Although the exact percent reduction will vary by road, the analysis clearly shows a high potential for sediment loading reduction by applying standard road BMPs in places where they are lacking or can be improved.

Application of Source Assessment Results

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

6.0 TMDL IMPLEMENTATION FRAMEWORK: WATER QUALITY RESTORATION AND MONITORING RECOMMENDATIONS

6.1 TMDL IMPLEMENTATION AND MONITORING FRAMEWORK

While certain land uses and human activities are identified as sources and causes of water quality impairment during TMDL development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section discusses the framework for TMDL implementation and a monitoring strategy to help ensure successful TMDL implementation and attainment of water quality standards.

6.1.1 Agency and Stakeholder Coordination

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. DEQ will work with participants to use these TMDLs as a basis for developing locally-driven watershed restoration plans, administer funding specifically for 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 goals which will progress toward meeting TMDL targets and load reductions. Specific stakeholders and agencies that have been and will likely continue to be vital to restoration and water quality maintenance efforts include the Kootenai River Network (KRN), the United States Forest Service - Kootenai National Forest (KNF), Montana Fish Wildlife & Parks (FWP), Montana Department of Environmental Quality (DEQ), the United States Fish and Wildlife Service (USFWS). Additionally, local land managers, stakeholder groups, and other state and federal agencies may be helpful in providing technical, financial or coordination assistance.

6.1.2 Water Quality Restoration Plan Development

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

- Implement best management practices (BMPs) to protect water conditions so that all streams in the watershed maintain good quality, with an emphasis on waters with completed TMDLs.

- Develop more detailed cost-benefit and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installments and efficiency results tracking.
- Provide information and education to reach out to stakeholders about approaches to restoration, its benefits, and funding assistance.

DEQ encourages collaboration among local stakeholders, interested parties, state and federal agencies toward development of a WRP for the Tobacco TPA, or preferably for the whole Tobacco watershed by combining WRP planning for the Tobacco TPA and Grave Creek watersheds since significant TMDL implementation and water quality protection activities are underway and well established for the Grave Creek watershed.

6.1.3 Adaptive Management and Uncertainty

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

The adaptive management approach is outlined below:

- TMDLs and Allocations: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and further assumes that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices.
- Water Quality Status: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified. Additionally, as restoration activities are conducted in the Tobacco TPA and target variables move towards target conditions, the impairment status of the 303(d) listed waterbodies is expected to change. An assessment of the impairment status will occur after significant restoration occurs in the watershed.

6.1.4 Funding and Prioritization

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

Section 319 funding

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

watersheds and to facilitate Grave Creek TMDL development as well as development of the TMDLs within this document.

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

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

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

6.2 Implementation Strategies and Recommendations

For each major source of human-caused pollutant loads in the Tobacco TPA, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Tobacco TPA should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. The source assessment results provided within **Appendices E, F** and **G** and summarized in **Section 5.6** provide information that should be used to help determine priorities for each major source type in the watershed and for each of the general management recommendations discussed below in **Sections 6.2.1** through **6.2.12**.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current 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 followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 6.3**.

6.2.1 Riparian and Floodplain Management

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Therefore, enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Tobacco TPA.

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

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

6.2.2 Grazing Management

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

Grazing management includes the timing and duration of grazing, the development of multipasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Tobacco TPA are providing off-site watering sources, limiting livestock access to streams, providing “water gaps” where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank

revegetation are a preferred BMPs, in some instances bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution can be obtained in **Appendix A** of Montana's NPS Management Plan (DEQ, 2007).

6.2.3 Small Acreages

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

6.2.4 Animal Feeding Operations

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

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

Further information may be obtained from the DEQ website at:
http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp. Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.

- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ internal (Permitting Division), as well as external entities (DNRC, local watershed groups, conservation districts, MSU Extension, etc.).

6.2.5 Cropland

The primary strategy of the recommended cropland 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 Tobacco TPA are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for filter strips and 50 percent for buffers (DEQ, 2007). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities which will also supply shade to reduce instream temperatures. Filter strips widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (DEQ, 2007).

6.2.6 Forestry and Timber Harvest

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

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. United States Forest Service (USFS) Inland Fish (INFISH) Riparian Habitat Conservation Area (RHCA) guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana's SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance

for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995b).

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

6.2.7 Unpaved Road BMPs

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

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.
- No new roads with long parallel sections within 150 feet of streams. Limit new road stream crossings to the extent practicable.

6.2.8 Culverts and Fish Passage

Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis found that approximately 62% of the culverts were designed to accommodate a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 47 culverts in the watershed and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. Because of the high road densities and resulting large number of culverts throughout most of the Tobacco watershed, as culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. A coarse assessment of fish passage indicated that a large percentage of culverts may pose a fish passage risk at all flows. Each fish barrier should be assessed individually to determine if it functions as an invasive

species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana FWP can aid in determining if a fish passage barrier should be mitigated, and, if so, can aid in culvert design.

6.2.9 Stormwater Construction Permitting and BMPs

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

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

6.2.10 Urban Area Stormwater BMPs

Even though the Eureka area does not have a large enough population to require a municipal stormwater permit, activities to reduce sediment or other pollutant loading from new development or redevelopment should be pursued consistent with the upland erosion allocations and efforts to avoid future water quality problems. Any BMPs which promote onsite or after collection infiltration, evaporation, transpiration or reuse of the initial flush stormwater should be implemented as practicable on all new or redevelopment projects. EPA provides more comprehensive information about stormwater best management practices on their website at:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

6.2.11 Beaver Populations and Sediment Yields

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

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

6.2.12 Nonpoint Source Pollution Education

Because most nonpoint source pollution (NPS) is generated by individuals, a key factor in reducing NPS is increasing public awareness through education. The KRN can provide educational opportunities to both students and adults through local water quality workshops, informational meetings and field trips to locations with successful BMP implementation or restoration project success. Continued education is key to ongoing understanding of water quality issues in the Tobacco TPA, and to the support for implementation and restorative activities.

6.3 MONITORING RECOMMENDATIONS

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

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

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

6.3.1 Tracking and Monitoring Restoration Activities and Effectiveness

Restoration activities which address nonpoint sources should be tracked watershed-wide as they are implemented. Information about specific locations, spatial extent, designs, contact information, and any effectiveness evaluation should be compiled about each project as they occur.

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the effects, or lack of effects, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutants that are targeted for each project.

Particularly for sediment, which has no numeric standard, effectiveness and reductions in loading should be evaluated using load estimate approaches applied within this document for each source category. Evaluating in-stream parameters used for sediment targets will not be practical for most projects since the sediment effects within a stream represent cumulative effects from many watershed scale activities.

Information about all restoration projects along with tracking overall extent of BMP implementation should be compiled into one location. If sufficient implementation progress is made within a watershed, DEQ will create a monitoring plan to assess target conditions and implement the monitoring. Results would be compared to targets to determine if the TMDL is achieved.

Forestry BMP audits represent an important monitoring tool to assist in evaluating forest practices BMP implementation and effectiveness. The statewide audits are conducted biennially by an interdisciplinary team comprised of persons from local, state and federal agencies as well as private companies and non-profit organizations. The audits look at road BMPs as well as timber harvest operations on the upland and in the riparian area. Whenever one of these audits occurs within the Tobacco watershed, the results can help evaluate if the individual or agency that sponsored the timber harvest is pursuing BMPs in a manner consistent with the applicable sediment TMDLs.

6.3.2 Baseline and Impairment Status Monitoring

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

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

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

- Riffle pebble count; using Wolman Pebble Count methodology and/or 49-point grid tosses in riffles and pool tails
- Residual pool depth and pool frequency measurements
- Greenline assessment

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

An important part of impairment determination and adaptive management is determining when a stream has fully recovered from past management practices where BMPs were not applied. This is particularly important in the Tobacco watershed, and ongoing PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) activity can provide critical insight into the extent of recovery from past practices via comparisons between reference and managed sites within the Tobacco watershed.

6.3.3 Source Assessment Refinement

In many cases, the level of detail provided by the source assessments only provides broad source categories or areas that need to reduce pollutant loads and additional source inventory and load estimate work may be desirable. Strategies for strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories such as bank erosion or road crossings to help prioritize implementation strategies based on an assessment of a larger population of eroding banks or road crossings of concern. Culverts should be assessed for fish passage and their capacity to pass storm event flows as culvert failure is often a source of discrete sediment loads.

Efforts to improve upon load estimates, either within a given source category or via a calibrated approach to allow improved comparison between source categories is also a possibility, but not a requirement for TMDL implementation. Improvements might include:

- a refined bank erosion retreat rate for Tobacco watershed streams,
- a better understanding of bank erosion impacts from historical land management activities,
- improved modeling for upland erosion delivery in forested watersheds where riparian zones have recovered from SMZ law implementation,
- evaluation of seasonal loading aspects for the major sources and potential implications regarding TMDL target parameters, and
- evaluation of “hot spots” that simple watershed scale models may not adequately address, such as a confined animal operation adjacent to a stream.

7.0 PUBLIC PARTICIPATION

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

7.1 PARTICIPANTS AND ROLES

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

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

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program. Project management support was provided by the EPA Regional Office in Helena, MT, including assistance developing the sediment water quality targets, assessing data and making TMDL determinations, developing the document, and providing technical review.

Kootenai River Network
The Kootenai River Network (KRN) is a non-profit organization whose primary purpose is to foster communication and implement collaborative processes among private and public interests in the Kootenai River watershed and basin. They strive to improve resource management practices and restore water quality and aquatic resources in the basin. Membership in the KRN includes representatives from the U.S. Fish and Wildlife Service; Natural Resources Conservation Service; Montana Fish, Wildlife and Parks; Lincoln Conservation District; and Plum Creek Timber Company; among other organizations.

The KRN administered several contracts with DEQ to conduct tasks in support of TMDL development, including data collection and technical assessments through third party contracting and coordination of local stakeholder outreach activities. The KRN provided invaluable assistance to DEQ in: identifying stakeholders and members of a Tobacco TMDL advisory group, providing information on local water quality concerns, helping obtain access to private property for stream sediment monitoring and assessment purposes, and coordinating advisory group meetings and public meetings. This collaborative

effort between DEQ and the KRN will continue through future TMDL development projects in the Tobacco River watershed and the entire Kootenai River watershed in Montana.

Conservation Districts
Majority of the Tobacco TMDL Planning Area falls within Lincoln County; however a small portion of the Lime Creek drainage is located in Flathead County. Therefore, DEQ provided both the Lincoln Conservation District and the Flathead Conservation District with consultation opportunity during development of the sediment TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

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

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

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

7.2 Response to Public Comments

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

The formal public comment period for the "Tobacco Planning Area Sediment TMDLs and Framework Water Quality Improvement Plan" was initiated on July 20, 2011 and closed on August 22, 2011. Electronic copies of the draft document were made available at the Flathead County, Eureka, Libby, and Whitefish Branch public libraries and at the State Library in Helena, MT.

A public informational meeting and open house was held in Eureka, MT on August 11, 2011. DEQ provided an overview of the document, answered questions, and solicited public input and comment on the TMDLs. The announcement for the meeting was distributed to the KRN, Lincoln and Flathead conservations districts, the Tobacco TMDL Advisory Group, the Statewide TMDL Advisory Group, and other identified interested parties via email. Notice of the meeting was posted on the DEQ webpage and DEQ wiki, and also advertised in the following newspapers: Daily Interlake, Missoulian, The Western News, and Tobacco Valley News. The comments received during the public comment period and DEQ responses to these comments are presented within **Appendix I**.

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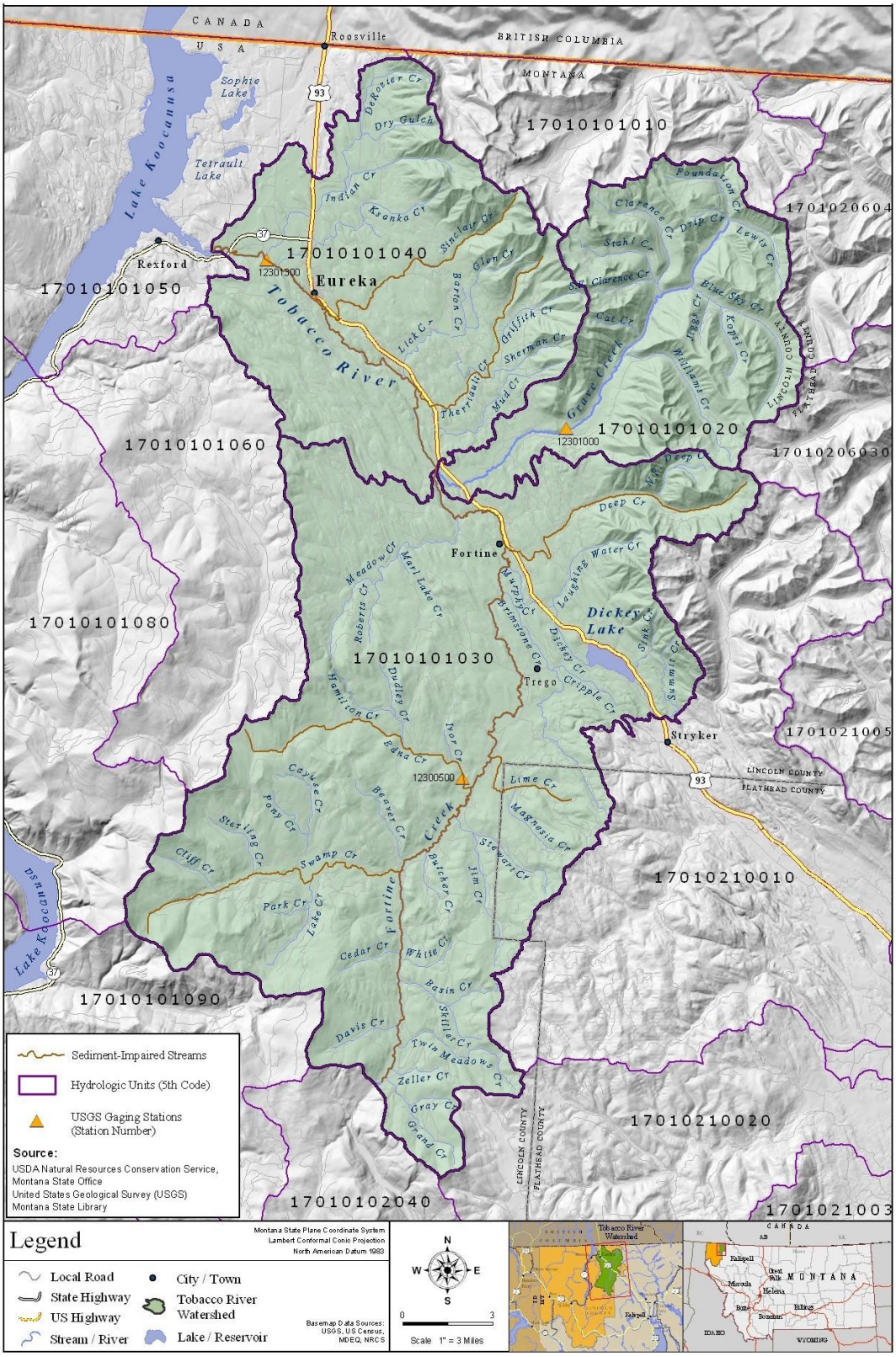


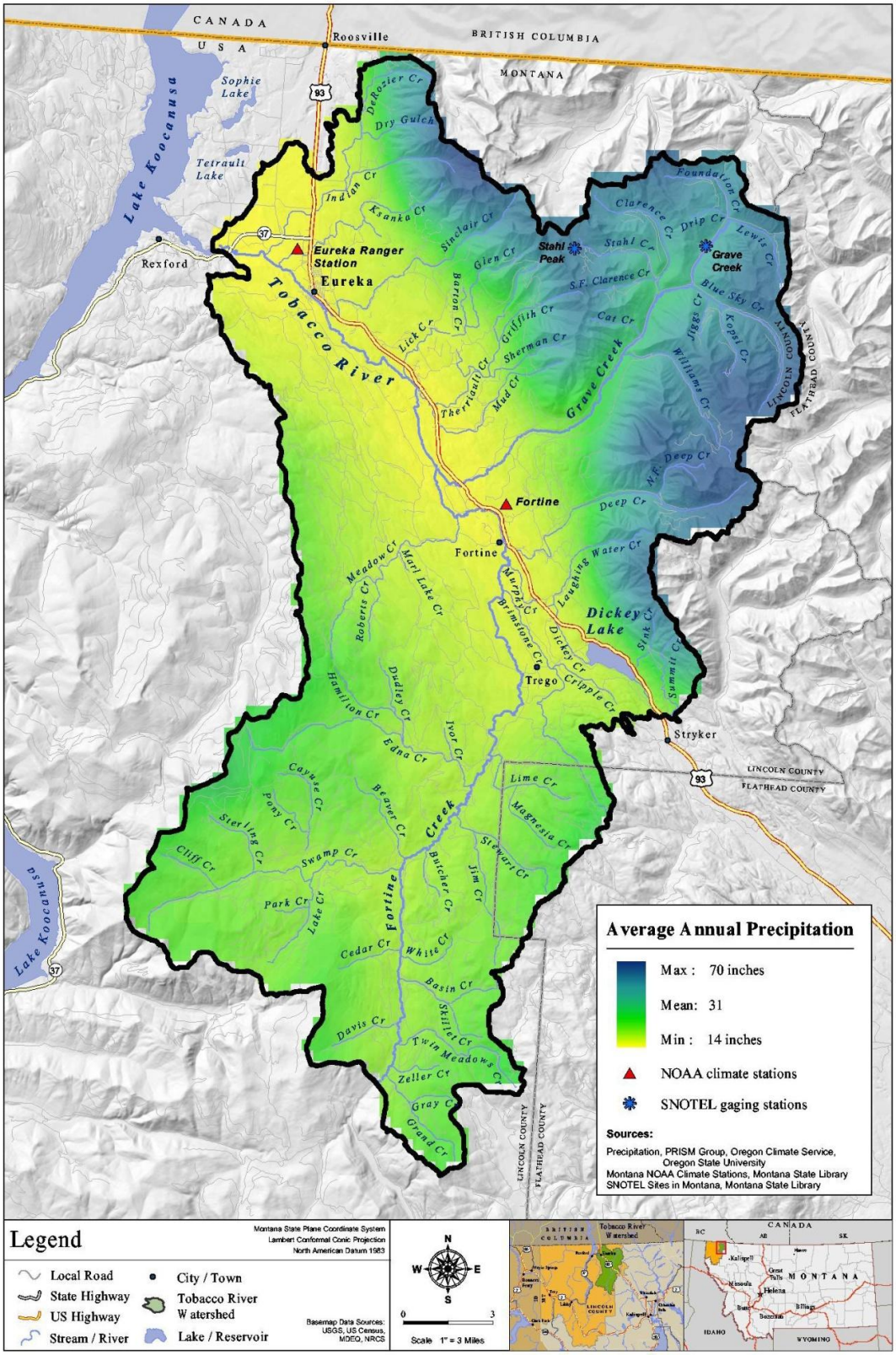
Map A-1. Boundary of the Tobacco TMDL Planning Area and waterbodies with completed sediment TMDLs in this document

Table A-1. 2010 Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Tobacco TPA

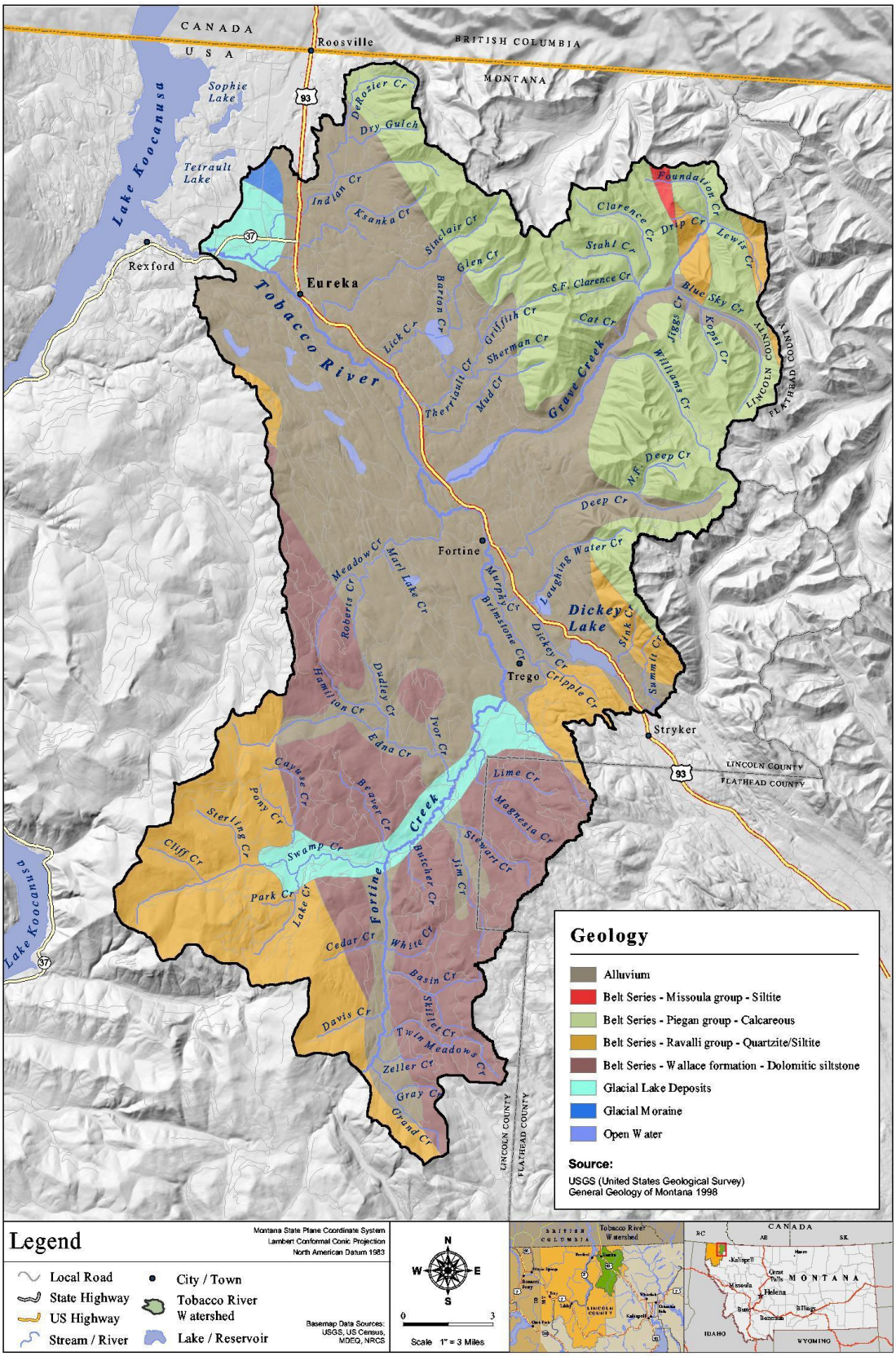
Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Deep Creek, headwaters to mouth (Fortine Creek)	MT76D004_080	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Excess Algal Growth	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
Edna Creek, headwaters to mouth (Fortine Creek)	MT76D004_030	Sedimentation / Siltation	Sediment	Aquatic Life	Sediment TMDL contained in this document
Fortine Creek, headwaters to mouth (Grave Creek)	MT76D004_020	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Excess Algal Growth	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Temperature, water	Temperature	Aquatic Life, Cold Water Fishery	To be completed in a future project

Table A-1. 2010 Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Tobacco TPA

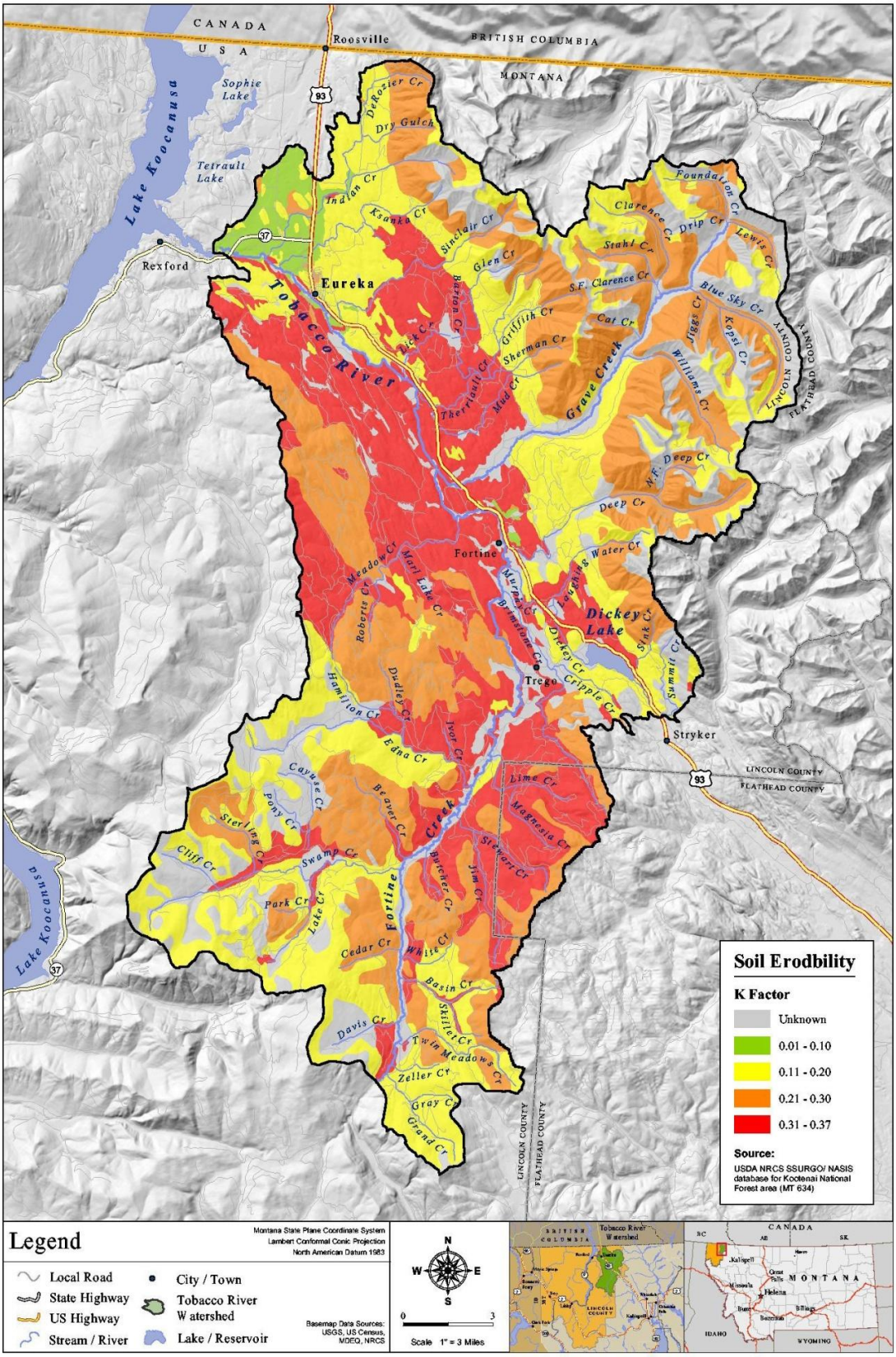
Waterbody & Location Description	Waterbody ID	Impairment Cause	TMDL Pollutant Category	Impaired Use(s)	Impairment Cause Status
Lime Creek, headwaters to mouth (Fortine Creek)	MT76D004_050	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Arsenic	Metals	Drinking Water	To be completed in a future project
		Chlorophyll-*a*	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery	To be completed in a future project
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery	To be completed in a future project
Swamp Creek, headwaters to mouth (Fortine Creek)	MT76D004_040	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not yet addressed by a TMDL or restoration plan
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
Therriault Creek, headwaters to mouth (Tobacco River)	MT76D004_070	Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
Tobacco River, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Sedimentation / Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document



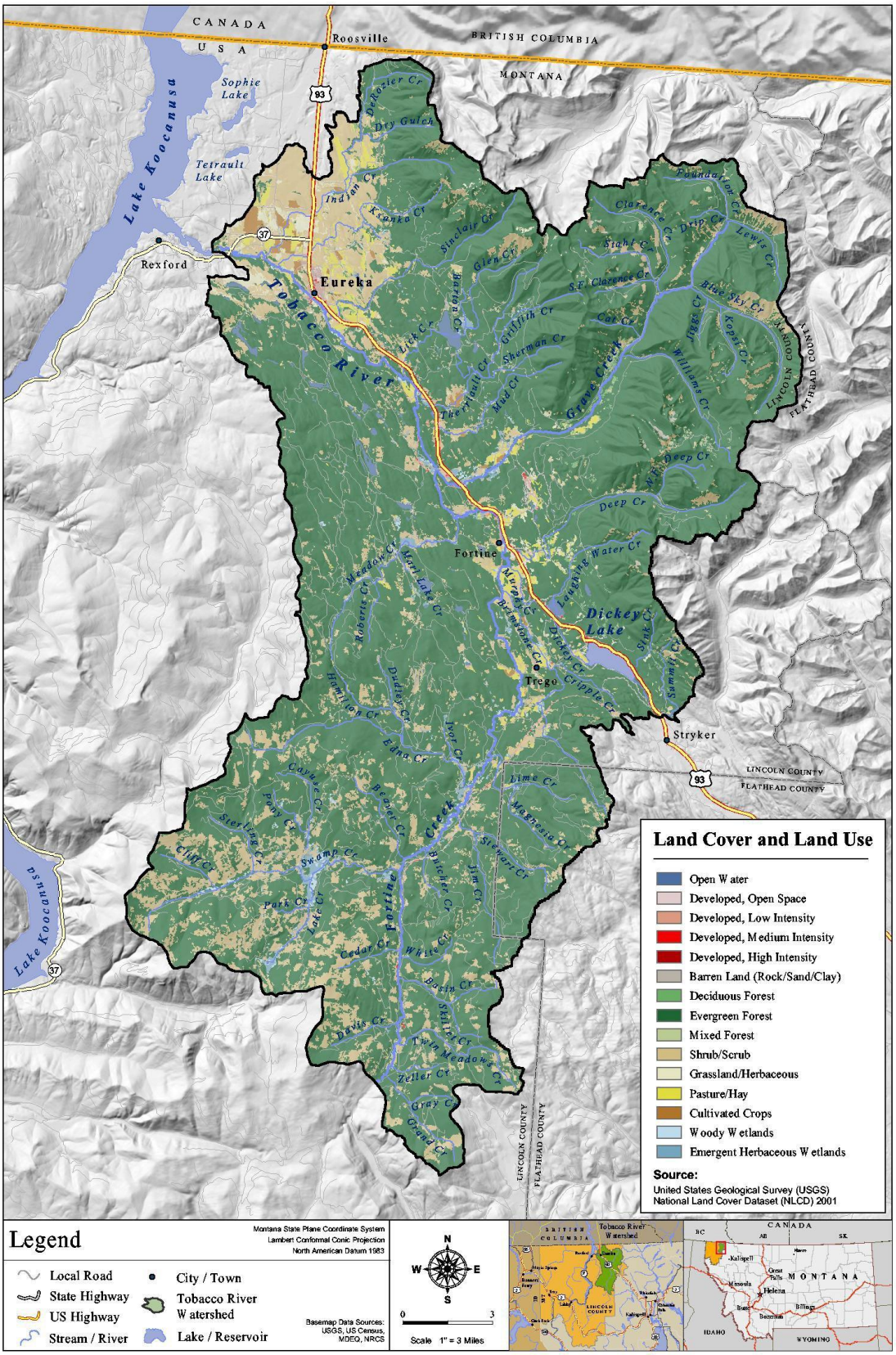
Map A-2. Average annual precipitation and location of climate and SNOTEL stations in the Tobacco River watershed



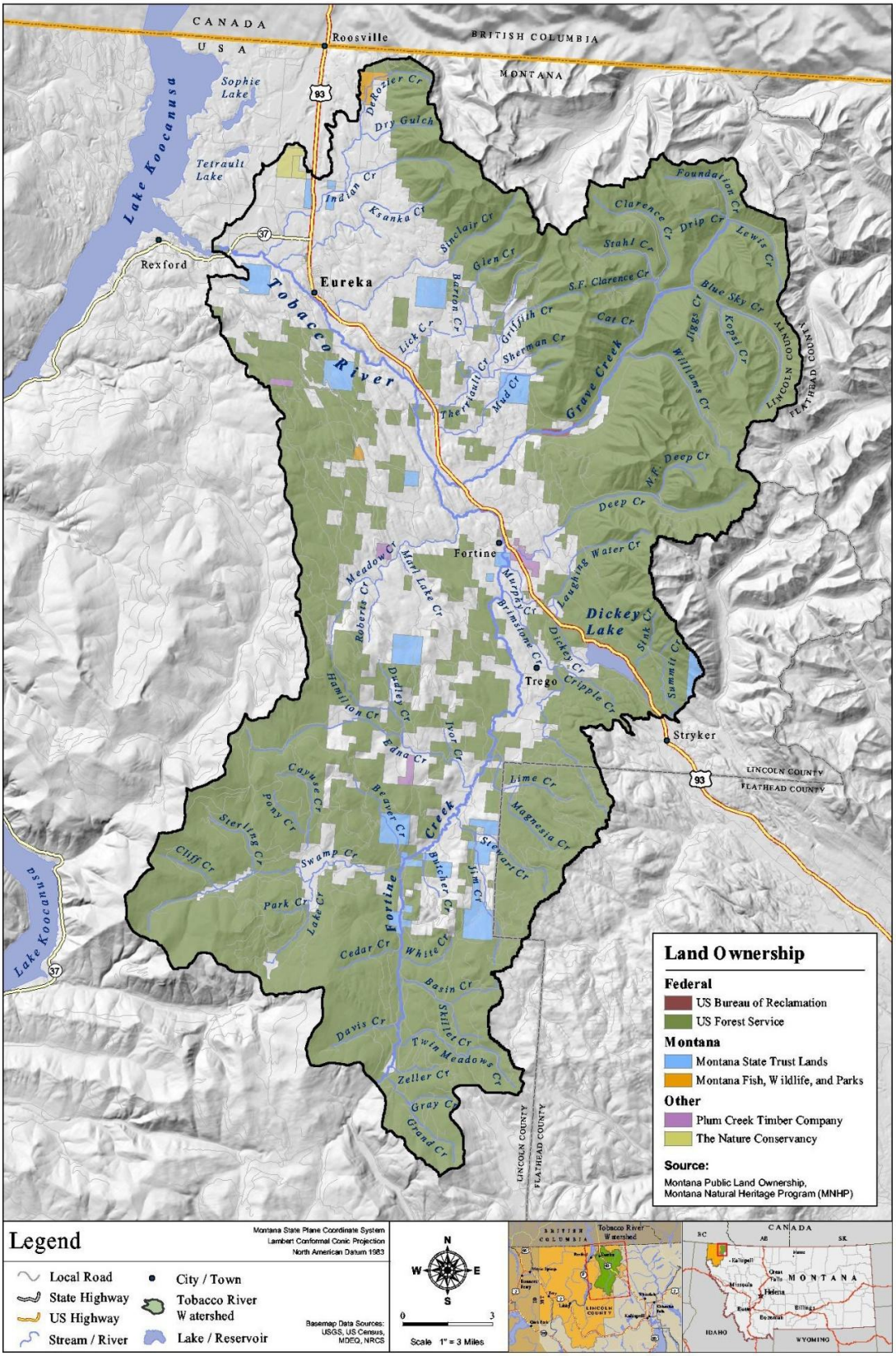
Map A-3. Geology of the Tobacco River watershed



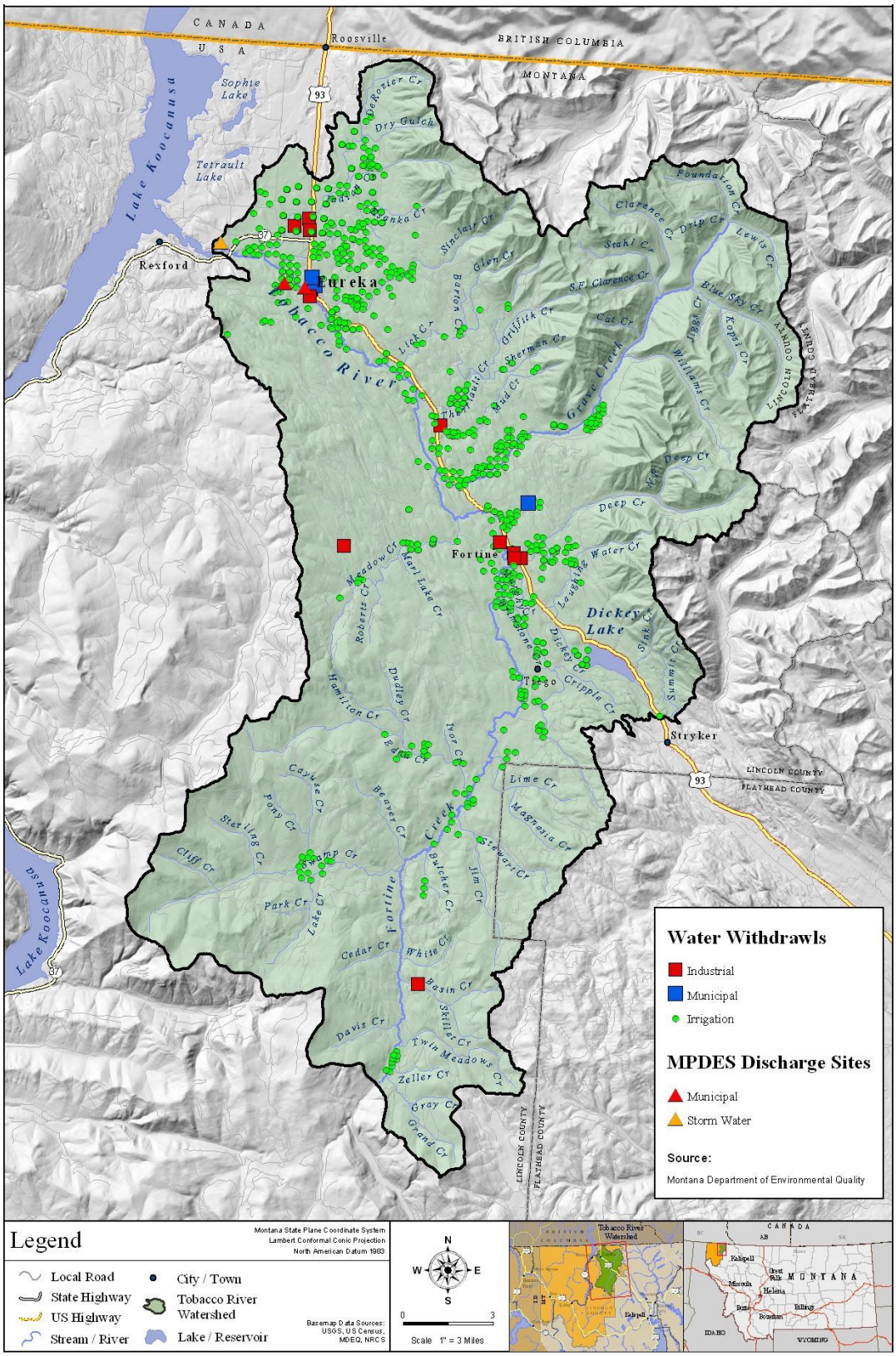
Map A-4. Soil Erodibility (K factors) in the Tobacco River watershed



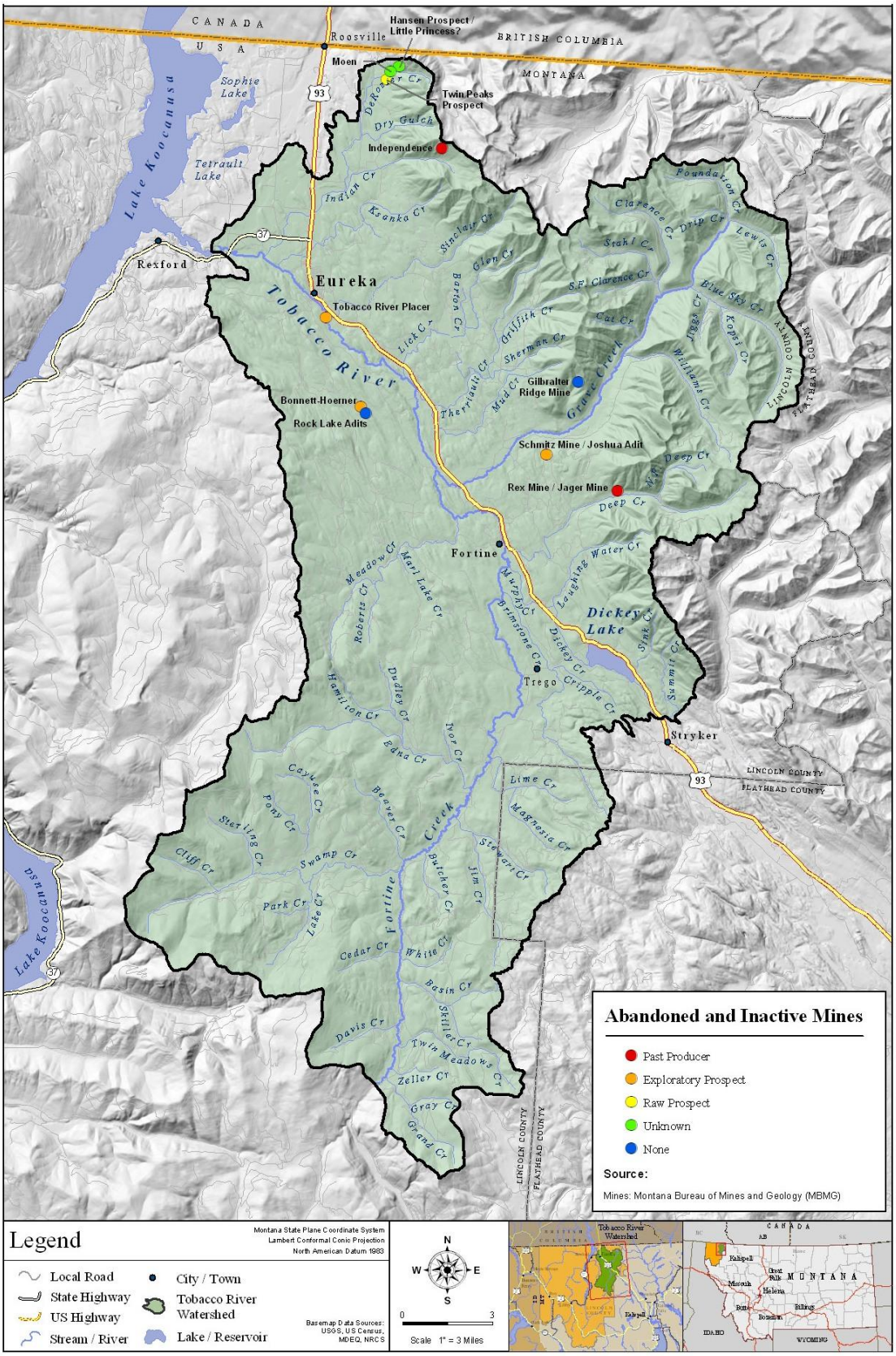
Map A-5. Types of land cover and land use in the Tobacco River watershed



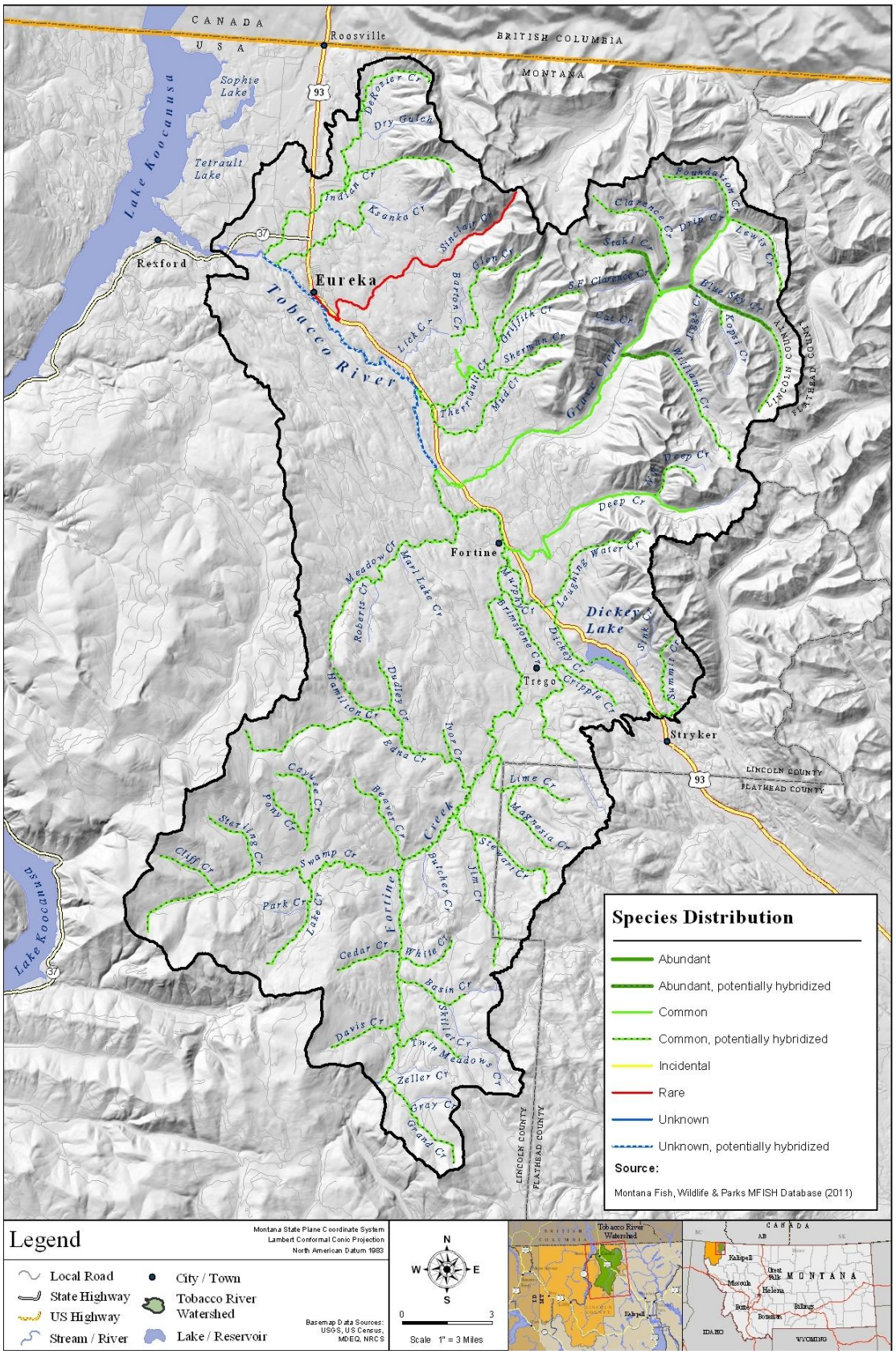
Map A-6. Land ownership in the Tobacco River watershed



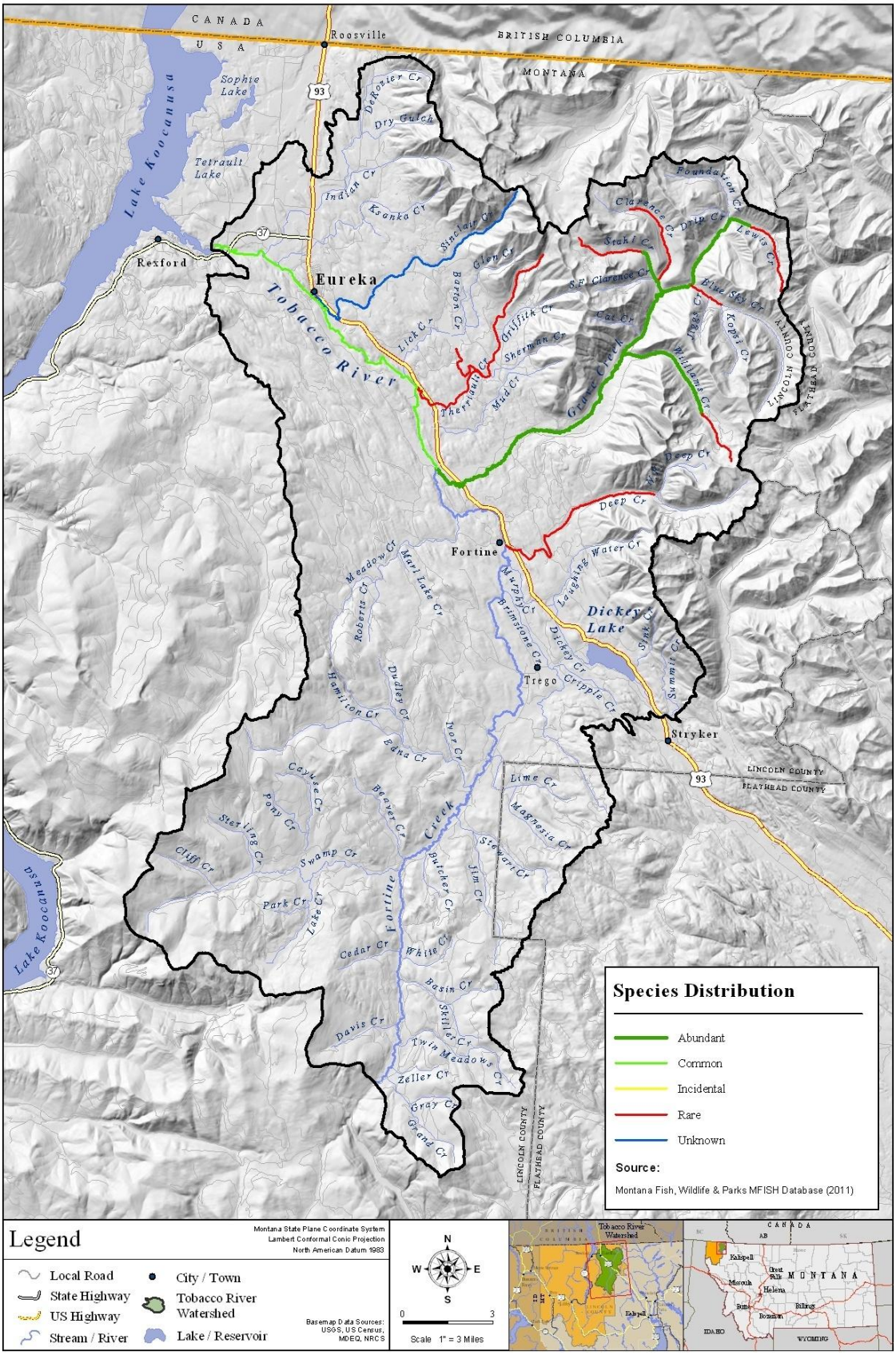
Map A-7. Locations of water withdrawals and permitted discharges in the Tobacco River watershed



Map A-8. Locations of active and abandoned mines in the Tobacco River watershed



Map A-9: Distribution of westslope cutthroat trout in the Tobacco River watershed



Map A-10: Distribution of bull trout in the Tobacco River watershed

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B1.0 INTRODUCTION

This watershed description provides an overview of watershed characteristics in the Tobacco TMDL Planning Area (TPA). This section also provides some detail regarding characteristics of the watershed that may play a significant role in pollutant loading (e.g., geographical distribution of soil types, vegetative cover, or land use). The information provided herein is intended to serve as a general description of physical, climatic, hydrologic, and other ecological features within the planning area. Maps illustrating information in this watershed description are included in **Appendix A**.

B2.0 PHYSICAL CHARACTERISTICS

B2.1 LOCATION OF THE TOBACCO TMDL PLANNING AREA

The majority of the Tobacco River watershed is located in Lincoln County in northwest Montana, with a small section located in Flathead County (**Map A-1** in **Appendix A**). The watershed is located in the Upper Kootenai 4th code hydrologic unit (17010104). The Tobacco River is a fifth order watershed draining approximately 440 mi^2 (282,000 acres) between the Kootenai River on the west and the Whitefish Range on the east. The Tobacco River is located south of the United States-Canadian border and north of the Fisher River watershed. The Tobacco River forms at the confluence of Grave and Fortine creeks and flows into Lake Koocanusa. The Tobacco River and six of its tributaries are listed as impaired waterbodies on Montana's 2010 Water Quality Integrated Report. These tributaries include: Deep Creek, Edna Creek, Fortine Creek, Lime Creek, Swamp Creek, and Therriault Creek, and are shown in **Map A-1** in **Appendix A**.

The entire Tobacco watershed lies within the Northern Rockies Level III Ecoregion (Omernik, 1987). The Tobacco River watershed includes the following Level IV Ecoregions: Tobacco Plains, Stillwater-Swan Wooded Valley, Western Canadian Rockies and Salish Mountains (Woods et al., 2002).

B2.2 TOPOGRAPHY

The majority of the Tobacco River watershed is characterized by moderate topographic relief. Fortine Creek drains the lower two-thirds of the Tobacco River watershed. It flows north for 31 miles from its headwaters in the Salish Mountains between Davis Mountain (6,050 feet) and Elk Mountain (6,560 feet), to its confluence with Grave Creek. The average slope in the Fortine Creek 5th hydrologic unit code (HUC) watershed is approximately 20 percent (RDG, 2004). Grave Creek flows southwest for 18 miles from its headwaters in the Whitefish Range between Stahl Peak (7434 feet) and Mount Lewis (7,323 feet). The Grave Creek watershed has greater relief, with an average slope of 43 percent. The confluence of Fortine Creek and Grave Creek forms the Tobacco River, which flows an additional 13.4 miles before joining the Kootenai River at Koocanusa Reservoir near the town of Eureka, Montana. The average slope in the Lower Tobacco River watershed is approximately 20 percent. The highest point in the Lower Tobacco River watershed is 7,500 feet at Ksanka Peak in the Whitefish Range.

B2.3 CLIMATE

The Tobacco River watershed is influenced by the Aleutian low and the Pacific high pressure systems with maritime air blowing into the area on predominately westerly winds (USDA, 1998). During the

winter months, the Aleutian low dominates bringing periods of heavy precipitation. During the summer months, the Pacific high dominates, resulting in hot and dry weather. There are two long-term climate stations within the Tobacco River watershed. Their locations, elevations and periods of operation are shown in **Table B2-1** below and in **Map A-2** found in **Attachment A**.

Table B2-1. Climate Stations within the Tobacco River Watershed, Montana

Location	**Elevation (feet)**	**Period of Operation** (as of 2006)
Eureka Ranger Station (242827)	2650	6/1/1960 to 10/31/2006
Fortine (243139)	2998	3/1/1906 to 10/31/2006

Both stations have nearly continuous data with rare, occasional dates without records. The climate stations in Eureka and Fortine are approximately 12 miles apart and are at similar elevations. The close proximity helps to explain the nearly identical patterns seen in temperature and precipitation between the two stations (**Figures B2-1**, **B2-2**, **B2-3**, and **B2- 4**).

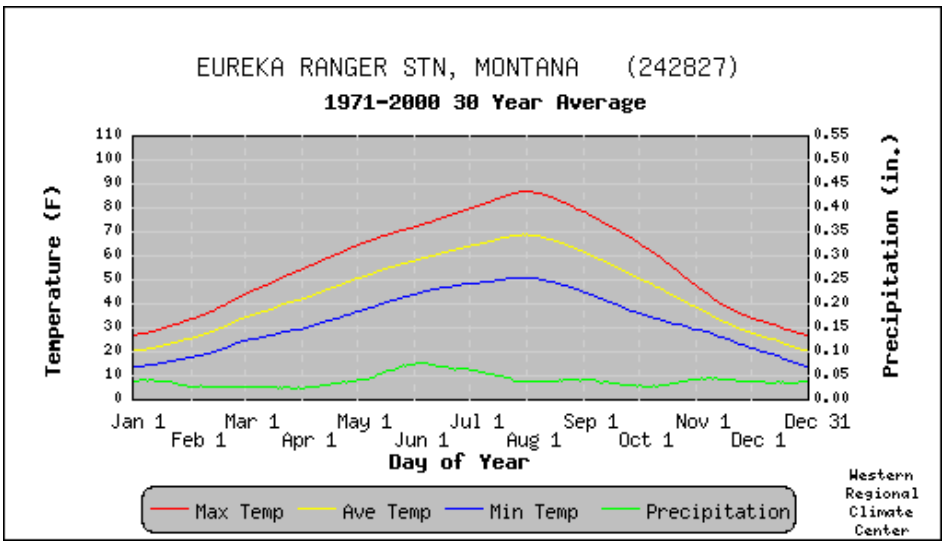

Figure B2-1. Patterns in Average Precipitation and Temperature for Eureka Ranger Station, MT (Western Regional Climate Center, 2001)

- Max. Temp. is the average of all daily maximum temperatures recorded for the day of the year between the years 1971 and 2000.
- Ave. Temp. is the average of all daily average temperatures recorded for the day of the year between the years 1971 and 2000.
- Min. Temp. is the average of all daily minimum temperatures recorded for the day of the year between the years 1971 and 2000.
- Precipitation is the average of all daily total precipitation recorded for the day of the year between the years 1971 and 2000.

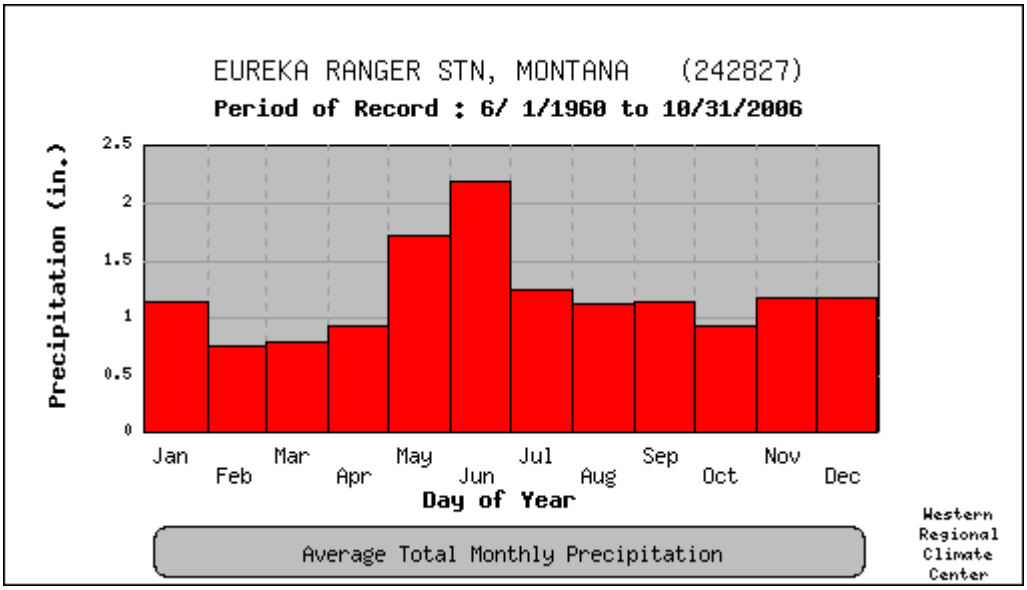

Figure B2-2. Average Total Monthly Precipitation for Eureka Ranger Station, MT (Western Regional Climate Center, 2001)

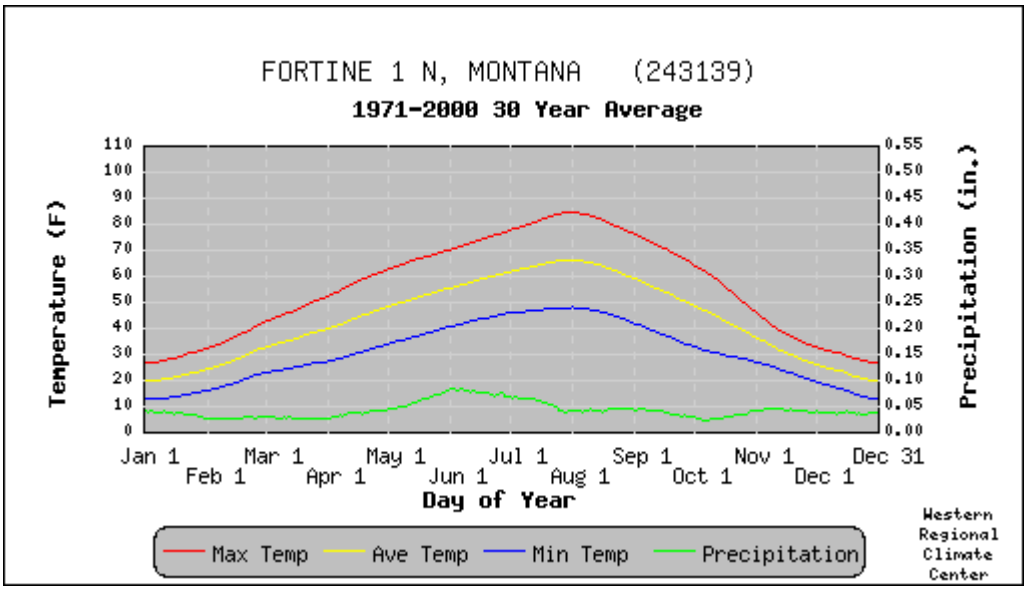

Figure B2-3. Patterns in Average Precipitation and Temperature for Fortine, MT (Western Regional Climate Center, 2001)

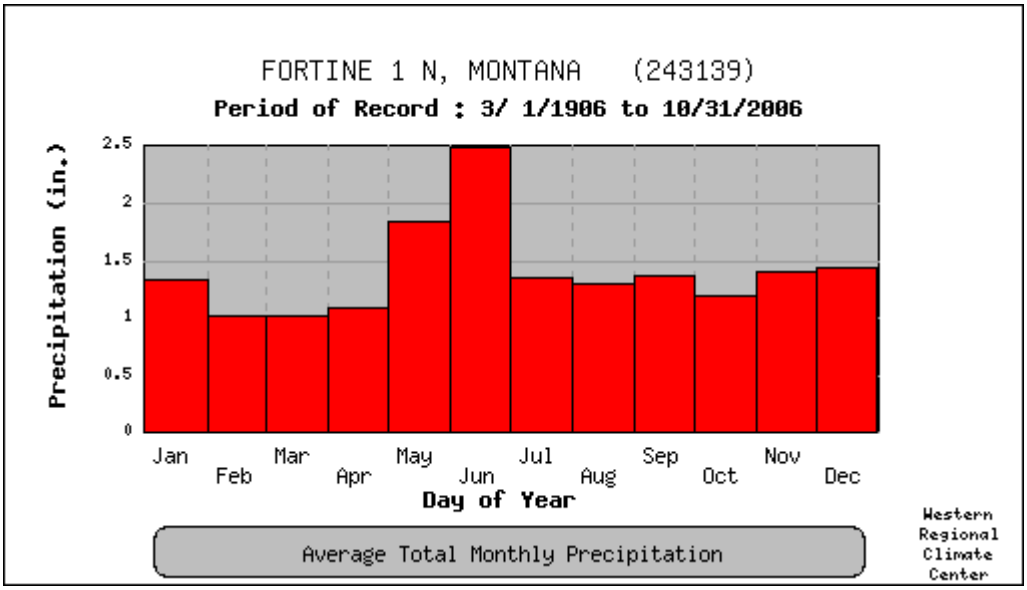

Figure B2-4. Average Total Monthly Precipitation for Fortine, MT (Western Regional Climate Center, 2001)

According to data from these stations, the Tobacco River watershed receives precipitation throughout the year with a slight peak seen in June at each station. Average total annual precipitation at the two weather stations was 15.84 inches at Fortine and 14.48 inches at Eureka (Western Regional Climate Center, 2001). These two climate stations are both located at relatively low elevations in the Tobacco Valley bottom. The Tobacco Valley is unique to this area for its mild climate. The area experiences a rain shadow effect from the Purcell Mountains to the west. Although the Purcell Mountains are relatively low at their southern end near the Tobacco Valley they apparently still present an effective barrier to some winter storms, resulting in decreased precipitation (Cooper, 2003). However, the distribution of moisture changes considerably with elevation in the Tobacco River watershed. **Map A-2** in **Appendix A** shows average annual precipitation for the entire Tobacco River watershed. This map illustrates that the precipitation in the higher elevation areas of the Whitefish Range is much greater than that recorded at the valley climate stations. This fact is also apparent when looking at data from the two SNOTEL sites located within the Tobacco River watershed (**Table B2-2**) (NRCS 1998, SNOTEL website).

Table B2-2. SNOTEL Stations within the Tobacco River Watershed, Montana

Location	ID	Elevation (feet)
Stahl Peak (787)	787	6030
Grave Creek (500)	500	4300

Both SNOTEL sites are located in the Grave Creek drainage, relatively high in the Whitefish Range. SNOTEL data has been collected continuously from these two sites since 1979. **Figure B2-5** shows the accumulated annual precipitation from 1979-2006 at the two SNOTEL sites.

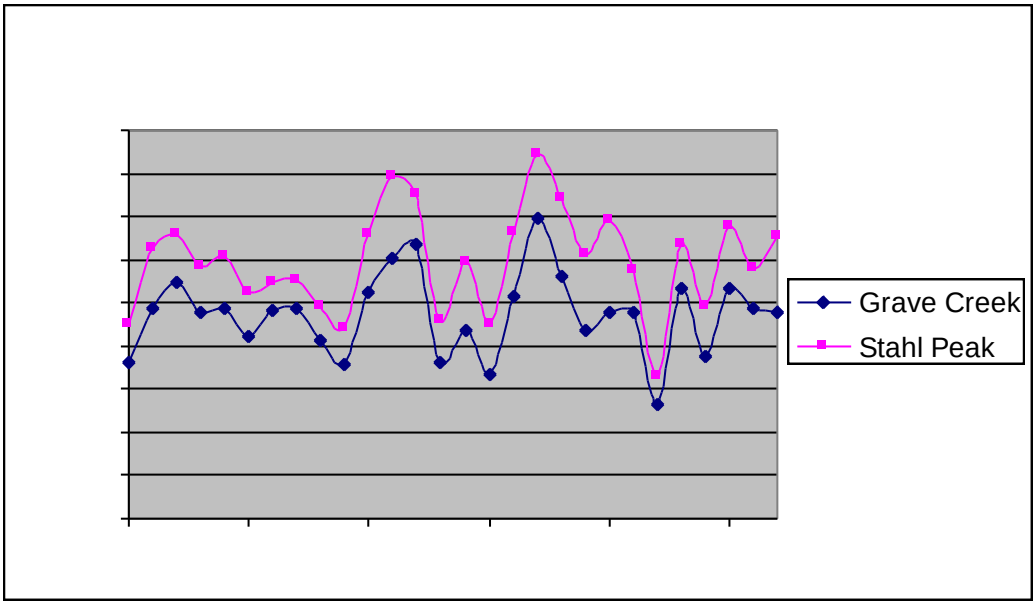

Figure B2-5. Average Accumulated Precipitation from 1979-2006 at SNOTEL Sites

This data shows much greater accumulated annual precipitation than 15-16 inches seen at the two valley bottom climate stations. The average accumulated precipitation for the years 1979-2006 was 47.3 and 59.6 inches for Grave Creek and Stahl Peak, respectively. At the Stahl Peak SNOTEL station over 84 inches of precipitation fell in the 1996 water year.

Temperatures also vary with elevation in the Tobacco River watershed. Maximum monthly average from the 1971-2000 dataset from the low elevation climate stations was 57.7°F at the Eureka Ranger Station and 55.5°F at Fortine (**Table B2-1**, **Figures B2-1** and **B2-2**). The minimum monthly average temperature was 33.0°F at Eureka and 29.1°F at Fortine. July is the hottest month of the year in the Tobacco River watershed, with an average maximum temperature of 84.9° F at Eureka and 82.4°F at Fortine. The coldest month of the year is January, with an average minimum temperature of 15.6˚F at the Eureka weather station and 11.6°F at the Fortine station. The higher elevation SNOTEL sites follow these basic trends but show average temperatures a few degrees cooler throughout the year (NRCS 1998, SNOTEL accessed 2/15/07).

B2.4 HYDROLOGY

B2.4.1 Streamflow Data

There are three USGS gaging stations located on the Tobacco River and its tributaries (**Table B2-3** below and **Map A-1** in **Appendix A**).

Table B2-3. Tobacco Watershed USGS Gaging Stations

Location	**ID**	**Dates of Operation** (as of 2006)
Tobacco River near Eureka MT	12301300	10/1958 - 9/2006
Grave Creek near Fortine, MT	12301000	4/1923 - 6/1924
Fortine Creek near Trego, MT	12300500	12/1946 - 9/1953

Data from Grave and Fortine Creeks is old and spans only a short period of time; however data from the Tobacco River station has been collected continuously since 1958. **Figure B2-6** is a hydrograph constructed from historical gage station data.

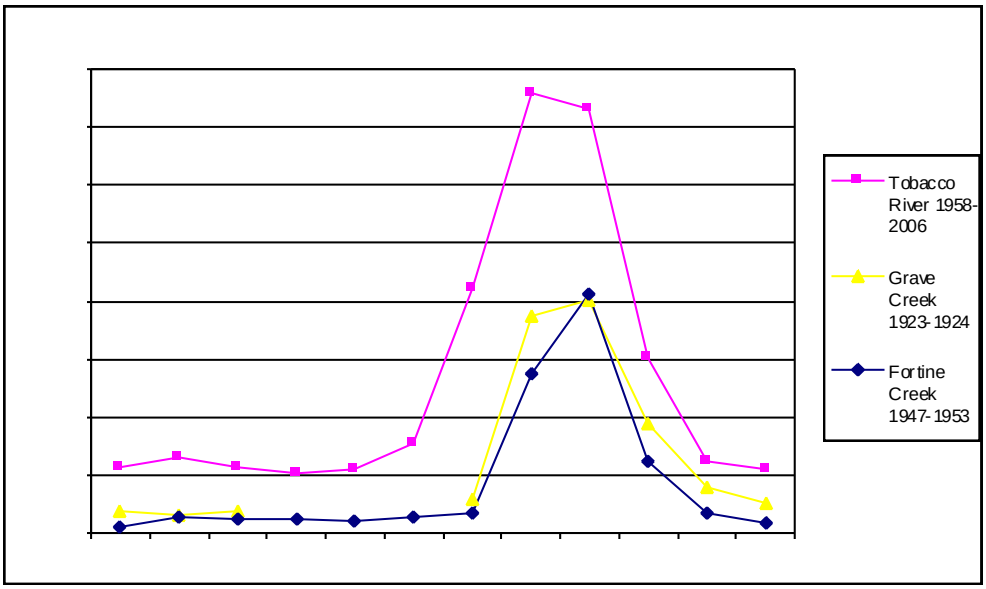

Figure B2-6. Historical Flow Data from Tobacco River watershed (USGS, accessed 2/15/07)

The data presented in **Figure B2-6** show that Fortine and Grave creeks contribute similar flows to the Tobacco River. Furthermore, all three streams peak in May or June. The data period from Grave Creek is limited to one year. For the Tobacco River, mean monthly discharge was below 150 cfs for August through February, on average over the last 50 years. Historical data indicate peak flow in May averages approximately 750 cfs. The mean historical flow does not reveal the magnitude of or variation in peak flows. As an example of the variability in flow, **Figure B2-7** illustrates daily mean discharge for 2006, which reached a peak of nearly 2,300 cfs in June.

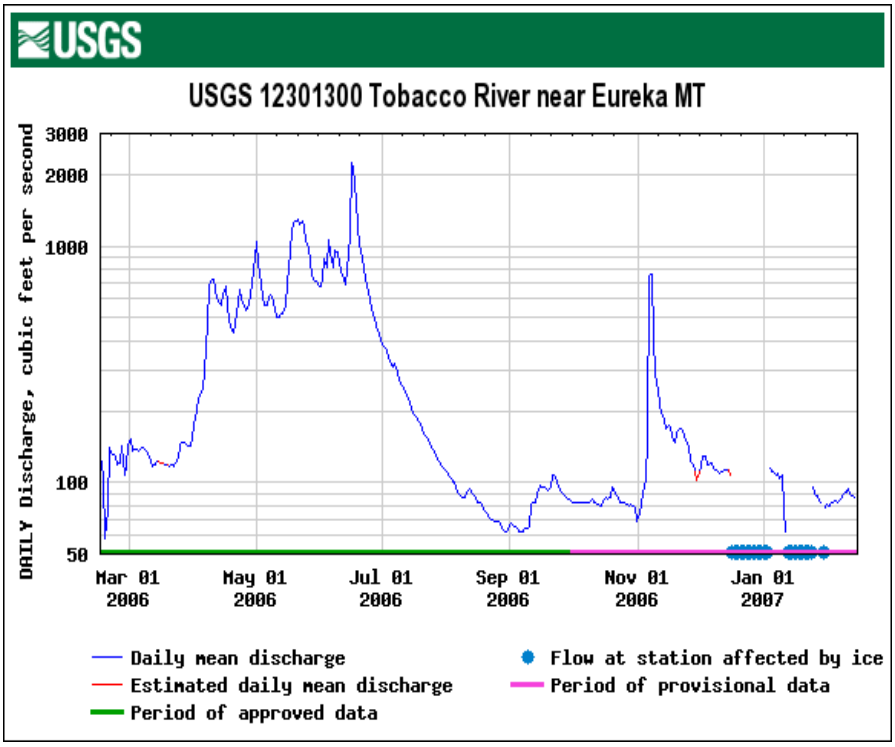

Figure B2-7. Recent Streamflow Data for Tobacco River (USGS, accessed 2/13/07)

Also worth noting in **Figure B2-7** is the peak in early November, which was caused by a rain on snow event. These events occur periodically in the Tobacco River watershed and can produce a tremendous amount of water over a short period of time (Bohn, 1998). **Figure B2-8** illustrates the range in historical peak flows on the Tobacco River at USGS gage station 12301300.

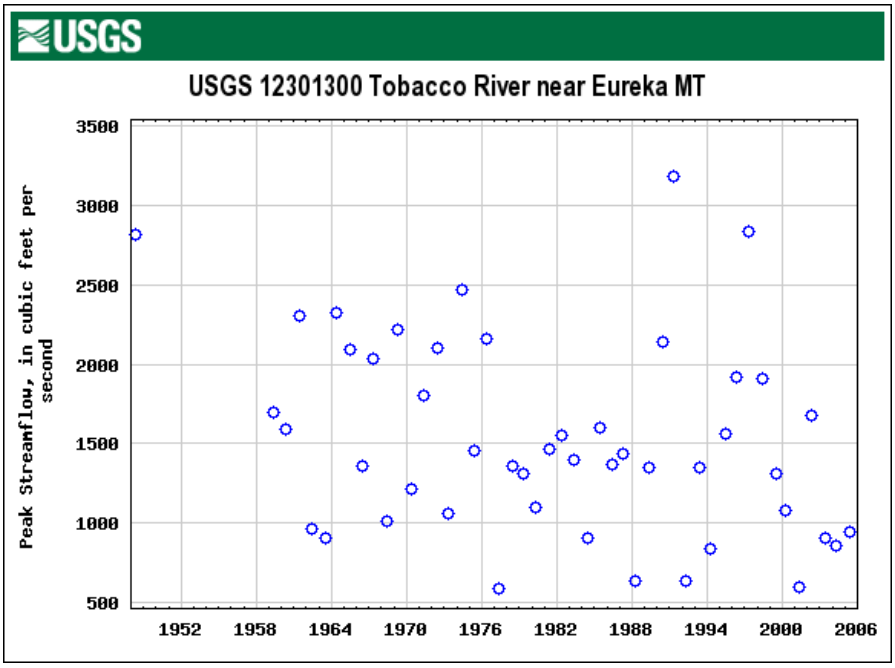

Figure B2-7. Historical peak flows for the Tobacco River (USGS, accessed 2/13/07)

These data demonstrate that the peak flow was over 2,500 cfs three times in the period of record. The highest flow on record for the Tobacco River was 3,180 cfs on May 13, 1991.

B2.4.2 Dam Information

The Tobacco River flows into Koocanusa Reservoir on the Kootenai River. Libby Dam was completed in 1972 and backs up water for 90 miles. The reservoir has some influence on fish species composition in the Tobacco River. In addition to Libby Dam, an irrigation diversion dam and head gate were installed in lower Grave Creek in 1923 (Bohn, 1998; USDA, 1999b). This structure and associated ditch provide irrigation water to the Tobacco Valley. The ditch runs over 11 miles to Eureka through Glen Lake, and is owned and operated by the Glen Lake Irrigation District. The log diversion dam had created a fish passage problem and was removed in 1999 to correct this problem (see **Section 3.5.1** for more detail) (USDA, 1999b).

B2.5 Geology, Soils, and Morphology

B2.5.1 Geology

A map of the Tobacco River watershed geology is included in **Appendix A** (**Map A-3**). Most of the bedrock exposed in the area belongs to the Belt Supergroup of Precambrian age, which exceeds 40,000 feet in thickness (Johns, 1970). The rocks are composed of primarily quartzites, siltites, argillites, and dolomites (USDA, 2002). Unconsolidated Quaternary alluvium is found in the Grave Creek valley bottom, most of the lower Tobacco River, and parts of the Fortine valley bottom. The unconsolidated alluvium includes a mix of silt, sand and gravels and is highly erodible when disturbed and exposed. Small exposures of sedimentary rock of the Cambrian Period and the Devonian Period (Belt Series) are seen the Swamp Creek area of the watershed (UDSA, 1998b, Harrison, Cressman, and Wipple, 1983). The Wallace Formation, also Belt Series rock, is found in Upper Fortine, Lower Swamp, Trego, Sunday, and Upper Meadow areas. The Wallace Formation is comprised of mixed lithologies including carbonate facies, which are naturally very erodible. The Lower Swamp Creek and Fortine Creek valley bottoms are filled with unconsolidated glacial lake deposits consisting primarily of silt. Another Belt Series Group, the Piegan Group, is located in the Grave Creek and Lower Tobacco/Ksanka area. Lithologies of the Piegan group include shale and limestone (USGS, 2002).

B2.5.2 Soils

The soil types in the Tobacco River watershed are mapped by erodibility in **Map A-4** of **Appendix A**. The Tobacco Valley is filled with Pleistocene and Holocene age outwash and till. In the past 12,000 years, glaciers left large deposits of sand, silt, and rock along the floor of the Tobacco Valley; consequently, much of the plain is covered with a mantle of very fine sandy loam to loamy fine sand. Many of these deposits are relatively erodible and release much sediment when cut by streams like Fortine Creek (USDA, 1998a). Accordingly, soils in these areas have the highest erodibility (K-factor) in the watershed (**Map A-4**, **Appendix A**). Kettle holes from glacial activity occur throughout the valley.

B3.0 SOCIAL PROFILE

B3.1 LAND COVER

B3.1.1 Vegetation Types and Cover

Land cover types in the Tobacco River watershed are listed in order of dominance in **Table B3-1** below.

Table B3-1. Land Use/Cover in Tobacco River Watershed

Land Use	**Percent of Total** (as of 2006)
Evergreen Forest	74.71%
Shrubland	10.85%
Grasslands/Herbaceous	7.27%
Transitional	2.40%
Pasture/Hay	1.45%
Open Water	0.79%
Small Grains	0.63%
Fallow	0.53%
Commercial/Industrial/Transportation	0.40%
Bare Rock/Sand/Clay	0.37%
Deciduous Forest	0.31%
Emergent Herbaceous Wetlands	0.14%
Low Intensity Residential	0.08%
Woody Wetlands	0.04%
Perennial Ice/Snow	0.01%
Orchards/Vineyards/Other	0.01%
Urban/Recreational Grasses	0.00%
High Intensity Residential	0.00%
Mixed Forest	0.00%

Data Source: NRIS, from NLCD files

As listed in **Table B3-1**, the dominant vegetation in the majority of the watershed is evergreen forest (74.71%). Shrubland, the second most abundant vegetation type, is found in 10.85% of the watershed. Grassland/Herbaceous is seen in 7.27% of the Tobacco River watershed. Land cover types are also illustrated in **Map A-5** (**Appendix A**), which shows that the grass rangeland and cropland are confined to the valley bottoms and the large grassland near Eureka. Very little of the land area in the Tobacco River watershed is commercial or urban; the watershed is largely undeveloped.

Limited areas of the lower Tobacco Valley are influenced by rainshadow effects and contain remnants of true shortgrass prairie (Cooper, 2003). Looking at the precipitation map (**Map A-2** in **Appendix A**), it is clear that the valley bottoms receive significantly less precipitation than the more mountainous areas, which is reflected in the vegetation distribution. In the relatively dry (annual precipitation below 15 inches) lowland areas of the watershed (called the Tobacco Plain), mountain grassland vegetation is abundant in the form of rough fescue (Festuca campestris), Idaho fescue (Festuca idahoensis), and bluebunch wheatgrass (Pseudoroegneria spicata) (USDA, 2002; USDA, 1998a).

In the surrounding upland landscape, the annual precipitation increases and grassland changes to forested areas. The majority of the Tobacco River watershed is dominated by evergreen forests (**Table B3-**). The overall matrix for the Tobacco River watershed is a mosaic of forested types with Douglas-fir (Pseudotsuga menziesii), Western red cedar (Thuja plicata), Western hemlock (Tsuga heterophylla), and Grand fir (Abies grandis) constituting the lower elevation (montane) climax series, and subalpine fir (Abies bifolia) and spruce (Picea engelmannii) the subalpine climax series. Past disturbances such as logging and fire contribute to the abundance of subclimax forests dominated by Douglas fir, ponderosa pine, lodgepole pine (Pinus contorta) and larch (Larix occidentalis) (Cooper, 2003; Leavell, 2000; USDA, 1998b). Despite a long history of logging in the watershed, some old growth forest remains. Based on the U.S. Forest Service (USFS) Region 1 definition of old growth, subbasins of Tobacco River watershed contain the following percent cover of old growth forest: Lower Tobacco HUC, 12.5%; Fortine Creek, 6.3%; and Grave Creek, 9.5% (USDA, 2006).

B3.1.2 Riparian Habitat and Non-Native/Invasive Species

Riparian habitat on the Tobacco River has been altered by past splash dams, log drives, irrigation diversions, riparian harvest, and road and railway construction. Early settlers in the Tobacco Valley noted extensive stands of riparian vegetation containing hardwoods, conifers, willows, and alders growing alongside streams; moist draws; and wet meadows. Over the past 100 years, the riparian areas and wetlands have been eliminated, reduced, or fragmented. These areas have been drained, filled, sprayed with herbicides, grazed, or logged to facilitate agriculture and development (USDA, 1998a).

Noxious weed introduction is another element of riparian vegetation alteration. The following noxious weeds are found in the watershed: Canada Thistle (Cirsium arvense), St. Johns-Wort (Hypericum perforatum), Spotted knapweed (Centaurea maculosa), Dalmation Toadflax (Linaria dalmatica), and Sulfur Cinquefoil (Potentilla recta) (USDA, 1999a; NRIS).

B3.2 LAND OWNERSHIP

The majority (67.5%, or 298 square miles) of the land in the Tobacco River watershed is public land managed by U.S. Forest Service (**Table B3-2** below and **Map A-6** in **Appendix A**).

Table B3-2. Land Ownership Summary for the Tobacco River Watershed

Owner	Ownership (mi^2)	Percent of HUC
USFS	297.9	67.5
Private	127	28.8
State	11.3	2.6
Water	2.8	0.6
Plum Creek	1.2	0.3
The Nature Conservancy	0.9	0.2
Bureau of Reclamation	0.3	0.1

Source: NRIS, MTNHP

The USFS land is managed by the Fortine Ranger District of the Kootenai National Forest. Private land holdings account for 28.8% (127 square miles) of the land. Private land is primarily located in the valley bottoms adjacent to stream corridors. In fact, 90% of the land directly adjacent to the Tobacco River is privately owned (USDA, 1999a). Approximately three percent (11 square miles) is owned by the state of Montana. In addition, Plum Creek Timber Company, The Nature Conservancy and the U.S. Bureau of

Reclamation each own less than one percent (1.2, 0.9 and 0.3 square miles, respectively) of the land in the Tobacco River watershed. The Nature Conservancy land (Dancing Prairie Preserve) is located in the remnant prairie ecosystem just north of Eureka, Montana.

B3.3 LAND USE

B3.3.1 Timber Production

Land use in the watershed is primarily timber production, and in the past, portions of the Tobacco River watershed have been heavily logged (USDA, 1987). Homesteaders began clearing timber from their land in the Tobacco Valley in the early 1900's to meet the terms of various land acquisition acts. This cleared area was cultivated for the thriving Christmas tree market in the 1930's (USDA, 1998a). The construction of the Great Northern Railroad at the turn of the century through the Tobacco River valley established a demand for the abundant supply of timber. Widespread timber harvesting resulted in road building to facilitate harvest (USDA, 1998a).

Throughout the early 1900's Fortine Creek and the Tobacco River were used as log drive channels. Photos show large log jams completely covering the channel for long distances. Impacts of this activity are not well documented, but it can be inferred that recovery is slow and occurs on the order of 50-100 years (USDA, 1996). Early logging and subsequent fire suppression have affected the relative proportions of pine, larch and fir. Stands that were selectively harvested in the mid-1900's are now composed primarily of Douglas-fir that were left or grew in after harvest (USDA, 1998a).

B3.3.2 Agricultural Uses

Table B3-1 above and **Map A-5** in **Appendix A** show that only relatively small areas of the watershed are cultivated. Total cultivated land includes Pasture/Hay 1.45%, Small Grains 0.63%, Fallow 0.53% and Orchards/Vineyards/Other 0.01%, totaling only 2.62% of the land in the Tobacco River watershed used in agriculture.

Map A-7 in **Appendix A** shows the industrial, municipal and irrigation water withdrawals from the Tobacco River and its tributaries. Most are irrigation withdrawals (NRIS – DNRC Water Rights website). In general, irrigation withdrawals are clustered around the mouth of streams and near the towns of Fortine and Eureka. When comparing the land ownership with water withdrawal data, it was found that all irrigation withdrawals are located on private property.

B3.3.3 Recreational Activities

The Tobacco River watershed provides many opportunities for recreation, including hunting, fishing, hiking, and camping. The Kootenai National Forest supports populations of elk, moose, bighorn sheep, mountain goats, whitetail and mule deer, black and grizzly bear, and mountain lion. Many of these animals are hunted and the rivers and lakes of the watershed provide ample fishing opportunities (USDA, 1987). The Tobacco River watershed is also used by firewood and Christmas tree gatherers, mountain bikers, and horseback riders. In addition to local use, there is some commercial growth in guiding of outdoor recreation in the area.

B3.3.4 Wildfire

In the Fortine River drainage, fire scar analysis of 1995 data shows large stand replacement fires occurred infrequently in the past – only once every 150-300 years (UDSA, 1996). The natural cycle of fires has been interrupted in parts of the watershed. Fuel is accumulating in the forest and has increased

the risk of high-intensity, large acreage, stand-replacement wildfires (USDA, 1998a). According to the Forest Service the period from 1900-1950 had the largest area of fire activity in the watershed.

B3.3.5 Mining Activity

Map A-8 in **Appendix A** shows active and abandoned mines in the Tobacco River watershed. Mining played a small role in the history of the area. A gold strike in the Kootenai in 1864 led miners to move north through the area and placer mine along the Kootenai River, parts of the Tobacco River, and Grave Creek during this period (Johnson, 1950; Johns, 1970). The most productive copper-silver-lead claims are clustered in the area of Bluebird Basin, Independence Peak, and Poorman Mountain northeast of Eureka on the western slope of the Whitefish Mountain range (Johns, 1970). The Independence mine, one of the district's most important discoveries, was located in this area in 1892. The mine operated intermittently until 1912 when the British Columbia Copper Company leased it and several other claims with plans to expand and develop the mining operations. These plans were thwarted by the outbreak of World War I. Small scale mining continued in the Tobacco River district for the next several decades (Johns, 1970; Renk, 1994; Johnson, 1950). Placer deposits continued to attract prospectors, and a small amount of gold was recovered from the Tobacco River in 1921 (Lyden, 1948). High unemployment during the Depression increased the amount of placer activity throughout the region, and small strikes were made; however, no additional large scale mining operations existed.

Recent mining is limited in the Tobacco River Watershed. According to the Montana DEQ Abandoned Mines Section database there are nine lode mines and one placer mine located within the watershed. Of these most are past producers or have unknown status. The lone placer mine “Tobacco River Placer” has a listed status of expected prospect (NRIS - MTDEQ Mines Database).

B3.3.6 Transportation

Areas of high road density in the watershed are linked to the prevalence of recreational and logging activities. Transportation corridors in the Tobacco River watershed include the railroad, US highway 93, and state, county, and private roads. Burlington Northern Santa-Fe Railroad runs through the watershed and roughly parallels Highway 93.

B3.4 POPULATION

B3.4.1 Towns and Cities Located in the Watershed

The Tobacco River watershed is sparsely populated. Eureka is the largest town, with a total of 1,017 year round residents, according to the 2000 census. Other communities located within the watershed boundary include Fortine (population 200), and Trego (population 30). The population of the area is reportedly growing; the Eureka Chamber of Commerce reports a population of 5,423 in the surrounding Eureka area in 2007 (Eureka website 2007).

B3.4.2 Demographics

According to the 2000 U.S. Census Bureau data, there were approximately 4,000 people living in the Tobacco River watershed in 2000. Of these people over 97% were white (NRIS-Census Bureau Data). Information for Lincoln County suggests that the population is increasing with much of the increase attributed to retirees attracted to the outdoor beauty and affordable living of the area (USDA, 2002). In 1999, Lincoln County had a per capita personal income (PCPI) of $16,711 (the national PCPI was $28,546 at that time). Data for employment by industry shows the following top employers for Lincoln County in 1999: 24.4% Services, 17.9% Retail Trade and 16.3% Manufacturing (USDA, 2002).

B3.4.3 Septic Density/MPDES Permits and Withdrawals

According to the 2000 Census Bureau data, 98% of the Tobacco Valley watershed has low septic density (NRIS). As mentioned previously in **Section B3.3.2**, irrigation withdrawals in the watershed are concentrated on the mainstem of the Tobacco River, Grave Creek, and Fortine Creek, and at the downstream end of the tributaries (**Map A-7** in **Appendix A**). Other types of water withdrawals use-types common in the Tobacco River watershed include: Domestic use - 909 permits (31%), Stock use - 542 permits (18%), Fish and Wildlife use – 319 permits (11%) and Lawn and Garden use – 215 permits (7%). Similar to irrigation withdrawals, municipal and industrial withdrawals are located in or around the towns in the Tobacco River watershed (**Map A-7**) (NRIS – DNRC Water Rights website).

There are multiple point sources within the Tobacco River watershed with a Montana pollutant discharge elimination system general permit:

- Eureka Sewage Treatment Facility (permit number: MTG580032)
- Timberline Ready Mix (permit number: MTR300259), and
- Less than ten general permits for stormwater related to construction activities

The Eureka sewage treatment facility and the Timberline ready mix facility both discharge to the Tobacco River. The construction sites with a general stormwater permit are located throughout the watershed. The location of each permitted facility is shown on **Map A-7** in **Appendix A**.

B3.5 Restorative Efforts

B3.5.1 Fisheries and Aquatic Life Restoration Projects

As mentioned earlier in **Section B2.4.2**, the dam and head gate built on Grave Creek in 1923 was a major barrier to migrating bull trout. In 1976, Montana Fish Wildlife and Parks modified the diversion dam to provide passage for most fish moving upstream (USDA, 1999b); however the dam was still a partial barrier. Additionally, hydrologists determined the structure to be unstable and prone to collapse (USDA, 1999b). Glen Lake Irrigation District, the U.S. Forest Service, Montana Fish Wildlife and Parks worked out an agreement to remove the log dam and replace it with a series of rock structures. The new rock weirs are expected to improve fish passage, transport sediment bedload, and divert water for irrigation. In addition, a fish screen was installed to prevent downstream migrating fish from entering the ditch system (USFWS, 2007).

B3.5.2 Stream (Morphological, Riparian Zone) Restoration Projects

There are recent and ongoing restoration projects in the Tobacco River watershed. The Kootenai River Network (KRN) facilitates stream restoration and monitoring projects throughout the Kootenai River Basin (KRN website). On Grave Creek, approximately 1,000 feet of stream channel was reconstructed to reduce sediment delivery from a high eroding bank. The bank was re-contoured, reinforced and planted to center the streamflow, increase fisheries habitat pool habitat and complexity, and stabilize streambanks.

On Therriault Creek, approximately 9,300 feet of channel and 55 acres of abandoned wetlands adjacent to the channel were restored. These projects were planned and funded through a partnership between Bonneville Power Administration, Montana Fish Wildlife and Parks, U.S. Fish and Wildlife Service - Partners for Fish and Wildlife, Fish and Wildlife Service Private Stewardship Grant Program, Montana Future Fisheries, and the Vredenburg Ranch (KRN website).

B4.0 BIOLOGICAL RESOURCES

B4.1 FISH SPECIES FOUND IN THE TOBACCO RIVER WATERSHED

As a tributary to the Kootenai River, the Tobacco River and its tributaries provide important spawning and rearing habitat for fluvial and adfluvial fish populations that produce some of western Montana's popular sport fisheries, such as brook trout (Salvelinus fontinalis) and rainbow trout (Oncorhynchus mykiss) (Martz et al., 1988). Streams in this watershed also support species of special concern, including westslope cutthroat trout (Oncorhynchus clarkii lewisi), bull trout (Salvelinus confluentus), and Torrent sculpin (Cottus rhotheus) (**Table B4-1**).

Table B4-1. Tobacco River Watershed Fish Species of Concern

Scientific Name	Common Name	State Rank	USFW Status	USFS Status
Fish Species				
Cottus rhotheus	Torrent Sculpin	S3		
Oncorhynchus clarkii lewisi	Westslope Cutthroat Trout	S2		SENSITIVE
Salvelinus confluentus	Bull Trout	S2	THREATENED	THREATENED

Westslope cutthroat trout (Oncorhynchus clarki lewisi) is a subspecies of cutthroat trout native to Montana where it is found in the Kootenai watershed, the Clark Fork watershed, and the headwaters of the Missouri River. Westslope cutthroat trout were first described by Lewis and Clark and were once extremely abundant (Gardner, N.d.). Various studies have estimated that the westslope cutthroat trout now only occupies between 19% - 27% of its historic range in Montana (Van Eimeren, 1996). Cutthroat trout have declined due to habitat loss caused by poor grazing practices, historic logging practices, mining, agriculture, residential development, the lingering impact of forest roads, dewatering and dams. Non-native species have also taken a huge toll on westslope cutthroat trout (Novinger and Rahel, 1999). Hybridization with rainbow trout and even other non-native cutthroat trout subspecies is another reason for the decline in population. Thus, genetically pure westslope cutthroat trout are estimated to exist in only 2% - 4% of their historic stream distribution (McIntyre and Rieman, 1995). **Map A-9** in **Appendix A** shows the distribution of westslope cutthroat trout in the Tobacco River watershed.

Bull trout (Salvelinus confluentus) are listed as threatened species under the Endangered Species Act (USFWS, 1998). The bull trout is a member of the Charr family of fishes and is the only Charr species native to western Montana where populations are limited to the Columbia and Saskatchewan River basins. Bull trout are long-lived fish that do not reach breeding age until at least five years of age. Bull trout may have either a resident or migratory life history. Resident fish are usually found in smaller tributaries and headwater streams, while migratory fish spawn. The resident and migratory bull trout life history forms can live together and interbreed. This variety of life history strategies is important to the stability and persistence of populations, but complicates restoration and conservation because a diversity of high quality habitats are needed to support all life stages of bull trout. When these habitats are degraded, bull trout population may be negatively impacted (MBTRT, 2000).

In addition to habitat degradation, bull trout are threatened by non-native species hybridization and competition, historical eradication efforts, poisoning to remove non-game species, historical over-harvest, and ongoing poaching and accidental harvest due to misidentification (Meehan and Bjornn 1991, Bond 1992; Leary et al., 1993). There is a bull trout restoration plan for the state of Montana, as

well as a federal recovery plan (MBTRT, 2000). Bull trout are still widely distributed, although declines in abundance are apparent throughout the Columbia River watershed and strong or protected populations are becoming less common (Rieman et al., 1997). Bull trout redds have been observed in the Tobacco River. However, most of the bull trout from Lake Koocanusa migrate up the Tobacco River and spawn in Grave Creek and its tributaries. Most of the migrating adults and their young return to Lake Koocanusa (USDA, 1998a). Based on FWP survey information provided in the Montana Fisheries Information System (MFISH) database, abundance of Bull trout are listed as common in the Tobacco River and abundant in Grave Creek (**Tables B4-2** and **B4-3**). **Map A-10** in **Appendix A** shows the distribution of bull trout within the Tobacco River watershed.

Burbot (Lota lota) is listed as a sensitive species on the Kootenai National Forest. The lower Kootenai River once supported a significant number of burbot and provided an important winter fishery. Burbot numbers have declined dramatically; this decline has been associated with habitat modification resulting from the construction and operation of Libby dam (USDA, 2002). Very little is known about burbot populations in the Tobacco River drainage; however they are thought to spawn and rear in the mouth of the Tobacco River (USDA, 1998b).

In Montana, the Torrent sculpin (Cottus rhotheus) is found only in the Kootenai River system. The Torrent sculpin is listed as a state sensitive species but is known currently to inhabit the Tobacco River and its tributaries (USDA, 1999a). Torrent sculpin require low gradient, large streams with bottom substrate that is a mix of gravel and cobbles with low to moderate surface sediment embeddedness. The construction of Lake Koocanusa probably removed important spawning habitat meeting these requirements (USDA, 1996).

Table B4-2 summarizes Montana Fisheries Information System (MFISH) data for species and their relative distribution found in the Tobacco River.

Table B4-2. Species and Relative Abundance for the Tobacco River

Species	RM 3.7-5.2	RM 5.2-6.0	RM 6.0-17.1
Brook trout	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Bull Trout	Common (e.s.)	Common (e.s.)	Common (e.s.)
Burbot	No data	No data	No data
Largescale Sucker	Common (p.j.)	Common (p.j.)	Common (p.j.)
Longnose Dace	Common (p.j.)	Common (p.j.)	Common (p.j.)
Mountain Whitefish	Common (e.s.)	Common (e.s.)	Common (e.s.)
Rainbow Trout	Common (e.s.)	Common (e.s.)	Common (e.s.)
Sculpin	Common (p.j.)	Common (p.j.)	Common (p.j.)
Westslope Cutthroat Trout	Unknown (e.s.)	Unknown (e.s.)	Unknown (e.s.)

p.j.= professional judgment
e.s.= extrapolation from surveys
RM = River Mile
Data Source: MFWP, MFISH

Kokanee are found in the Tobacco River, and their abundance is listed as common in the MFISH database. These landlocked salmon live in Lake Koocanusa and then ascend the Tobacco River (MFISH; Books 1996). Rainbow trout are listed as common and have been historically stocked in Lake Koocanusa. As of 2006, Montana Fish Wildlife and Parks stocked approximately 45,000 rainbow trout into Lake Koocanusa (Hensler, 2007). Rainbow trout compete directly with native westslope cutthroat trout for

habitat and food sources. Through hybridization, they also are a threat to genetically pure strains of native fish (USDA, 2002). They are generally rare in the Tobacco River and Grave Creek drainages and common in some Fortine Creek drainages. Brook trout are also a concern throughout the Tobacco River watershed. FWP stocking records indicate that brook trout were first introduced into the Tobacco River in 1924 (USDA, 1999). Brook trout also compete directly with cutthroat trout. Brook trout are aggressive and highly adaptable generalists. In addition to competition for food and potential hybridization, brook trout compete with bull trout for spawning and rearing habitat (USDA, 2002). These non-native threats prevail in Fortine Creek (**Table B4-4**).

Table B4-3 summarizes MFISH data for species and their relative distribution found in Grave Creek. As mentioned above, Grave Creek is an important spawning area for the federally listed bull trout. **Table B4-4** summarizes MFISH data for species and their relative distribution found in Fortine Creek.

Table B4-3. Species and Relative Abundance for Grave Creek

Species	RM 0-9.4	RM 9.4-11.9	RM 11.9-13.2	RM 13.2-15.9
Brook trout	Rare (e.s.)	Rare (e.s.)	Rare (e.s.)	Rare (e.s.)
Bull trout	Abundant (e.s.)	Abundant (e.s.)	Abundant (e.s.)	Abundant (e.s.)
Mountain Whitefish	Common (e.s.)	Common (e.s.)	Common (e.s.)	Common (e.s.)
Rainbow Trout	Rare (e.s.)	Rare (e.s.)	Rare (e.s.)	Rare (e.s.)
Sculpin	No Data	No Data	No Data	No Data
Torrent Sculpin	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Westslope Cutthroat Trout	Common (e.s.).	Common (e.s.)	Common (e.s.)	Common (e.s.)

p.j.= professional judgment
e.s.= extrapolation from surveys
RM = River Mile
Data Source: MFWP, MFISH

Table B4-4. Species and Relative Abundance for Fortine Creek

Species	RM 0-22.8	RM 22.8-26.6	RM 26.6-30.7
Brook trout	Common (e.s.)	Abundant (p.j.)	Common (p.j.)
Largescale Sucker	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Longnose Dace	Common (p.j.)	Common (p.j.)	Common (p.j.)
Longnose Sucker	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Mountain Whitefish	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Rainbow Trout	Rare (p.j.)	Rare (p.j.)	Rare (p.j.)
Torrent Sculpin	Common (e.s.)	Common (e.s.)	Common (e.s.)
Westslope Cutthroat Trout*	Common (p.j.)	Common (p.j.)	Common (p.j.)

*MFISH shows that the genetic status of Westslope Cutthroat Trout in Fortine Creek is potentially hybridized and may not contain genetically pure populations. Therefore, non-hybridized populations may not be common.
p.j.= professional judgment
e.s.= extrapolation from surveys
RM = River Mile
Data Source: MFWP, MFISH

B4.2 Species of Special Concern

The Tobacco River watershed is home to 16 animal and 23 plant species of concern in the state of Montana's Natural Heritage Program (**Table B4-5**).

Table B4-5. Tobacco River Watershed Species of Concern

Scientific Name	Common Name	State Rank	USFW Status	USFS Status
Animal Species				
Ammodramus savannarum	Grasshopper Sparrow	S3B		
Canis lupus	Gray Wolf	S3	ENDANGERED, Experimental Population	ENDANGERED
Contopus cooperi	Olive-sided Flycatcher	S3B		
Gavia immer	Common Loon	S2B		SENSITIVE
Corynorhinus townsendii	Townsend's Big-eared Bat	S2		SENSITIVE
Histrionicus histrionicus	Harlequin Duck	S2B		SENSITIVE
Lynx canadensis	Canada Lynx	S3	THREATENED	THREATENED
Spizella breweri	Brewer's Sparrow	S2B		
Otus flammeolus	Flammulated Owl	S3B		SENSITIVE
Poecile hudsonica	Boreal Chickadee	S1S2		
Tympanuchus phasianellus columbianus	Columbian Sharp-tailed Grouse	S1		
Ursus arctos	Grizzly Bear	S2S3	THREATENED	THREATENED
Plant and Lichen species				
Botrychium ascendens	Upward-lobed Moonwort	S1S2		SENSITIVE
Botrychium crenulatum	Wavy Moonwort	S2S3		SENSITIVE
Botrychium hesperium	Western Moonwort	S2		SENSITIVE
Botrychium paradoxum	Peculiar Moonwort	S2		SENSITIVE
Botrychium pallidum	Pale Moonwort	S1		
Botrychium pedunculosum	Stalked Moonwort	S1		SENSITIVE
Brachythecium reflexum	---	S1		
Carex sychnocephala	Many-headed Sedge	S1		
Lathyrus bijugatus	Latah Tule Pea	S1		SENSITIVE
Scirpus subterminalis	Water Bulrush	S2		SENSITIVE
Silene spaldingii	Spalding's	S1	THREATENED	THREATENED

Table B4-5. Tobacco River Watershed Species of Concern

Scientific Name	Common Name	State Rank	USFW Status	USFS Status
	Campion			
Aloina brevirostris	---	S1		
Amerorchis rotundifolia	Round-leaved Orchid	S2S3		SENSITIVE
Carex prairea	Prairie Sedge	S2		SENSITIVE
Carex vaginata	Sheathed Sedge	S1		SENSITIVE
Cypripedium passerinum	Sparrow's-egg Lady's-slipper	S2		SENSITIVE
Eleocharis rostellata	Beaked Spikerush	S2		SENSITIVE
Eriophorum gracile	Slender Cottongrass	S2		SENSITIVE
Mimulus breviflorus	Short-flowered Monkeyflower	S1S2		SENSITIVE
Mimulus patulus	Stalk-leaved Monkeyflower	S1		SENSITIVE
Ophioglossum pusillum	Adder's Tongue	S2		SENSITIVE
Scheuchzeria palustris	Pod Grass	S2		SENSITIVE
Scirpus cespitosus	Tufted Club-rush	S2		SENSITIVE
Scirpus subterminalis	Water Bulrush	S2		SENSITIVE
State Rank Scale: 1=High Risk to 5=Common Source: Montana Natural Heritage Program				

These include several of the fish species discussed above in this section and also include two threatened mammals: the Canada Lynx and the Grizzly Bear, and the endangered Gray Wolf. The Gray Wolf has recently been proposed for delisting.

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APPENDIX C - REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

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

C1.0 TMDL DEVELOPMENT REQUIREMENTS

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

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

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

A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State law and Section 303 of the CWA also require TMDL development for waterbodies threatened by a pollutant cause. There are no threatened waterbodies within the Tobacco TPA.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded. TMDLs are often expressed

in terms of an amount, or mass, of a particular pollutant over a particular time period (e.g. pounds of total nitrogen per day). TMDLs can also be expressed in other appropriate measures such as a percent reduction in pollutant loading. TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS.

To satisfy the Federal CWA and Montana state law, TMDL development will eventually be needed for each waterbody-pollutant combination identified on Montana's 2010 303(d) List of impaired waters in the Tobacco TPA, unless new data and associated analyses is sufficient to remove a pollutant cause of impairment from one or more waterbodies. State law (Administrative Rules of Montana 75-5-703(8)) also directs Montana DEQ to "...support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

C2.0 Applicable Water Quality Standards

Water Quality Standards (WQS's) include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Water quality standards form the basis for the targets described in **Section 5.4.1**. Sediment is the only pollutant addressed via TMDL development in this document. This section provides a summary of the applicable water quality standards for sediment. These sediment TMDLs inherently address the additional non-pollutant causes of impairment identified in **Section 1**, **Table 1-1**.

C2.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana Water Quality Act directs the Board of Environmental Review (BER) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (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 have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source activities or pollutant discharges may not make the natural conditions worse.

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

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table C2-1**. All but one waterbody within the Tobacco TPA are classified as B-1 except for Deep Creek. Deep Creek is classified as A-1 because at one time it was used as a public drinking water source.

Table C2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

C2.2 STANDARDS

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

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

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

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the Department. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the 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 WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a waterbody. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Tobacco 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 C2-2**. The standards applicable to a B-1 classification are used in **Table C2-2** and are the same for A-1 classification unless otherwise noted within **Table C2-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table C2-2**). Naturally occurring levels are evaluated using a reference approach as defined in **Section C-3**.

Table C2-2. Applicable Rules for Sediment Related Pollutants

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

Turbidity

Turbidity is a measure of light scatter in water. Suspended or colloidal solids like phytoplankton, metal precipitates or clay may cause the light scatter. As identified in **Table C2-2**, the allowable changes in turbidity (above naturally occurring levels) is a rather small 5 nephelometric turbidity units (NTUs) for a B-1 stream, and no increase above naturally occurring for an A-1 stream. The likely direct effects of increased turbidity are on recreation and aesthetics as well as drinking water supplies. Increased turbidity can indirectly be linked to potential increased concentrations in pathogens, total recoverable metals and total suspended sediment. In some cases it may be a useful surrogate for total suspended

solids (TSS) based on a statistical correlation between paired turbidity and TSS data collected during varying flow conditions; preferably a full hydrograph for the stream of interest.

C3.0 Reference Conditions

C3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment (2006)

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic land use activities.

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.

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

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

The following methods may be used to determine reference conditions:

Primary Approach

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

Secondary Approach

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

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

C3.2 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 C3-1 is an example boxplot presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

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

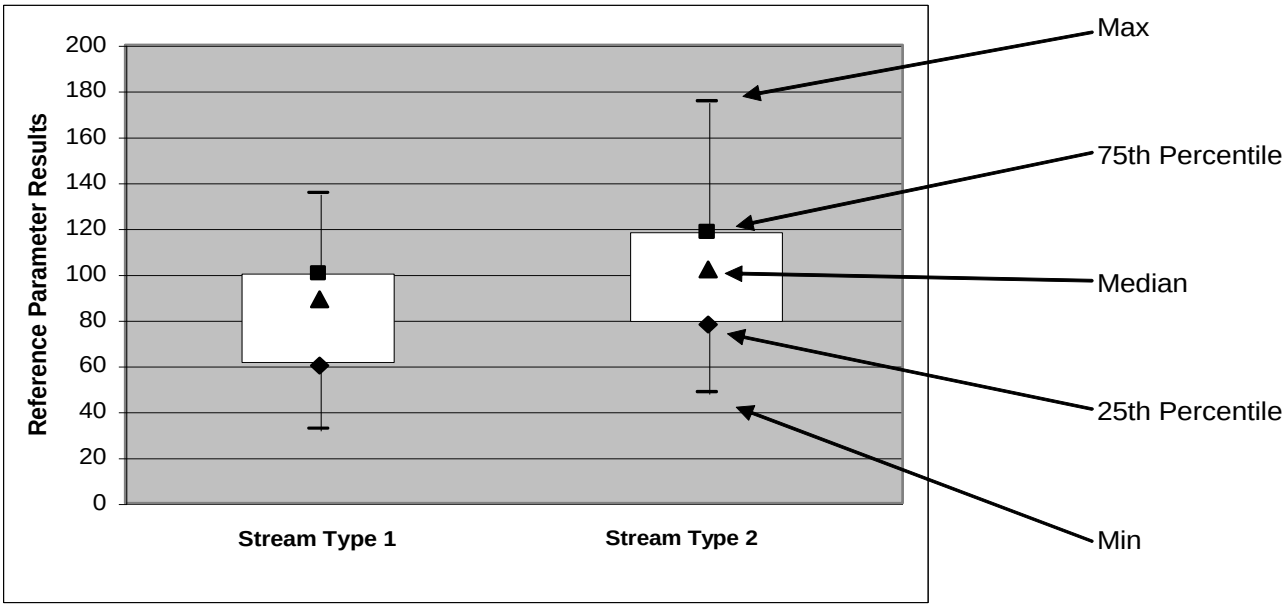

Figure C3-1. Boxplot Example for Reference Data

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

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.

4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table C2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

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

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

Options When Regional Reference Data is Limited or Does Not Exist

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

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck, et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure C3-2** is an example statistical distribution where higher values represent better water quality. In **Figure C3-2**, the median

and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

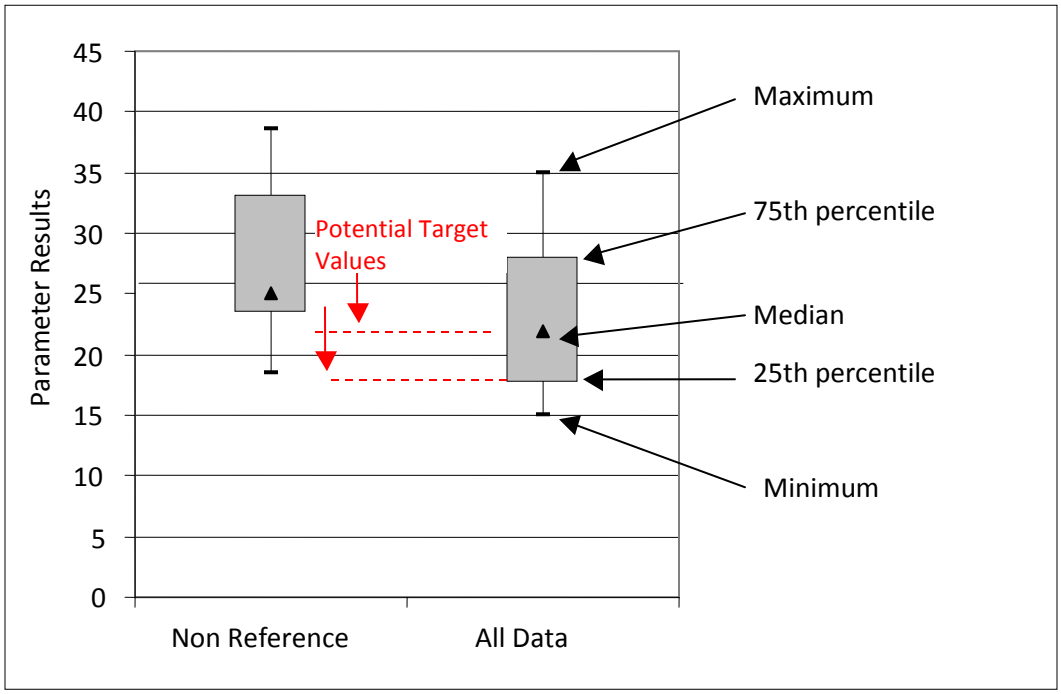

Figure C3-2. Boxplot Example for the Use of all Data to Set Targets

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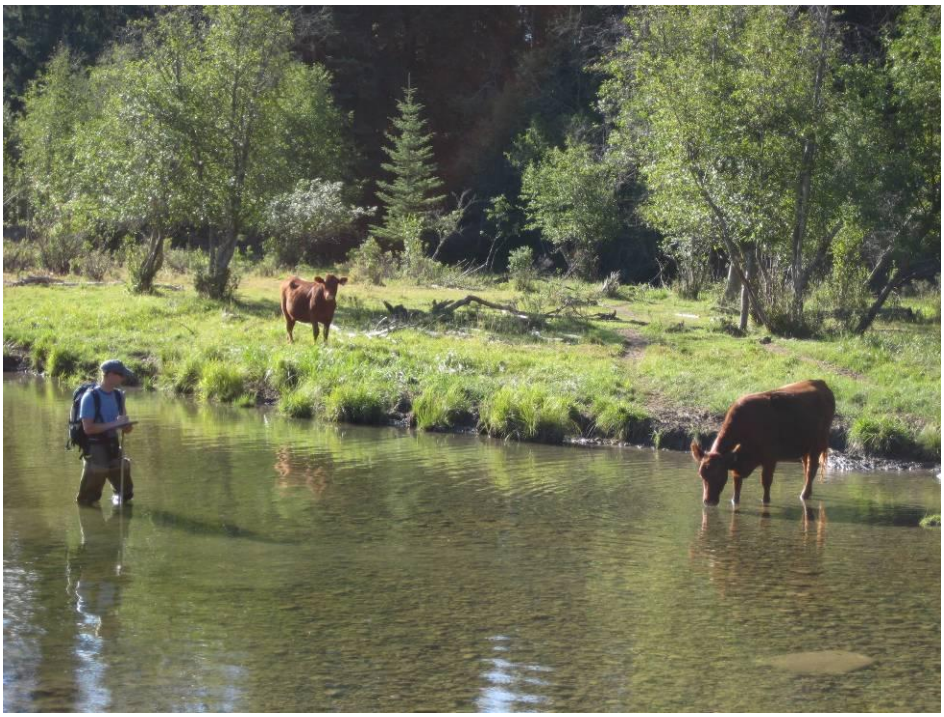
APPENDIX D - SEDIMENT AND HABITAT ASSESSMENT



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D1.0 INTRODUCTION

This appendix is derived from a sediment and habitat assessment report prepared by Water and Environmental Technologies (2008) for presentation to the Kootenai River Network and the Montana Department of Environmental Quality (DEQ). In 2008, DEQ initiated an effort to collect data to support the development of sediment TMDLs for streams within the Tobacco River TPA. The data collection effort involved assessing sediment and habitat conditions within the Tobacco River watershed, as these conditions influence aquatic life beneficial uses. The data collection effort included stream stratification, sampling design, ground surveys, and sediment and habitat analyses, and is intended to assist DEQ in evaluating the impairment status of tributary streams in the Tobacco River TPA and for developing TMDLs where necessary.

The 2006 303(d) List includes the following streams listed as impaired due to sediment: Tobacco River, Grave Creek, Fortine Creek, Deep Creek, Therriault Creek, Lime Creek, Edna Creek, and Swamp Creek. In addition to these streams, Sinclair Creek was included due to stakeholder interest in this stream. A TMDL and Water Quality Restoration Plan has already been prepared for the Grave Creek Watershed (DEQ 2005), but the stream was included in the watershed stratification and a limited assessment efforts for the purposes of consistency and extrapolation of sediment loads.

The stream stratification method is intended to develop waterbody 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 human influences. Stratification for the Tobacco River TPA streams began by dividing the waterbodies into reaches and sub-reaches. These divisions were based on aerial photo interpretation of stream characteristics, landscape conditions, and land-use factors. This preliminary work was completed in summer 2008.

Following the initial primary reach stratification, representative sub-reaches were chosen by DEQ for data collection. A two-day sampling reach reconnaissance was conducted on July 21 and 22, 2008, and field personnel completed full site surveys from August 21 to 28, 2008. Field personnel visited the selected sub-reaches and recorded bank erosion sites, vegetation, and channel characteristics data. Additional sites were surveyed for streambank erosion conditions only from September 8 to 12, 2008. These data were analyzed in January and February 2009, resulting in full descriptions of sediment and habitat conditions for all of the surveyed reaches and the ability to extrapolate to non surveyed reaches.

D2.0 AERIAL ASSESSMENT REACH STRATIFICATION

D2.1 METHODS

An aerial assessment of streams in the Tobacco River TPA was conducted using geographic information systems (GIS) software and 2005 color aerial imagery. 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 (NRIS) database. Layers include the following data sets:

- Ecoregion (USEPA)
- Scanned and Rectified Topographic Maps, 1:24,000 and 1:100,000 (USGS)
- National Hydrography Dataset Lakes and Streams (USGS)
- 2005 National Aerial Image Program (NAIP – NRIS)

GIS data layers were used to stratify streams into primary reaches based on stream characteristics, 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* (Montana Department of Environmental Quality, 2008). The reach stratification methodology involves delineating a waterbody stream segment into stream reaches and sub-reaches. This process was completed for the following stream segments in the Tobacco River TPA: Tobacco River, Grave Creek, Fortine Creek, Deep Creek, Therriault Creek, Lime Creek, Edna Creek, Swamp Creek, and Sinclair Creek.

D2.1 STREAM REACHES

Waterbody 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 waterbody segment is the smallest unit for which an impairment determination is made, the stratification approach described in this document initially stratifies individual waterbody segments into discrete assessment reaches that are delineated by distinct variability in landscape controls such as Ecoregion, Strahler stream order, valley gradient, and valley confinement. The reason for this stratification 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 waterbody 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 primary watershed characteristics, including Level IV Ecoregion, valley gradient, Strahler stream order, and valley confinement. Once stream reaches have been classified by the four watershed characteristics, reaches are further divided based on the surrounding vegetation and land-use characteristics as observed in the color aerial imagery using GIS. 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.

For ease of labeling, each listed stream in the assessment was assigned an abbreviation based on the stream name. These labels were use in the individual stream reach classification. **Table D2-1** shows the abbreviations developed for each waterbody.

Table D2-1. Waterbody naming key

Waterbody	Label Abbreviation
Deep Creek	DEP
Edna Creek	ENA
Fortine Creek	FTN
Grave Creek	GRV
Lime Creek	LME
Sinclair Creek	SNC
Swamp Creek	SWP
Therriault Creek	THR
Tobacco River	TOB

D2.2 Reach Types

Individual stream reaches were delineated by reach type based on four watershed characteristics. For the purposes of this report, a "reach type" is defined as a unique combination of Ecoregion, valley gradient, Strahler stream order, and valley confinement, and are designated using the following naming convention based on the reach type identifiers provided in **Table D2-2**:

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

Table D2-2. Reach type identifiers

Watershed Characteristic	Stratification Category	Reach Type Identifier
Level III Ecoregion	Northern Rockies	NR
	Canadian Rockies	CR
Valley Gradient	0-2%	0
	2-4%	2
	4-10%	4
	> 10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
	fifth order	5
Confinement	confined	C
	unconfined	U

For example, a reach identified as NR-0-3-U is in the Northern Rockies Level III Ecoregion, has a low valley gradient (0-2%), is a 3rd order stream, and is within an unconfined valley.

The Tobacco River TPA exists within two Level III Ecoregions, including Northern Rockies (Ecoregion 15) and Canadian Rockies (Ecoregion 41). The Northern Rockies Level III Ecoregion contains three Level IV Ecoregions in the Tobacco River TPA, including the Tobacco Plains (15d), Salish Mountains (15l), and the

Stillwater-Swan Wooded Valley (15t). The Canadian Rockies Level III Ecoregion contains one Level IV Ecoregion in the Tobacco River TPA, which is the Western Canadian Rockies Level IV Ecoregion (41c).

Present reach type combinations for the Tobacco River TPA are provided in **Table D2-3**, including the number of monitoring sites assessed for each reach type. Overall, 32 monitoring sites were selected for field evaluation, including 18 sites that received full site assessments (including all habitat parameters and evaluation of streambank erosion conditions) and 14 sites that received streambank erosion assessments (BEHI) only.

Table D2-3. Stratified reach types within the Tobacco River TPA

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confinement	Reach Type	Number of Reaches	Number of Full Monitoring Sites	Number of BEHI Monitoring Sites
Canadian Rockies	0 - 2%	2	U	CR-0-2-U	17	4	
		3	U	CR-0-3-U	1		
		4	C	CR-0-4-C	1		
			U	CR-0-4-U	9		
	2 - 4%	1	U	CR-2-1-U	3		
		2	C	CR-2-2-C	1		
			U	CR-2-2-U	7		
		3	U	CR-2-3-U	6	1	
		4	U	CR-2-4-U	2		
	4 - 10%	1	U	CR-4-1-U	6		
		2	C	CR-4-2-C	3		
			U	CR-4-2-U	6	1	2
		3	U	CR-4-3-U	5	1	
		4	U	CR-4-4-U	1		
	>10%	1	C	CR-10-1-C	2		
			U	CR-10-1-U	6		
		2	U	CR-10-2-U	2		
Northern Rockies	0 - 2%	1	U	NR-0-1-U	1		
		2	U	NR-0-2-U	4		
		3	U	NR-0-3-U	24	3	2
		4	U	NR-0-4-U	32	3	4
		5	U	NR-0-5-U	11	2	2
	2 - 4%	1	U	NR-2-1-U	3		
		2	U	NR-2-2-U	5		1
		3	U	NR-2-3-U	12	1	1
	4 - 10%	1	U	NR-4-1-U	3		
		2	U	NR-4-2-U	7		2
		3	U	NR-4-3-U	4	2	
	>10%	1	U	NR-10-1-U	2		
Totals:					**187**	**18**	**14**

Listed waterbodies included in this assessment exist within the different reach types listed above. **Table D2-4** shows the assessed waterbodies and monitoring sites included within each reach type. A map of monitoring site locations is provided as **Attachment A**.

Table D2-4. Monitoring sites in assessed reach types

Reach Type	Waterbody	Monitoring Site (Full and BEHI)
CR-0-2-U	Sinclair Creek, Therriault Creek	SNC-8-2, SNC 10-3, THR-9-5, THR-14-1
CR-2-3-U	Deep Creek	DEP 13-2
CR-4-2-U	Deep Creek, Sinclair Creek, Clarence Creek	DEP 7-1, SNC 5-1, Clarence
CR-4-3-U	Deep Creek	DEP 9-2
NR-0-3-U	Edna Creek, Fortine Creek, Swamp Creek	ENA 11-1, FTN 4-1, FTN 4-3, FTN 6-1, SWP 5-1
NR-0-4-U	Fortine Creek	FTN 9-3, FTN, 12-2, FTN 12-7, FTN 12-9, FTN 13-1, FTN 15-2, FTN 15-3
NR-0-5-U	Tobacco River	TOB 1-1, TOB, 1-3, TOB 2-3, TOB, 2-6
NR-2-2-U	Edna Creek	ENA 8-1
NR-2-3-U	Fortine Creek, Swamp Creek	FTN 7-2, SWP 9-1
NR-4-2-U	Edna Creek Swamp Creek	ENA 7-2, SWP 3-1
NR-4-3-U	Edna Creek, Lime Creek	ENA 10-2, LME 6-1

D3.0 SEDIMENT AND HABITAT DATASET REVIEW

D3.1 FIELD METHODOLOGY

The following sections include descriptions for the various field methodologies that were employed for the stream assessments. The methods follow standard DEQ protocols for sediment and habitat assessment as presented in the document *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007). All field data were collected on DEQ standard forms for sediment and habitat assessments, and are summarized and provided in tabular format in **Attachment B**. For most survey sites, a minimum of 5 team members were present, which were always divided into 3 teams, referred to as the "Greenline", "Longitudinal Profile" or "Long-Pro", 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 instream disturbance.

D3.1.1 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; 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 and upstream ends 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**.

D3.1.2 Field Determination of Bankfull

All members of the field crew 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.

D3.1.3 Channel Cross-Sections

The "Cross-Section team" was composed of two members of the assessment crew, who also performed pebble counts, riffle stability index, and riffle grid tosses. Channel cross-section surveys were performed at the first riffle in each cell moving upstream using a line level and a measuring rod. Channel surveys were recorded in the **Channel Cross-section Field Form**. Cross-sections were surveyed in each cell containing a riffle. 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 surveyed. If only 1 or 2 riffles were present in the entire reach, all riffle cross-sections were surveyed.

To begin each survey, 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 were present which prevented a clean line across the channel, the protocol provided in the field methodology document was followed (Montana Department of Environmental Quality, 2007). Depth measurements at bankfull were collected to a tenth of a foot across the channel at regular intervals depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals. From the recorded data, the following data were calculated for each cross-section:

Mean depth = sum of depth measurements / number of depth measurements (excluding the right bank and left bank measurements, unless they were greater than zero, such as 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

The floodprone elevation was determined by doubling the maximum channel depth. 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.

D3.1.4 Channel Bed Morphology

A variety of channel bed morphology features were measured and recorded by the “Long-Pro” 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 for riffles and 33% for pools. 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 (Montana Department of Environmental Quality, 2007).

D3.1.4.1 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 at its deepest point was measured. No pool tail crest depth was recorded for dammed pools (see **Section 3.1.4.2**). 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.

D3.1.4.2 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 estimated relative to bankfull channel width was recorded as Small (S), Medium (M), or Large (L). Small pools were defined as <1/3 of the bankfull channel width; medium pools were >1/3 and <2/3 of the bankfull channel with; and large pools were determined to be those >2/3 of the bankfull channel width or >20 feet wide.
3. Pool formative features were recorded as lateral scour (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.

D3.1.4.3 Fine Sediment in Depositional Spawning Areas

A measurement of the percent of fine sediment in depositional spawning areas was taken using the grid toss method at the first and second scour pool of each cell. Grid toss readings were focused in those 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 *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007). 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 presence of spawning gravels was recorded as Yes (Y) No (N) at each pool location.

D3.1.4.4 Fine Sediment in Riffles

Measurements of fine sediment in riffles were recorded by the Cross-Section team using the same grid toss method as used in pools (**Section D3.1.4.3**). Grid tosses were performed in the same general location but before the pebble counts (**Section D3.1.4.6**) to avoid disturbances to fine sediments. These measurements were recorded in the **Riffle Pebble Count Field Form.**

D3.1.4.5 Woody Debris Quantification

The amount of large woody debris (LWD) was recorded by the Habitat 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 *Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007).

D3.1.4.6 Riffle Pebble Count

A 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. These data were 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 can be found in the field methods document (Montana Department of Environmental Quality, 2007).

D3.1.4.7 Riffle Stability Index

In stream reaches that had well developed point bars downstream of riffles, a riffle stability index (RSI) was performed to determine the average size of the largest recently deposited particles, and to calculate an RSI which evaluates riffle particle stability (Kappesser, 2002). For stream reaches in which well developed gravel bars were present, a RSI was determined by first measuring the intermediate axis (*b-axis*) of 15 of the largest recently deposited particles on a depositional bar. This information was recorded in the **Riffle Pebble Count Field Form**. During post-field data processing, the arithmetic mean of the largest recently deposited particles is calculated. This value is then compared to the cumulative particle size distribution of an adjacent riffle, as determined by the Wolman pebble count. The RSI is reported as the cumulative percentile of the particle size classes that are smaller than the arithmetic mean of the largest recently deposited particles. The RSI value generally represents the percent of mobile particles within the riffle that is adjacent to the sampled bar.

D3.1.5 Riparian Greenline Assessment

After the entire survey station length was measured by the "Greenline" team member, an assessment of riparian vegetation cover was performed. The reach 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 was 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, riparian buffer width was estimated for both banks by evaluating 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.

D3.1.6 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) and Near Bank Stress (NBS) 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 **Sections** D**4.2** and D**4.3**.

D3.1.7 Water Surface Slope

Where possible, 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.

D3.1.8 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; and
- Description of riparian vegetation conditions.

D3.1.9 Quality Assurance/Quality Control

Quality assurance and quality control (QA/QC) was achieved through strict adherence to the project's sampling and analysis plan (Water & Environmental Technologies, 2008). Prior to field data collection, one full day of training was held to familiarize the entire crew with all the field forms and procedures. During each stream assessment, the field team leader and most experienced crew members led the separate teams. Equipment checks were done each morning and field maps were reviewed with drivers before approaching field sites. Field forms were distributed and double-checked before teams left the vehicles to the survey sites. At the conclusion of each stream assessment, all field forms were reviewed for completeness and accuracy. Any questions that arose from field teams were brought to the attention of the field team leader until resolved to the leader's satisfaction.

Despite the best efforts to adhere to the project's sampling and analysis plan (SAP), some deviations did occur while in the field and during data processing. Additionally, parameters used for sediment loading calculations were adjusted during data processing and following review of field photos to better represent actual field conditions. These adjustments and any deviations from the SAP are described in QA/QC notes provided in **Attachment C**.

D3.2 Sampling Parameter Descriptions and Summaries by Reach Type

The following sections provide definitions of sampling parameters that were measured at each reach, and basic statistical summaries of data for each parameter organized by reach type. Parameters described in this section include width/depth ratio, entrenchment ratio, percent understory shrub cover, percent bare/disturbed ground, riffle pebble count data (% <2 mm and <6 mm, D50), riffle grid toss data (% <6 mm), riffle stability index, mean pool depth, pool frequency, pool grid toss data (% <6 mm), and large woody debris (LWD) frequency. Data for each individual measurement site were used in the statistical analysis (i.e. data from each of the individual cross sections in one assessment reach were used), and then sample reaches and waterbodies were grouped into reach types as shown in **Table D2-3**.

Data provided for each parameter include box plots and data tables organized by each reach type and for the total planning area. The box plots and data tables provide the minimum and maximum observed values, and the 25th (Q1), 50th (median), and 75th (Q3) percentile values. Outliers, defined as values which are 1.5 times outside the interquartile range, are indicated by an asterisk on the box plots. Examples of these statistical parameters are shown on the first box plot of this section (**Figure D3-1)**. The statistics tables also provide the number of data cases available for each parameter. Parameters with a limited number of cases (N<4) will appear as a single line on the box plots.

D3.2.1 Width/Depth Ratio

The stream 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, 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.

The measured width/depth ratios for are presented in **Figure D3-1** by reach type, and summary statistics are provided in **Table D3-1**. All surveyed cross sections are included in the statistics generated within each reach type**.**

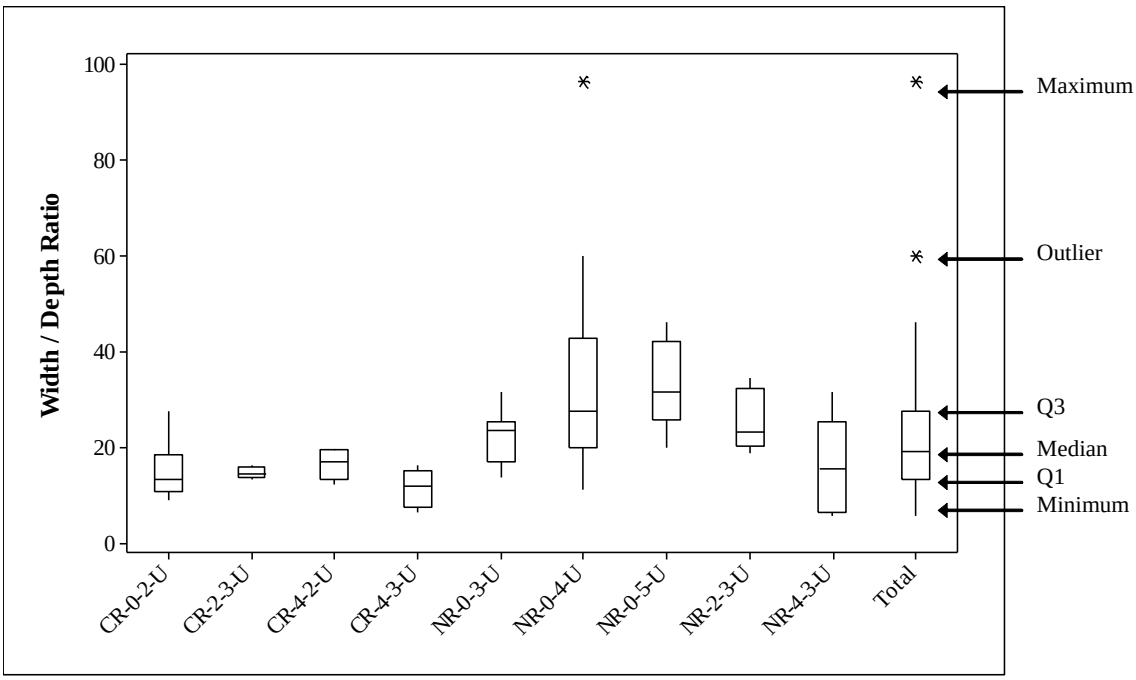

Figure D3-1. Boxplot of width/depth ratio by reach type

Table D3-1. Summary statistics of width/depth ratio by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	17	9.1	11	13.5	18.5	27.5
CR-2-3-U	1	4	13.6	13.8	14.4	15.9	16.3
CR-4-2-U	1	5	12.5	13.5	17.1	19.6	19.8
CR-4-3-U	1	4	6.4	7.7	11.9	15.3	16.4
NR-0-3-U	3	11	13.8	17.3	23.7	25.5	31.7
NR-0-4-U	3	11	11.2	20.2	27.8	43.1	96.5
NR-0-5-U	2	9	20	26	31.7	42.3	46.3
NR-2-3-U	1	5	19.1	20.3	23.2	32.5	34.6
NR-4-3-U	2	9	5.9	6.7	15.6	25.6	31.6
Total	**18**	**75**	**5.9**	**13.5**	**19.3**	**27.8**	**96.5**

D3.2.2 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.

The entrenchment ratios by reach type are presented in **Figure D3-2**, and summary statistics are provided in **Table D3-2**. All surveyed cross sections are included in the statistics generated within each reach type**.**

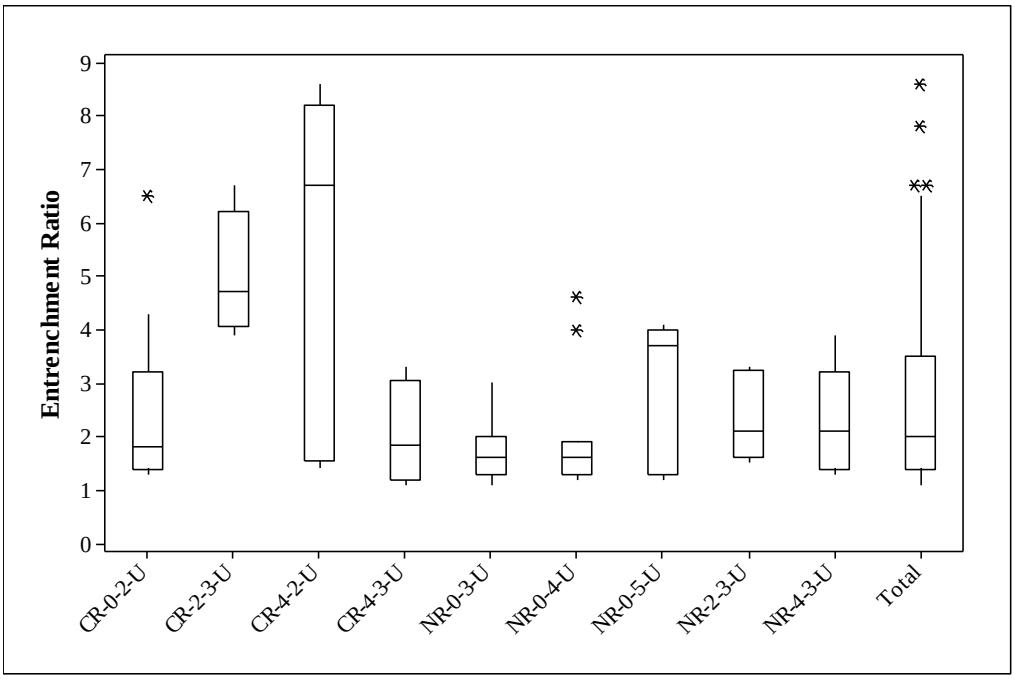

Figure D3-2. Entrenchment ratio by reach type

Table D3-2. Summary statistics of entrenchment ratio by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	17	1.3	1.4	1.8	3.2	6.5
CR-2-3-U	1	4	3.9	4.1	4.7	6.2	6.7
CR-4-2-U	1	5	1.4	1.6	6.7	8.2	8.6
CR-4-3-U	1	4	1.1	1.2	1.8	3.0	3.3
NR-0-3-U	3	11	1.1	1.3	1.6	2.0	3.0
NR-0-4-U	3	11	1.2	1.3	1.6	1.9	4.6
NR-0-5-U	2	9	1.2	1.3	3.7	4.0	4.1
NR-2-3-U	1	5	1.5	1.6	2.1	3.3	3.3
NR-4-3-U	2	9	1.3	1.4	2.1	3.2	3.9
Total	**18**	**75**	**1.1**	**1.4**	**2.0**	**3.5**	**8.6**

D3.2.3 Riffle Pebble Count: Substrate Fines (% <2 mm)

Clean stream bottom substrates are essential for optimum habitat for many fish and aquatic insect communities. The most obvious forms of degradation occur when critical habitat components such as spawning gravels (Chapman and McLeod, 1987) and cobble surfaces are physically covered by fines, thereby decreasing inter-gravel oxygen and reducing or eliminating the quality and quantity of habitat for fish, macroinvertebrates and algae (Waters, 1995; Lisle, 1989). Chapman and McLeod found that size of bed material is inversely related to habitat suitability for fish and macroinvertebrates and that excess

sediment decreased both density and diversity of aquatic insects. Specific aspects of sediment-invertebrate relationships may be described as follows: 1) invertebrate abundance is correlated with substrate particle size; 2) fine sediment reduces the abundance of original populations by reducing interstitial habitat normally available in large-particle substrate (gravel, cobbles); and 3) species type, species richness, and diversity all change as particle size of substrate changes from large (gravel, cobbles) to small (sand, silt, clay) (Waters, 1995).

The percent of fine sediment in a stream channel provides a measure of the siltation occurring in a river system and is an indicator of stream bottom habitat. Although it is difficult to correlate percent surface fines with sediment loading 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 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.

In addition to being a direct measure of impairment to the aquatic macroinvertebrate community, riffle percent surface fines can be used as an indicator of possible impairment condition to coldwater fish since the elevated riffle surface fines are likely an indicator of elevated subsurface fines within spawning gravels.

The pebble count measurements for particles <2 mm by reach type are presented in **Figure D3-3**, and summary statistics are provided in **Table D3-3**.

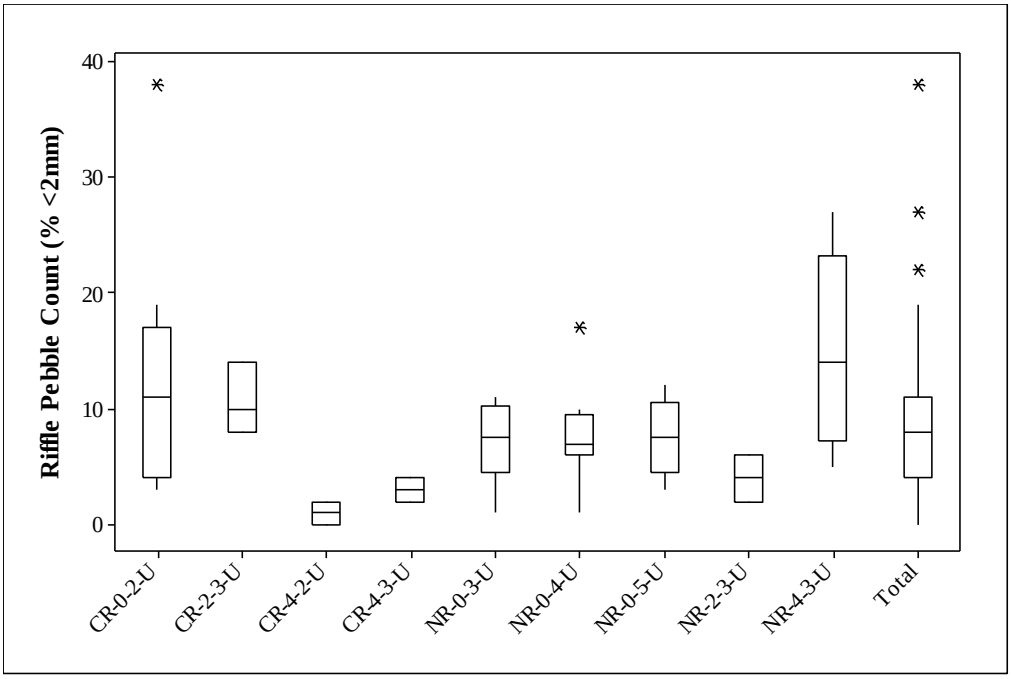

Figure D3-3. Riffle pebble count (% <2 mm) by reach type

Table D3-3. Summary statistics of riffle pebble count (% <2 mm) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	11	3	4	11	17	38
CR-2-3-U	1	3	8	8	10	14	14
CR-4-2-U	1	3	0	0	1	2	2
CR-4-3-U	1	3	2	2	3	4	4
NR-0-3-U	3	8	1	5	8	10	11
NR-0-4-U	3	9	1	6	7	10	17
NR-0-5-U	2	6	3	5	8	11	12
NR-2-3-U	1	3	2	2	4	6	6
NR-4-3-U	2	6	5	7	14	2	27
Total	**18**	**52**	**0**	**4**	**8**	**11**	**38**

D3.2.4 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 also indicate excess sedimentation and has the potential to negatively impact the spawning success of coldwater fish. 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.

The pebble count measurements for sediment fines (% <6 mm) by reach type are presented below in **Figure D3-4** and summary statistics are provided in **Table D3-4**.

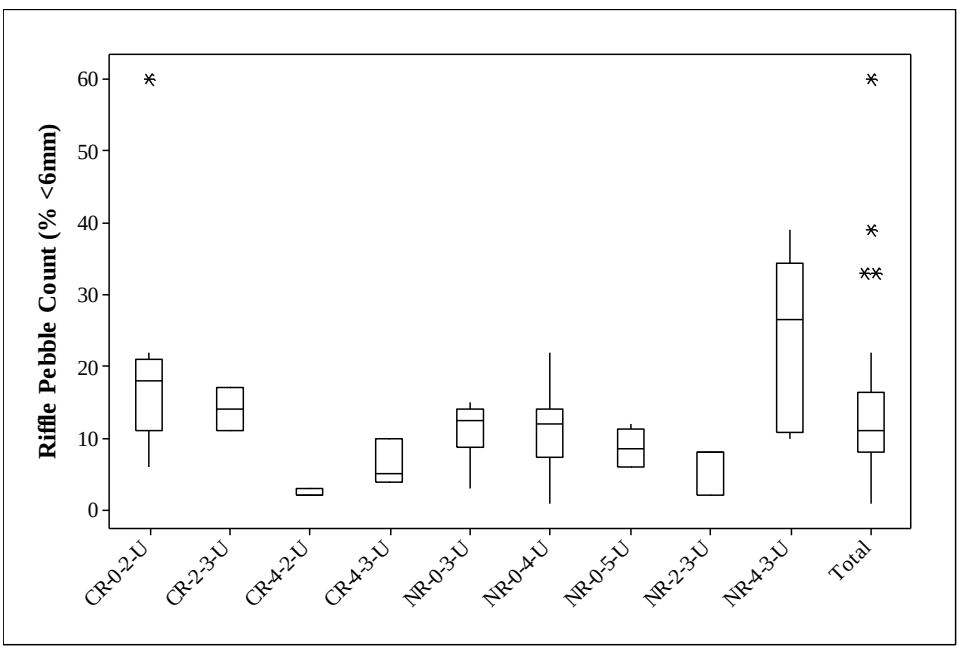

Figure D3-4. Riffle pebble count (% <6 mm) by reach type

Table D3-4. Summary statistics of riffle pebble count (% <6 mm) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	11	6	11	18	21	60
CR-2-3-U	1	3	11	11	14	17	17
CR-4-2-U	1	3	2	2	2	3	3
CR-4-3-U	1	3	4	4	5	10	10
NR-0-3-U	3	8	3	9	13	14	15
NR-0-4-U	3	9	1	8	12	14	22
NR-0-5-U	2	6	6	6	9	11	12
NR-2-3-U	1	3	2	2	8	8	8
NR-4-3-U	2	6	10	11	27	35	39
Total	**18**	**52**	**1**	**8**	**11**	**17**	**60**

D3.2.5 Riffle Pebble Count: D50

The D50 represents the median (50th percentile) particle size of a riffle as determined by the Wolman pebble count. This value can be used to evaluate the suitability of a riffle as spawning gravel for salmonids. Kondolf and Wolman (1993) state that the appropriate size of spawning gravels varies based on stream size and fish species, since larger fish are capable of moving larger particles. In general, appropriate sized spawning gravels should be less than approximately 40 mm for salmonids.

Results of the riffle pebble count D50 are presented below by reach type in **Figure D3-5** and summary statistics are provided in **Table D3-5**.

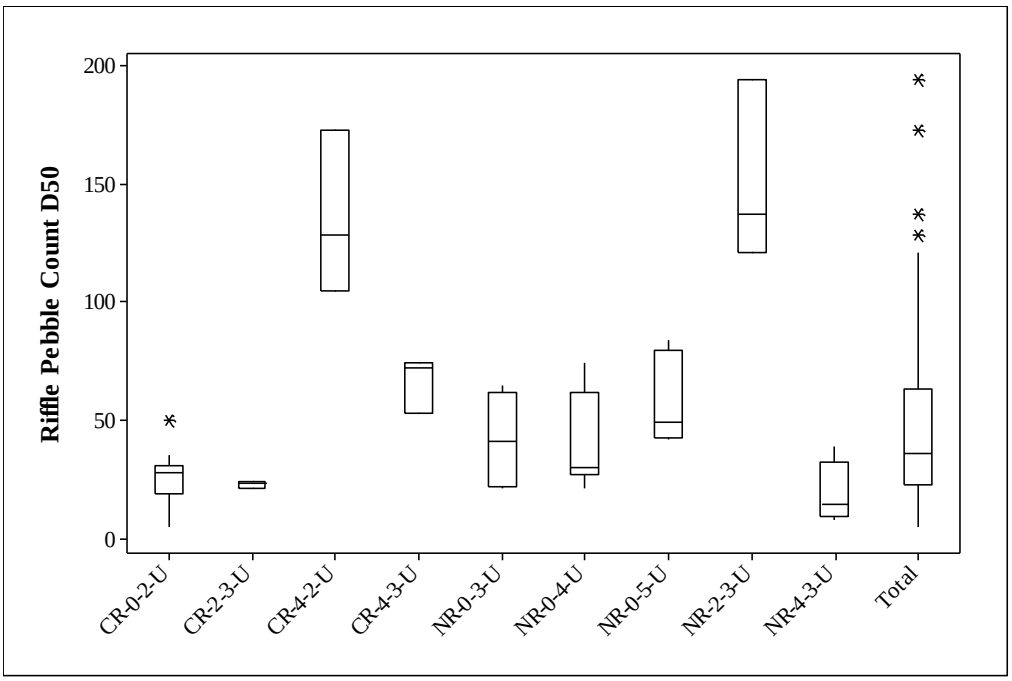

Figure D3-5. Riffle pebble count D50 (mm) by reach type

Table D3-5. Summary statistics of riffle pebble count D50 (mm) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	11	5	19	28	31	50
CR-2-3-U	1	3	21	21	23	24	24
CR-4-2-U	1	3	105	105	128	173	173
CR-4-3-U	1	3	53	53	72	74	74
NR-0-3-U	3	8	21	22	41	61.5	65
NR-0-4-U	3	9	21	27	30	62	74
NR-0-5-U	2	6	42	42.8	49.5	79.5	84
NR-2-3-U	1	3	121	121	137	194	194
NR-4-3-U	2	6	8	9.5	14.5	32.3	39
Total	**18**	**52**	**5**	**22.3**	**36**	**63.5**	**194**

D3.2.6 Riffle Stability Index

The riffle stability index (RSI) is used to evaluate riffle particle mobility in an area receiving excessive sediment input (Kappesser, 2002). The mobile fraction in a riffle is estimated by comparing the particle sizes in the riffle to the arithmetic mean of the largest mobile particles on an adjacent depositional bar. Riffle particles of the size class smaller than the largest particles on a depositional bar are interpreted as mobile, and the RSI value represents the percent of mobile particles within a riffle. Riffles that have received excessive sediment from upstream eroding banks have a higher percent of mobile particles than riffles in equilibrium. The following breaks are provided as general guidelines for interpreting RSI values:

RSI Value	Description
< 40	High bedrock component to riffle (very stabile system) or channel has been scoured
40 – 70	Stream is in dynamic equilibrium – good channel and watershed stability
70 – 85	Riffle is somewhat loaded with excessive sediment
> 85	Riffle is loaded with excessive sediment

Limited RSI data were collected during this field effort due to the frequency of poorly developed point bars downstream of actively eroding banks. The riffle stability index results for all reaches are provided below in **Table D3-6**.

Table D3-6. Riffle stability index results for all reaches

Reach ID	Cell	Reach Type	Arithmetic Mean (cm)	Riffle Stability Index
DEP 13-2	1	CR-2-3-U	53	93
ENA 10-2	3	NR-4-3-U	34	44
FTN 6-1	1	NR-0-3-U	94	67
SWP 5-1	2	NR-0-3-U	85	51

D3.2.7 Riffle Grid Toss: Substrate Fines (% <6 mm)

The wire grid toss is a standard procedure frequently used in aquatic habitat assessment. This measurement does not cover the entire channel width, as in the Wolman pebble count, but rather provides a more focused measurement of surface fines in a subsample of the cross-section.

The riffle grid toss results for sediment fines (% <6 mm) are presented below in **Figure D3-6** and summary statistics are provided in **Table D3-7**. The scale was adjusted on the boxplot to show greater detail; as a result, one outlier for CR-0-2-U (100% fines) is not shown in the figure.

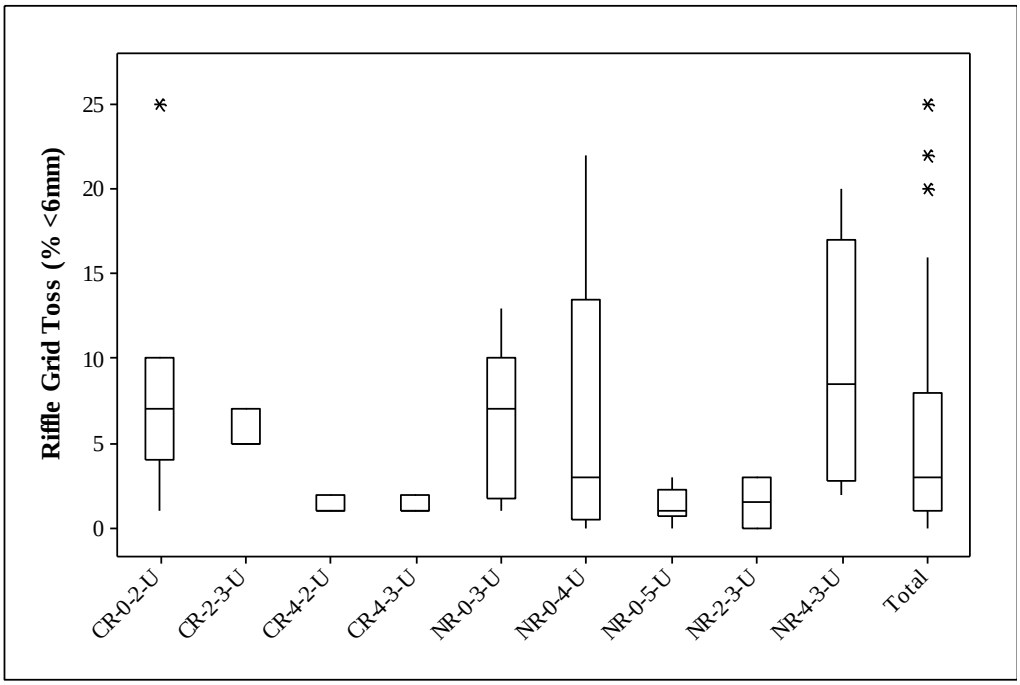

Figure D3-6. Riffle grid toss (% <6 mm) by reach type

Table D3-7. Summary statistics of riffle grid toss (% <6 mm) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	11	1	4	7	10	100
CR-2-3-U	1	3	5	5	5	7	7
CR-4-2-U	1	3	1	1	1	2	2
CR-4-3-U	1	3	1	1	1	2	2
NR-0-3-U	3	8	1	2	7	10	13
NR-0-4-U	3	9	0	1	3	14	22
NR-0-5-U	2	6	0	1	1	2	3
NR-2-3-U	1	3	0		2		3
NR-4-3-U	2	6	2	3	9	17	20
Total	**18**	**52**	**0**	**1**	**3**	**8**	**100**

D3.2.8 Pool Grid Toss within Depositional Spawning Areas: Sediment Fines (% <6 mm)

Grid toss measurements in depositional spawning areas provide a measure of fine sediment accumulation in potential spawning sites. 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 6.35mm and the emergence success of westslope cutthroat trout and bull trout

Grid toss results for sediment fines (% <6 mm) found within depositional spawning areas are provided below in **Figure D3-7** and summary statistics are provided in **Table D3-8**. The data presented represents only those features sampled that were identified as having the appropriate sized gravels to support spawning. There were four assessment sites (Clarence, DEP 9-2, LME 6-1, and SWP 9-1) where spawning gravels were not noted; as a result, these reach types were not reported. Also, the boxplot scale was adjusted to show greater detail throughout the reach types; as a result, three outliers for reach type CR-0-2-U (100% fines) are not shown in the figure.

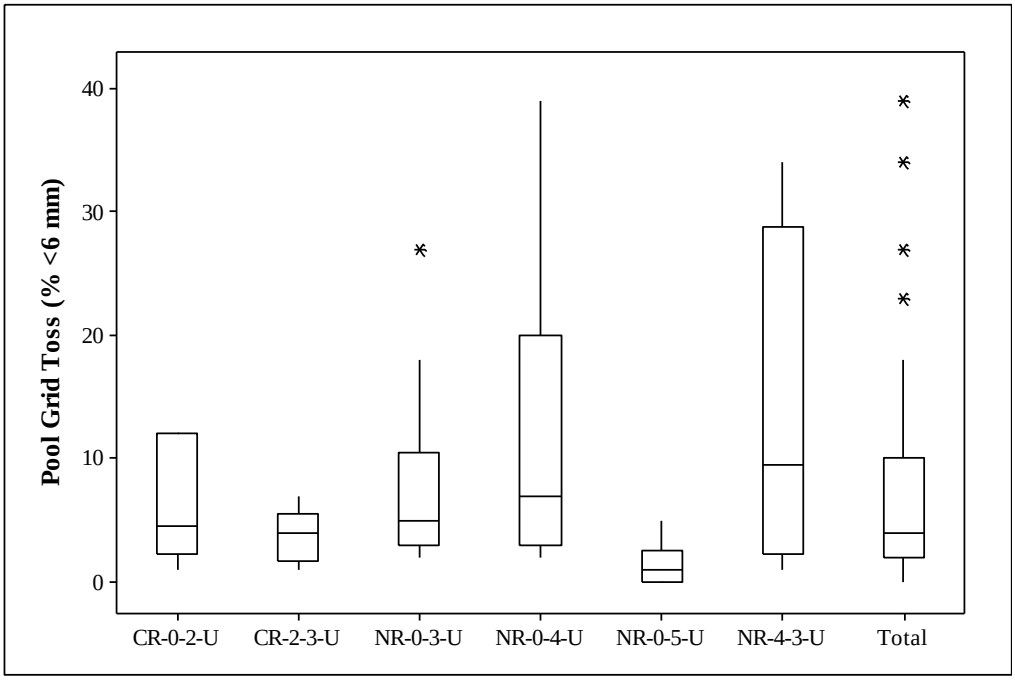

Figure D3-7. Pool grid toss (% <6 mm) by reach type

Table D3-8. Summary statistics of pool grid toss (% <6 mm) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	16	1	2	5	12	100
CR-2-3-U	1	10	1	2	4	6	7
NR-0-3-U	3	17	2	3	5	11	27
NR-0-4-U	3	9	2	3	7	20	39
NR-0-5-U	2	9	0	0	1	3	5
NR-4-3-U	1	4	1	2	10	29	34
Total	**14**	**65**	**0**	**2**	**4**	**10**	**100**

D3.2.9 Pool Residual Depth

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.

Data are presented below in **Figure D3-8** and **Table D3-9**. Note that the summary database contains the average residual pool depth for each monitoring site, while this analysis utilized all residual pool depth measurements for scour pools. Residual pool depths for dammed pools were not calculated.

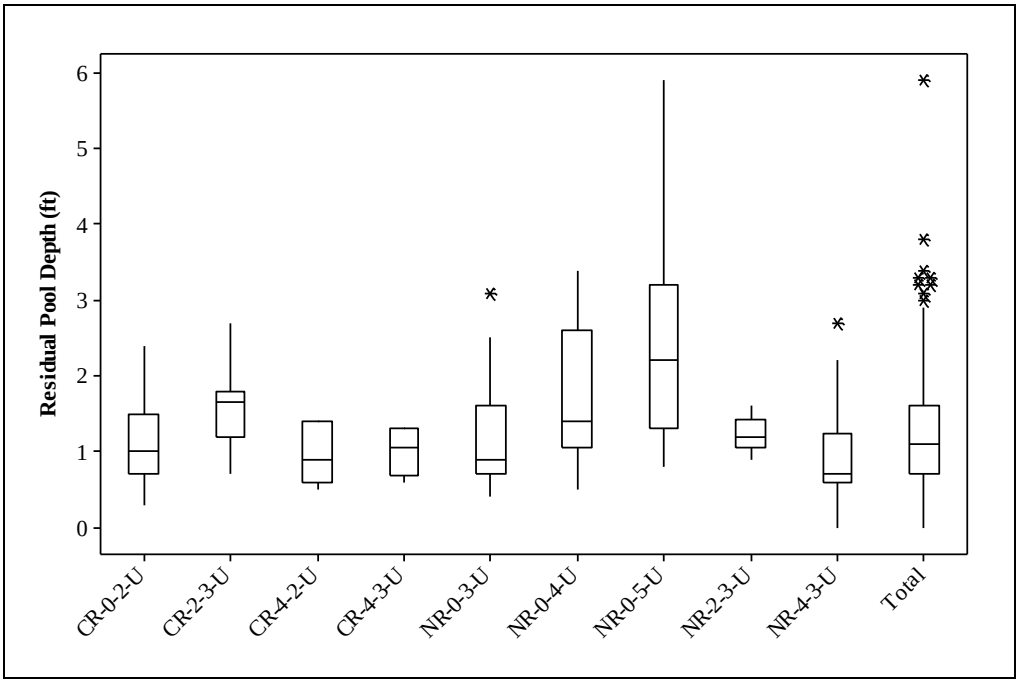

Figure D3-8. Residual pool depth (ft) by reach type

Table D3-9. Summary statistics of residual pool depth (ft) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	65	0.3	0.7	1.0	1.5	2.4
CR-2-3-U	1	16	0.7	1.2	1.7	1.8	2.7
CR-4-2-U	1	7	0.5	0.6	0.9	1.4	1.4
CR-4-3-U	1	6	0.6	0.7	1.1	1.3	1.3
NR-0-3-U	3	35	0.4	0.7	0.9	1.6	3.1
NR-0-4-U	3	30	0.5	1.1	1.4	2.6	3.4
NR-0-5-U	2	15	0.8	1.3	2.2	3.2	5.9
NR-2-3-U	1	8	0.9	1.1	1.2	1.4	1.6
NR-4-3-U	2	21	0.0	0.6	0.7	1.3	2.7
Total	**18**	**203**	**0.0**	**0.7**	**1.1**	**1.6**	**5.9**

D3.2.10 Pool Frequency (reach mean value)

Pool frequency is a measure of the availability of pools within a reach 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.

The pool frequencies per 1,000 ft for each reach type are presented in below **Figure D3-9** and summary statistics are provided in **Table D3-10**. As with residual pool depth, some reach types are represented by only a single value.

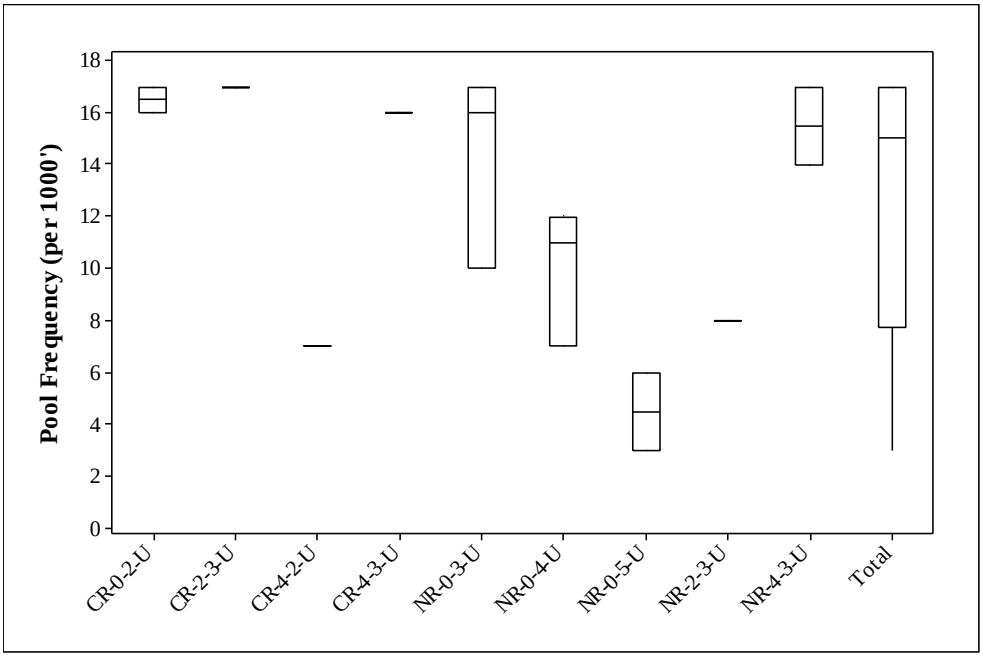

Figure D3-9. Pool frequency (per 1,000 ft) by reach type

Table D3-10. Summary statistics of pool frequency by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	4	16	16	16.5	17	17
CR-2-3-U	1	1	17		17		17
CR-4-2-U	1	1	7		7		7
CR-4-3-U	1	1	16		16		16
NR-0-3-U	3	3	10	10	16	17	17
NR-0-4-U	3	3	7	7	11	12	12
NR-0-5-U	2	2	3		4.5		6
NR-2-3-U	1	1	8		8		8
NR-4-3-U	2	2	14		15.5		17
Total	**18**	**18**	**3**	**7.75**	**15**	**17**	**17**

D3.2.11 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of salmonid habitat, providing stream complexity, pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD frequency can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under reference conditions. Too little or too much LWD 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 1000 feet, represents an average of target values from other studies. 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 and soils, among other factors.

The LWD frequencies for each reach type are provided below in **Figure D3-10** and summary statistics are provided in **Table D3-11**.

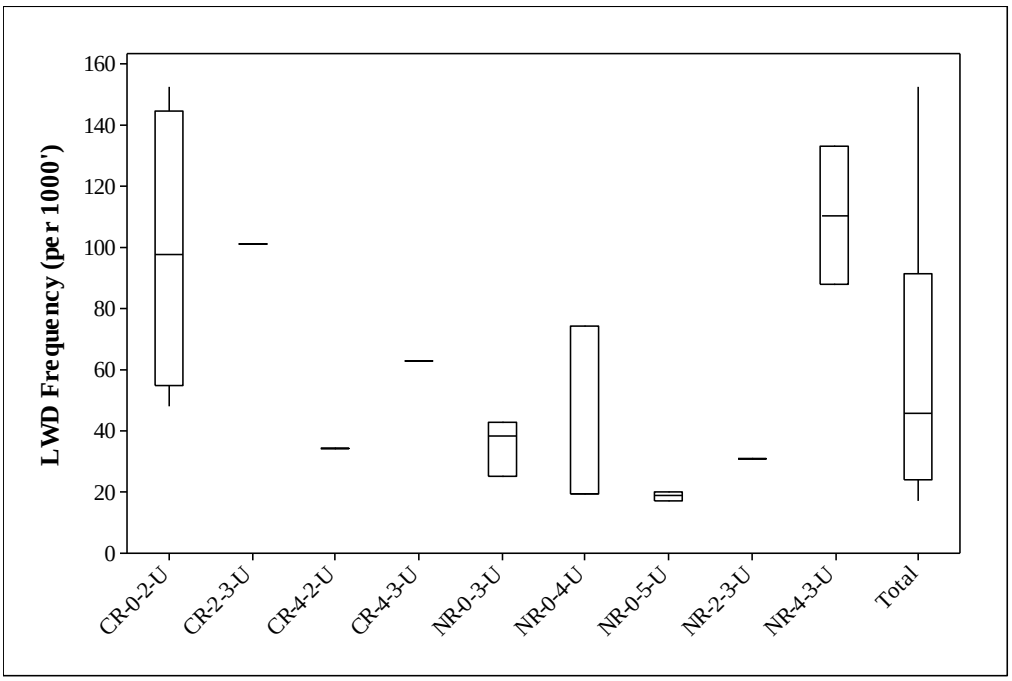

Figure D3-10. LWD frequency (per 1,000 ft) by reach type

Table D3-11. Summary statistics of LWD frequency by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	4	48	54.8	97.5	144.8	153
CR-2-3-U	1	1	101		101		101
CR-4-2-U	1	1	34		34		34
CR-4-3-U	1	1	63		63		63
NR-0-3-U	3	3	25	25	38	43	43
NR-0-4-U	3	3	19	19	19	74	74
NR-0-5-U	2	2	17		18.5		20
NR-2-3-U	1	1	31		31		31
NR-4-3-U	2	2	88		110.5		133
Total	**18**	**18**	**17**	**23.8**	**45.5**	**91.3**	**153**

D3.2.12 Greenline Inventory: Percent Understory Shrub Cover

Riparian shrub cover is an important factor 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 which reduce solar inputs and help maintain cooler water temperatures. 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.

The Greenline understory shrub cover percentages by reach type are presented in **Figure D 3-11**. The summary data are also presented in **Table D3-12**.

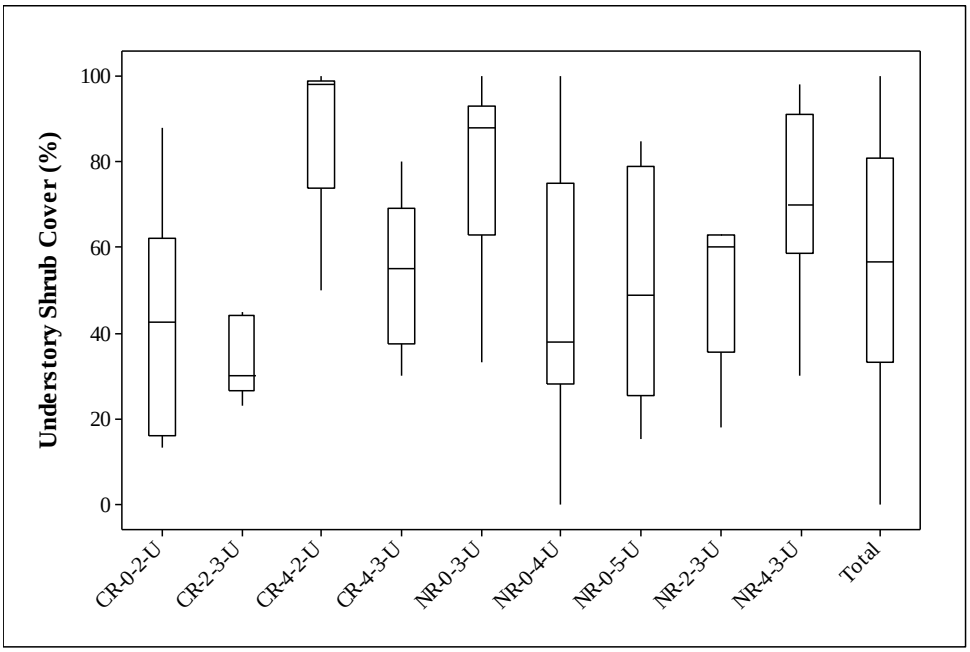

Figure D3-11. Greenline understory shrub cover (%) by reach type

Table D3-12. Summary statistics of understory shrub cover (%) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	20	13	16	43	63	88
CR-2-3-U	1	5	23	27	30	44	45
CR-4-2-U	1	5	50	74	98	99	100
CR-4-3-U	1	5	30	38	55	69	80
NR-0-3-U	3	15	33	63	88	93	100
NR-0-4-U	3	15	0	28	38	75	100
NR-0-5-U	2	10	15	26	49	79	85
NR-2-3-U	1	5	18	36	60	63	63
NR-4-3-U	2	10	30	59	70	91	98
Total	**18**	**90**	**0**	**33**	**57**	**81**	**100**

D3.2.13 Greenline Inventory: Percent Bare/Disturbed 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 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.

Results of the Greenline survey for percent bare/disturbed ground are provided by reach type below. 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 D3-13**.

Table D3-13. Summary statistics of bare/disturbed ground (%) by reach type

Reach Type	Reaches	Count	Minimum	Q1	Median	Q3	Maximum
CR-0-2-U	4	20	0	0	0	0	10
CR-2-3-U	1	5	0	0	0	0	0
CR-4-2-U	1	5	0	0	0	0	0
CR-4-3-U	1	5	0	3	10	15	20
NR-0-3-U	3	15	0	0	0	0	5
NR-0-4-U	3	15	0	0	0	0	18
NR-0-5-U	2	10	0	0	0	2	4
NR-2-3-U	1	5	0	0	0	0	0
NR-4-3-U	2	10	0	0	0	0	0
Total	**18**	**90**	**0**	**0**	**0**	**0**	**20**

D3.3 Assessment Reach Field Descriptions

The following sections provide brief descriptions of each sampled reach. Descriptions are provided for human impacts, stream channel conditions, and riparian vegetation conditions. Streambank erosion conditions are provided with sediment loading results in **Section D 4.6**. Assessment reaches are organized by waterbody and reach location starting at the downstream end and moving upstream.

D3.3.1 Clarence Creek

Note: *One site on Clarence Creek was assessed instead of Grave Creek reach 2-1.*

Description of Human Impacts and Severity

This reach has no apparent human impacts, and is described as a “very nice” reach.

Description of Stream Channel Conditions
Stream channel is Rosgen type B3/C3b within the sample reach. Stream has large particle size, minimal spawning gravels, and a fairly steep grade. Some algae exist on rocks. Pools are shallow and infrequent. Stream is mostly step/riffle.

Description of Riparian Vegetation Conditions
Riparian vegetation is very dense with lots of woody species and wetter vegetation types including alder, snowberry, and moss.

D3.3.2 Deep Creek

D3.3.2.1 DEP 13-2

Description of Human Impacts and Severity
Reach is between road and Plum Creek mill near Fortine, but has no apparent human impacts.

Description of Stream Channel Conditions
Reach is a Rosgen C4 channel type consisting of a meandering channel through flat valley with minimal riffle development and long runs. Reach contained many lateral scour pools and wood pools, and many wood and debris jams. Beaver activity is evident downstream of reach and evidence of historical beaver activity is evident within the sampled reach. Bank material includes a cobble/gravel deposited over a layer of fines. Channel has small particle size, with higher fines in pools, and point bars near riffles.

Description of Riparian Vegetation Conditions
Reach has good grass cover (reed canary) with alder, chokecherry, sedges, raspberries, and minimal overstory.

D3.3.2.2 DEP 9-2

Description of Human Impacts and Severity
This reach parallels Deep Creek Road. A large (50-100' tall) eroding bank is in cells 2, 3, and 4. Rock barbs were installed in places to deflect flow, causing erosion on opposite bank, as well as scour erosion on large bank. Rock dams were put in to stop stream movement (see note below).

Description of Stream Channel Conditions
Stream channel measurements resemble Rosgen types F4b, C4b, B3, and E3b in various cells of the sample reach depending on entrenchment, width/depth ratio, and sediment size, but stream is likely a B channel type that is in disequilibrium. Stream shows evidence of downcutting, undercutting, and lateral movement due excessive sediment input and human alteration. Reach is steep, with almost all riffle/run, boulder structure. Reach has minimal pools, and no spawning habitat noted due to large cobble substrate. Channel braids in cells 3 and 4, and entire side channel (approximately 10 CFS) runs approximately 100-200' left of left bank and runs past end of reach. Large debris jams have caused deposition and braiding. The lowest cell and the area upstream of cell 5 appear to be returning to reference condition.

Description of Riparian Vegetation Conditions
Reach has good vegetation conditions, with alder, birch, snowberry, conifers, mossy duff layer, and lots of downed wood. All vegetation appears natural.

D3.3.2.3 DEP-7-1

Description of Human Impacts and Severity

Reach has a bridge at upper end of reach. Logged clear-cuts exist nearby, but there is no evidence of impact on stream.

Description of Stream Channel Conditions

Reach is a cascading step-pool system with steep gradient, lots of woody debris, and log jams that form dams. Substrate is predominantly large cobble. Several small trout were observed during sampling. Reach is a good example of reference reach for high elevation tributaries.

Description of Riparian Vegetation Conditions

Riparian vegetation is in great condition, and includes dense conifer overstory and lots of cedar, alder, raspberry and moss.

D3.3.3 Edna Creek

D3.3.3.1 ENA 11-1

Description of Human Impacts and Severity

Site is heavily impacted by agriculture, and surrounding land is actively mowed for hay.

Description of Stream Channel Conditions

Stream has high amount of fines with few stretches of gravel. Several fish were observed in the stream. Site has several multi-channel sections with heavily vegetated islands.

Description of Riparian Vegetation Conditions

Site has very extensive reed canary grass covering the banks and riparian corridor, and frequent clumps of willow that cover the entire channel (20-50 feet in length).

D3.3.3.2 ENA 10-2

Description of Human Impacts and Severity

No human impacts were present in this reach.

Description of Stream Channel Conditions

Stream channel is a B4c/C4 type channel that also resembles an F4 channel type in areas due to entrenchment. Reach shows no signs of human impact, although some historic beaver activity is present, and some areas appear overwidened. Channel has medium sized gravel substrate.

Description of Riparian Vegetation Conditions

Riparian vegetation was in good condition, with all vegetation buffers greater than 200 feet.

D3.3.3.3 ENA 8-1

Description of Human Impacts and Severity

Site has no visible evidence of human impacts although road runs adjacent to right bank (50-100 feet distance). The riparian corridor has not been recently logged.

Description of Stream Channel Conditions

Reach is step-pool system with occasional cascades over rocks or logs and nice pool development.

Description of Riparian Vegetation Conditions
Alders formed a dense corridor that was difficult to pass through. Overstory is dense with conifers and cedar.

D3.3.3.4 ENA 7-2

Description of Human Impacts and Severity
Site has no apparent human impacts, and is in old growth forest with many large larch and cedar.

Description of Stream Channel Conditions
Reach is step-pool system with lots of woody debris. Lower end of reach contains a massive log jam and deadfall which is impossible to walk through.

Description of Riparian Vegetation Conditions
Site has excellent riparian vegetation including cedar, alder, and conifers.

D3.3.4 Fortine Creek

D3.3.4.1 FTN 15-3

Description of Human Impacts and Severity
Reach has a railroad bridge at upper end of reach, and automobile bridge at lower end of reach. Evidence of historic riparian grazing exists, but a fence lines the left bank along entire reach.

Description of Stream Channel Conditions
Site has moderate pool development, and channel seems to be slightly overwidened (possibly from historic grazing). Approximately 50 spawning salmon were observed during sampling.

Description of Riparian Vegetation Conditions
Site has good riparian buffer on right bank. Left bank buffer is less extensive and has agriculture fields within 100-200 feet of stream. Some knapweed and reed canary grass exists with cottonwood overstory.

D3.3.4.2 FTN 15-2

Description of Human Impacts and Severity
Railroad tracks exist along right bank for entire reach. Channel was likely channelized in the past. Approximately 100 feet of log riprap exists at upper end of reach.

Description of Stream Channel Conditions
Site has poor pool development. Some spawning salmon were present along the reach.

Description of Riparian Vegetation Conditions
Site has fair to good vegetation along left bank, and fair brush cover on right bank. Vegetation includes cottonwood overstory, not much knapweed, and occasional reed canary grass.

D3.3.4.3 FTN 13-1

Description of Human Impacts and Severity
Reach has railroad encroachment at lower end of reach. There appears to have been some effort to restore banks.

Description of Stream Channel Conditions
Stream channel is primarily Rosgen type B4c, but resembles an F4 channel in areas of entrenchment. Multiple compound pools exist, with infrequent small riffles. Channel is downcut toward upper end of reach and above top of reach.

Description of Riparian Vegetation Conditions
Riparian vegetation is mature and good condition with alder, snowberry, and reed canary grass.

D3.3.4.4 FTN 12-9

Description of Human Impacts and Severity
Reach has minimal human impacts. Area was logged ~15 years ago (owner mentioned) and they didn't log close to the stream. There is a 20-50 feet riparian buffer.

Description of Stream Channel Conditions
Reach has two beaver dams that divert flow into side channels. Channel with the most water was sampled. Reach has minimal pool development, and rocks are slimy and covered with brown algae. Site may be receiving nutrient input from livestock upstream.

Description of Riparian Vegetation Conditions
Riparian vegetation conditions are okay, but not great. Site consists of mostly a conifer overstory with brush and grass. Game use is evident and the landowner is doing some cleanup on the floodplain.

D3.3.4.5 FTN 12-7

Description of Human Impacts and Severity
Reach has severe grazing impacts with heavily browsed vegetation. An attempt to fence out cows appears to be unsuccessful. Upper end of reach has had past restoration and tree planting.

Description of Stream Channel Conditions
Stream channel is Rosgen type B4c/C4 in the upper reach and type B3c in the lower reach where larger substrate was encountered. Channel is severely overwidened in several places. Large substrate is cemented in fine sediment or films of algae. Channel is also downcutting in areas.

Description of Riparian Vegetation Conditions
Riparian vegetation is in poor quality due to grazing. Shrubs and woody species have been browsed. Alder, grasses, and some sedges exist in areas with no grazing.

D3.3.4.6 FTN 12-2

Description of Human Impacts and Severity
Reach has evidence of historic logging along both banks. Trees were cut down at the bank edge.

Description of Stream Channel Conditions
Stream reach is low gradient with average pool development. There were some muddy areas within the sample reach, and a fine film of sediment coated the streambed material.

Description of Riparian Vegetation Conditions
Site has average riparian conditions. The vegetation is not very dense on the old floodplain. The forest is conifer dominated with occasional alder and reed canary grass.

D3.3.4.7 FTN 9-3

Description of Human Impacts and Severity

Reach has some evidence of historic riparian logging. Several invasive weeds were noted, including spotted knapweed and tansy, although most vegetation appears natural.

Description of Stream Channel Conditions

Reach is a Rosgen B4c/C4 channel type. Reach is slow and meandering with flat long pools and short sporadic riffles. Reach appears overwidened in places. Some woody debris and log jams. Pools have minimal or no spawning gravels and substrate has a coating of fine sediment on top. There is evidence of beaver activity, but no dams or lodges were encountered.

Description of Riparian Vegetation Conditions

Riparian vegetation is in fairly good condition, with reed canary grass, alder, chokecherry, and snowberry. Overstory is minimal at top of reach, but more common toward reach bottom.

D3.3.4.8 FTN 7-2

Description of Human Impacts and Severity

Site has minimal human impact with no evidence of logging except for two big old growth logs that may have come from past logging upstream. Railroad seems far enough away from the measured reach to have no impact on stream.

Description of Stream Channel Conditions

Stream channel has minimal pool development, and not a lot of deadfall. Rocks did not have much algae.

Description of Riparian Vegetation Conditions

Reach has good riparian vegetation with conifer overstory, some alders, and few noxious weeds.

D3.3.4.9 FTN 6-1

Description of Human Impacts and Severity

Reach is channelized at the top and bottom by railroad. Some historic logging activity is present.

Description of Stream Channel Conditions

Reach is B3c/B4c channel type which resembles a F3 channel type is areas due to entrenchment. Both gravel and cobble substrate exists. Bottom of reach has some beaver activity in the railroad section, while middle of reach looked more natural with large cobble substrate. Top of reach is again channelized by railroad. Beaver dams exist at top of reach with deep pools and some good spawning gravel.

Description of Riparian Vegetation Conditions

River left had riprap at top and bottom of reach adjacent to railroad. Top of reach was historically logged near stream. Middle of reach looked good with alder and mature conifers.

D3.3.4.10 FTN 4-3

Description of Human Impacts and Severity

Severe grazing impacts were noted throughout the upper four cells of this reach. Cattle crossings exist everywhere, especially through riffles and pool tails. Riparian areas are trampled, with lots of fine sediment in stream.

Description of Stream Channel Conditions

Stream channel is a Rosgen C4 channel type. Reach is slow, flat and meandering through a meadow, with minimal riffle development, long scour pools, and minimal woody debris. An old beaver dam exists at station 835.

Description of Riparian Vegetation Conditions

Reach has lots of grass cover with sedges, alder and willow, although almost no overstory.

D3.3.4.11 FTN 4-1

Description of Human Impacts and Severity

Site is within old growth forest and has no apparent human impacts (right and left bank) other than man-made log cascades within stream channel.

Description of Stream Channel Conditions

Reach contains lots of woody debris (log jams) and three man-made log cascades. Channel has lots of step pools from logs, and logs totally crossing stream. Some fish were observed.

Description of Riparian Vegetation Conditions

Stream reach has good riparian corridor in old growth forest. Banks have alder, and no noxious weeds were observed.

D3.3.5 Lime Creek

D3.3.5.1 LME 6-1

Description of Human Impacts and Severity

Minimal human impacts were observed, although there is evidence of historic logging at the upper end of reach. Road culvert may be influencing some bank erosion near top. An old log bridge exists in cell 3.

Description of Stream Channel Conditions

Stream channel measurements suggest reach is a Rosgen type E4b channel with a high entrenchment ratio and low width/depth ratio, but stream appears to be a B type channel that is incised in areas. Lots of natural fines exist and stream has chalky appearance from eroded limestone. Large particles are cemented together and will break with hand pressure. No spawning gravels exist. Field measured slope is approximately 4%. Lots of woody debris exists in channel, with minimal pools and long riffles.

Description of Riparian Vegetation Conditions

Vegetation is in very good condition with thick canopy and understory including alder, snowberry, dogwood, young and old coniferous trees, and few old stumps. Banks have shallow rooting depth.

D3.3.6 Sinclair Creek

D3.3.6.1 SNC 10-3

Description of Human Impacts and Severity

Stream reach is encroached by roads on both sides, and likely receives sediment input from downstream culvert (backup) or from upstream land uses. Debris (tires, metal, coolers, and garbage) exists throughout reach. Reach located in Town of Eureka.

Description of Stream Channel Conditions

Stream reach is a Rosgen type B4c channel in riffle areas, and B5c throughout much of the reach due to high percent of fine material. The stream has few small riffles, and is overwidened and multi-channel in areas. Some evidence of backwater exists, possibly from backup from the downstream culvert. Reach contains lots of wood and has long shallow pools with high fines. Several deeper pools exist near upper end. Channel looks to be aggrading.

Description of Riparian Vegetation Conditions

Riparian vegetation primarily includes reed canary grass, cottonwoods, chokecherry, and alder. Vegetation is in relatively good condition considering human impacts.

D3.3.6.2 SNC 8-2

Description of Human Impacts and Severity

Bridges exist at upstream and downstream ends of reach, with grazing on both sides of stream. Recent riparian fencing and restoration was done on section upstream of reach. Some evidence of grazing exists upstream, but not severe.

Description of Stream Channel Conditions

Stream reach is a B4c/C4 Rosgen type channel, but resembles a F4 type channel in areas due to entrenchment. Overall, reach has good morphological structure with lots of woody debris and good fish habitat, but minimal spawning gravels. One dead bull trout (approx. 4”) was observed. Lower end of reach is incised.

Description of Riparian Vegetation Conditions

Riparian vegetation includes old stands of alder and hawthorn. Vegetation has been impacted by grazing, but appears to be recovering.

D3.3.6.3 SNC 5-1

Description of Human Impacts and Severity

Site has no signs of human impact, and is a very remote stream in tight valley.

Description of Stream Channel Conditions

Reach consists of cascading step pool system. Reach is steep with lots of large woody debris and large boulders. There is evidence of large flood that has moved extremely large material (> 3ft boulders) well out in floodplain. Site may serve as reference reach for high mountain tributary.

Description of Riparian Vegetation Conditions

Site has minimal grasses and understory with large old growth overstory consisting of conifer and cedar. Thick forest duff exists in most areas.

D3.3.7 Swamp Creek

D3.3.7.1 SWP 9-1

Description of Human Impacts and Severity

Reach contains very little human influence. Reach has been clear-cut at lower end, but has good buffer from streams. A stream gauging device was present at station 600 in cell 4.

Description of Stream Channel Conditions

The stream reach is a Rosgen type B3/C3b channel within the sample reach. Stream is a step-pool system near top half of reach, with large substrate and low quality pools. Amount of woody debris appears to be low, but natural to this system.

Description of Riparian Vegetation Conditions

Riparian vegetation is in good condition with large cottonwoods, pine, and aspen. Banks have some willow, alder, and reed grass.

D3.3.7.2 SWP 5-1

Description of Human Impacts and Severity

Stream reach has previously been logged in riparian areas. Grazing impacts are minor. Some grade control structure and geotextile fabric exists in channel, possibly from past restoration work. A new pipe arch bridge exists at upstream road crossing, which is causing channel widening and erosion downstream.

Description of Stream Channel Conditions

This reach is a Rosgen type B4 channel in the upper cells, and a type F4b in the lower cells due to entrenchment. The stream contains large cobble substrate. At time of sampling, stream contained very low flow relative to the channel size, and flow becomes disconnected in places. Some algae exist in stagnant areas. Channel contains frequent large woody debris.

Description of Riparian Vegetation Conditions

Stream contains willow, snowberry, and alder along banks. A few sedges were also present. Some weeds species were observed near bridge at top of reach, possibly due to recent disturbance.

D3.3.7.3 SWP 3-1

Description of Human Impacts and Severity

Site has good riparian corridor (not logged) for lower part of reach, but corridor was narrow at upper end due to historic logging near the creek.

Description of Stream Channel Conditions

Site is a step pool system with lots of woody debris and big trees across the stream. Many sections up to 75-100' were totally covered with down trees. Very little water was in the creek at time of sampling, but there were some trapped fish in several pools.

Description of Riparian Vegetation Conditions

Site has abundant vegetation with conifer and cedar overstory. Understory has lots of alder and small conifers. Upper end of reach sees more impact from historic logging than lower end.

D3.3.8 Therriault Creek

D3.3.8.1 THR 14-1 (Extending onto THR 13-2)

Description of Human Impacts and Severity

Culvert below bottom of reach appears undersized and is failing and causing deposition upstream. Some signs of historic grazing exist, but new fencing has been installed along riparian areas. Stream has some evidence of historic riparian logging. Some residential impacts exist, including clearing around residences.

Description of Stream Channel Conditions

Stream reach is a Rosgen type C4 channel in the upper portion, and resembles an E4 type channel in the lower cells due to low width/depth ratio. Reach has long reaches of compound riffles, and long distances between pools. Some sediment aggradation occurs above culvert. Woody debris is plentiful, and is forming plunge pools between compound riffles.

Description of Riparian Vegetation Conditions

Stream contains minimal understory on lower reach likely due to historic grazing. Alder bunches are present, but no willows. There is evidence of historic logging in riparian areas in upper part of reach.

D3.3.8.2 THR 9-5

Description of Human Impacts and Severity

Reach contains historic riparian logging. Some active logging is occurring on upper bench, but not significant. Lots of unnatural wood (planed and milled) exists in stream. Stream has two side channels within reach.

Description of Stream Channel Conditions

Stream reach resembles an E4 type channel with low width/depth ratio and gravel substrate, but is also slightly entrenched in areas resembling a B4c type channel. Reach has fairly steep slope, poor spawning habitat, and marginal pool habitat.

Description of Riparian Vegetation Conditions

Vegetation is in good condition with dense understory, minimal coniferous overstory, and good grass cover in riparian areas. Reach contains evidence of past riparian logging.

D3.3.9 Tobacco River

D3.3.9.1 TOB 2-6

Description of Human Impacts and Severity

Stream reach has rural residential encroachment, and severely eroding banks with poor restoration work and flood control. Railroad grade is on river left and upper end of reach.

Description of Stream Channel Conditions

Stream channel is Rosgen type C4 in the lower cells, and type F4 in the upper cells due to entrenchment. Stream appears to be aggrading and is overwidened in places. Reach has multiple transverse bars with high bedload that appears to be from eroding banks.

Description of Riparian Vegetation Conditions

Reach has fair riparian vegetation with alder, dogwood, and chokecherry. Vegetation has been impacted in some areas from rural residents.

D3.3.9.1 TOB 2-3

Description of Human Impacts and Severity

Site is very confined by bridge at downstream end, with urban impacts to the north and railroad and lumber yard to south. A walking trail exists along river in lower half of reach. Reach experiences high human impact within downtown Eureka. Upper part of reach is more natural. Lots of riprap exists along reach to stop eroding banks.

Description of Stream Channel Conditions

Reach is confined at lower part between railroad and town, but generally has good riffles, poor habitat, fair amount of woody debris, and good point bar development. Significant active spawning noted.

Description of Riparian Vegetation Conditions

Vegetation has lots of urban impacts including a limited overstory. Vegetation appears to be less disturbed toward top of reach. Grasses are in good condition with some alder and cottonwoods.

D3.3.9.2 TOB 1-3

Description of Human Impacts and Severity

The only evidence of agriculture is at upper end of reach (grazing). There is a good riparian buffer along most of stream on both sides. Rural residence exists on east side at good distance.

Description of Stream Channel Conditions

Site has good riffle/pool development, very abundant spawning activity, fair amount of woody debris and good point bar development. Therriault Creek enters at station 810.

Description of Riparian Vegetation Conditions

Site has significant weed impact (knapweed, reed canary grass) at upper end. Overstory is mostly cottonwood with snowberry, chokecherry, and alder understory. Site has good overall riparian buffer along reach which minimizes impact from agriculture.

D3.3.9.3 TOB 1-1

Description of Human Impacts and Severity

Stream reach is influenced by rural residential impact and some minor historic grazing. Some restoration work was performed on an eroding bank in cell 3.

Description of Stream Channel Conditions

Stream reach is a Rosgen type C4 channel, but resembles a F4 channel type in cell 2 due to entrenchment. Stream reach is just below confluence of Fortine and Grave Creek, and has high energy, large substrate, moderate erosion, and a minimal number of pools and spawning gravels.

Description of Riparian Vegetation Conditions

Reach appears to be historically grazed, but is recovering. Riparian vegetation includes cottonwoods, conifers, wild rose, horsetail, and some sedges.

D3.4 Sampling Parameter Summaries by Individual Reach

The following section provides descriptions and basic statistics of stream channel and riparian zone parameters measured in each of the 18 reaches where a full habitat assessment was completed.

D3.4.1 Width/Depth Ratio

Width depth ratio data for each site are displayed in **Figure D3-12** and **Table D3-14**. The high w/d ratio noted at FTN 12-7 likely stems from significant grazing impacts and riparian vegetation clearing at the site, which has led to overwidening of the channel.

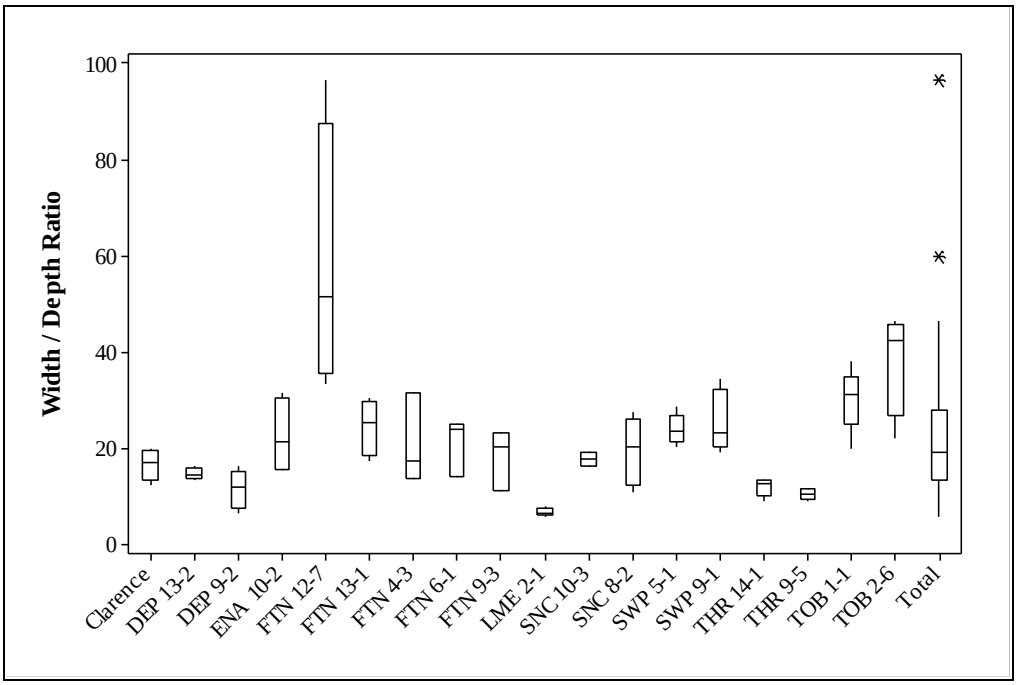

Figure D3-13. Width/depth ratio by reach

Table D3-14. Summary statistics of width/depth ratio by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	5	12.5	13.5	17.1	19.6	19.8
DEP 13-2	4	13.6	13.8	14.4	15.9	16.3
DEP 9-2	4	6.4	7.7	11.9	15.3	16.4
ENA 10-2	5	15.6	15.7	21.5	30.7	31.6
FTN 12-7	4	33.2	35.7	51.5	87.4	96.5
FTN 13-1	4	17.3	18.7	25.3	29.8	30.5
FTN 4-3	3	13.8	13.8	17.3	31.7	31.7
FTN 6-1	3	14.2	14.2	24.0	25.2	25.2
FTN 9-3	3	11.2	11.2	20.2	23.2	23.2
LME 2-1	4	5.9	6.0	6.7	7.7	8.0
SNC 10-3	3	16.2	16.2	17.7	19.3	19.3
SNC 8-2	5	11.0	12.3	20.3	26.3	27.5
SWP 5-1	5	20.4	21.4	23.7	27.0	28.5
SWP 9-1	5	19.1	20.3	23.2	32.5	34.6
THR 14-1	5	9.1	10.2	12.8	13.5	13.5

Table D3-14. Summary statistics of width/depth ratio by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
THR 9-5	4	9.2	9.5	10.6	11.5	11.6
TOB 1-1	5	20.0	25.0	31.1	34.9	38.1
TOB 2-6	4	22.0	26.8	42.3	45.6	46.3
Total	**75**	**5.9**	**13.5**	**19.3**	**27.8**	**96.5**

D3.4.2 Entrenchment Ratio

Entrenchment ratio data for each site are displayed in **Figure D3-13** and **Table D3-15**. The Clarence Creek reach shows wide variability most likely due to the stream down-cutting to reach its confluence with Grave Creek. THR 14-1 is also a transitional reach moving from forested valley into pasture ground, and an undersized culvert near the downstream end may be impacting the reach.

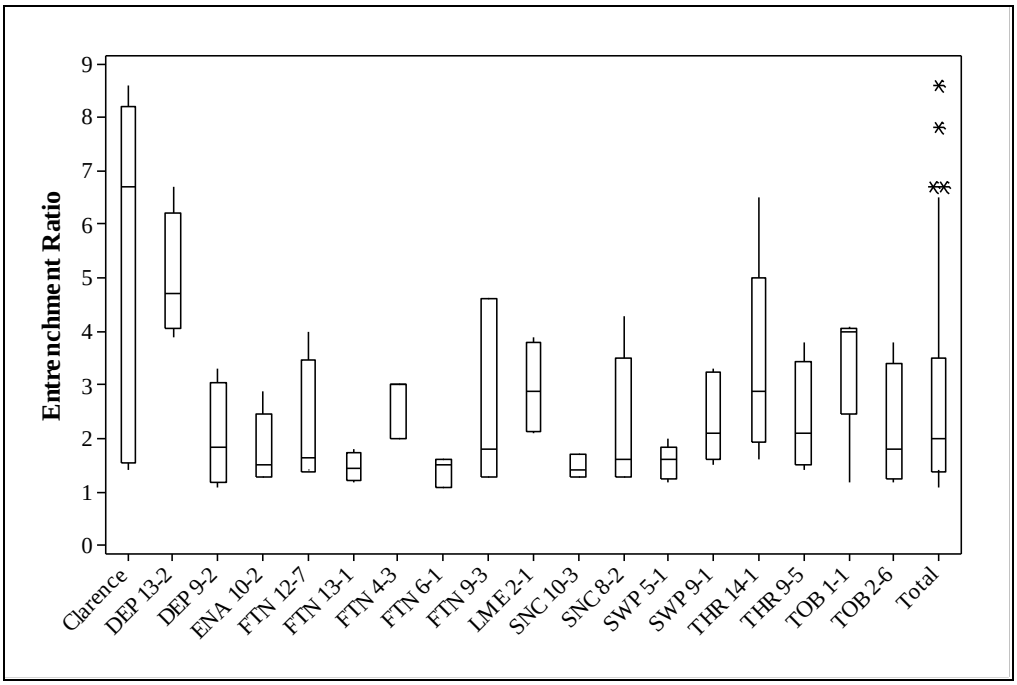

Figure D3-13. Entrenchment ratio by reach

Table D3-15. Summary statistics of entrenchment ratio by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	5	1.4	1.6	6.7	8.2	8.6
DEP 13-2	4	3.9	4.1	4.7	6.2	6.7
DEP 9-2	4	1.1	1.2	1.8	3.1	3.3
ENA 10-2	5	1.3	1.3	1.5	2.5	2.9
FTN 12-7	4	1.4	1.4	1.7	3.5	4.0
FTN 13-1	4	1.2	1.2	1.5	1.8	1.8
FTN 4-3	3	2.0	2.0	3.0	3.0	3.0
FTN 6-1	3	1.1	1.1	1.5	1.6	1.6
FTN 9-3	3	1.3	1.3	1.8	4.6	4.6
LME 2-1	4	2.1	2.2	2.9	3.8	3.9
SNC 10-3	3	1.3	1.3	1.4	1.7	1.7
SNC 8-2	5	1.3	1.3	1.6	3.5	4.3

Table D3-15. Summary statistics of entrenchment ratio by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
SWP 5-1	5	1.2	1.3	1.6	1.9	2.0
SWP 9-1	5	1.5	1.6	2.1	3.3	3.3
THR 14-1	5	1.6	2.0	2.9	5.0	6.5
THR 9-5	4	1.4	1.5	2.1	3.5	3.8
TOB 1-1	5	1.2	2.5	4.0	4.1	4.1
TOB 2-6	4	1.2	1.3	1.8	3.4	3.8
Total	**75**	**1.1**	**1.4**	**2.0**	**3.5**	**8.6**

D3.4.3 Riffle Pebble Count: Substrate Fines (% <2 mm)

Substrate fines less than 2 mm in riffle pebble count data for each site are displayed in **Figure D3-14** and **Table D3-16**. Two sites, LME 6-1 and SNC 10-3, exhibited high percentages of fine materials. Lime Creek contains fine sediment that appears to be naturally occurring from limestone deposits in the area. SNC 10-3 exhibited significant urban and transportation impacts, including a culvert that appeared to be causing significant deposition of fines upgradient.

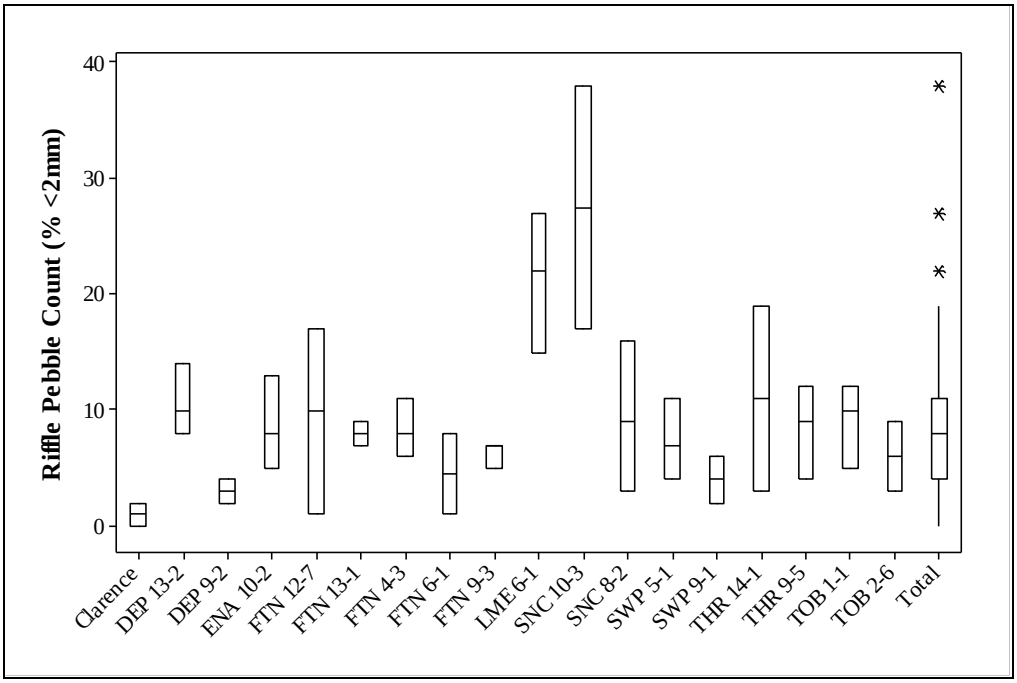

Figure D3-14. Riffle pebble count (% <2 mm) by reach

Table D3-16. Summary statistics of riffle pebble count (% <2 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	3	0	0	1	2	2
DEP 13-2	3	8	8	10	14	14
DEP 9-2	3	2	2	3	4	4
ENA 10-2	3	5	5	8	13	13
FTN 12-7	3	1	1	10	17	17
FTN 13-1	3	7	7	8	9	9
FTN 4-3	3	6	6	8	11	11
FTN 6-1	2	1		4.5		8

Table D3-16. Summary statistics of riffle pebble count (% <2 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
FTN 9-3	3	5	5	7	7	7
LME 6-1	3	15	15	22	27	27
SNC 10-3	2	17		27.5		38
SNC 8-2	3	3	3	9	16	16
SWP 5-1	3	4	4	7	11	11
SWP 9-1	3	2	2	4	6	6
THR 14-1	3	3	3	11	19	19
THR 9-5	3	4	4	9	12	12
TOB 1-1	3	5	5	10	12	12
TOB 2-6	3	3	3	6	9	9
Total	**52**	**0**	**4**	**8**	**11**	**38**

D3.4.4 Riffle Pebble Count: Substrate Fines (% <6mm)

Substrate fines less than 6 mm in riffle pebble count data for each site are displayed in **Figure D3-15** and **Table D3-17**. Similar to the less than 2 mm data, LME 6-1 and SNC 10-3 exhibited elevated percentages of fines less than 6 mm due to impacts listed previously.

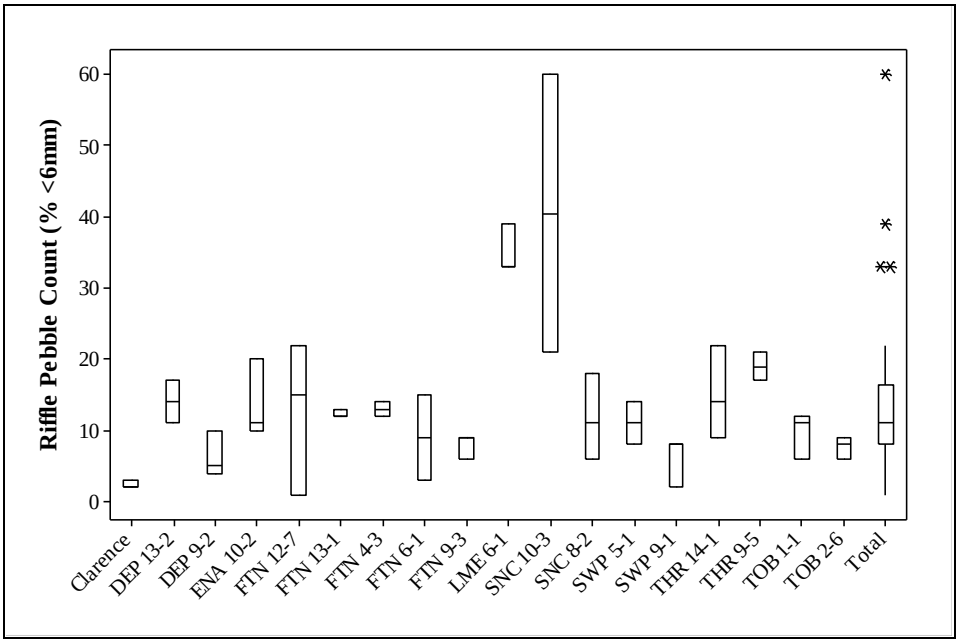

Figure D3-15. Riffle pebble count (% <6 mm) by reach

Table D3-17. Summary statistics of riffle pebble count (% <6 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	3	2	2	2	3	3
DEP 13-2	3	11	11	14	17	17
DEP 9-2	3	4	4	5	10	10
ENA 10-2	3	10	10	11	20	20
FTN 12-7	3	1	1	15	22	22
FTN 13-1	3	12	12	12	13	13
FTN 4-3	3	12	12	13	14	14

Table D3-17. Summary statistics of riffle pebble count (% <6 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
FTN 6-1	2	3		9		15
FTN 9-3	3	6	6	9	9	9
LME 6-1	3	33	33	33	39	39
SNC 10-3	2	21		40.5		60
SNC 8-2	3	6	6	11	18	18
SWP 5-1	3	8	8	11	14	14
SWP 9-1	3	2	2	8	8	8
THR 14-1	3	9	9	14	22	22
THR 9-5	3	17	17	19	21	21
TOB 1-1	3	6	6	11	12	12
TOB 2-6	3	6	6	8	9	9
Total	**52**	**1**	**8**	**11**	**16.5**	**60**

D3.4.5 Riffle Pebble Count: D50 (mm)

The D50 (mm) of riffle pebble counts for each site are displayed in **Figure D3-16** and **Table D3-18**. Similar to the less than 2 mm data, LME 6-1 and SNC 10-3 exhibited elevated percentages of fines less than 6 mm due to impacts listed previously.

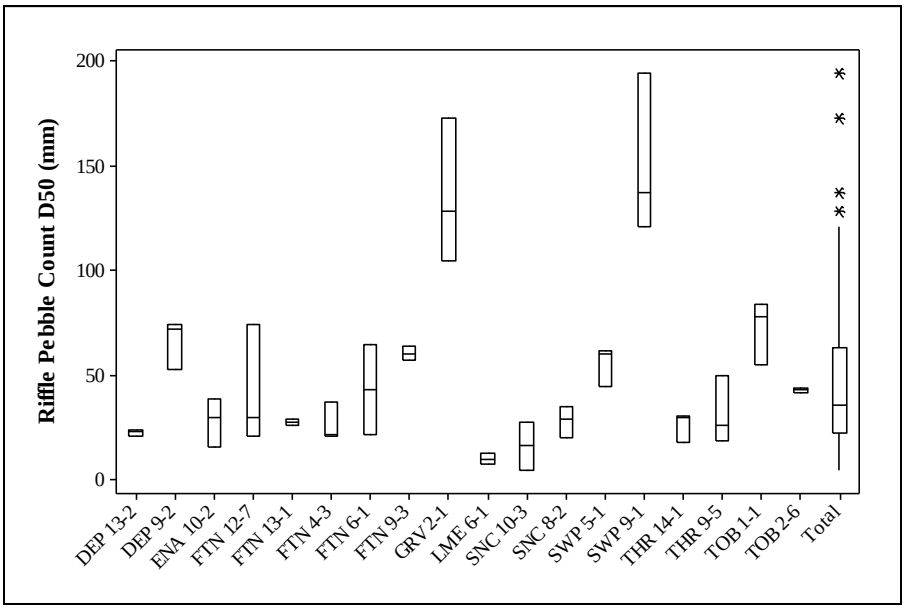

Figure D3-16. Riffle pebble count D50 (mm) by reach

Table D3-18. Summary statistics of riffle pebble count D50 (mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	3	105	105	128	173	173
DEP 13-2	3	21	21	23	24	24
DEP 9-2	3	53	53	72	74	74
ENA 10-2	3	16	16	30	39	39
FTN 12-7	3	21	21	30	74	74
FTN 13-1	3	26	26	28	29	29
FTN 4-3	3	21	21	22	37	37

Table D3-18. Summary statistics of riffle pebble count D50 (mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
FTN 6-1	2	22		44		65
FTN 9-3	3	57	57	60	64	64
LME 6-1	3	8	8	10	13	13
SNC 10-3	2	5		17		28
SNC 8-2	3	20	20	29	35	35
SWP 5-1	3	45	45	60	62	62
SWP 9-1	3	121	121	137	194	194
THR 14-1	3	18	18	30	31	31
THR 9-5	3	19	19	26	50	50
TOB 1-1	3	55	55	78	84	84
TOB 2-6	3	42	42	43	44	44
Total	**52**	**5**	**22**	**36**	**64**	**194**

D3.4.6 Riffle Grid Toss: Substrate Fines (% < 6mm)

Substrate fines less than 6 mm in riffle grid toss data for each site are displayed in **Figure D3-17** and **Table D3-19**. SNC 10-3 displayed elevated fines in riffles due to urban and transportation impacts. FTN 12-7 data were slightly elevated likely due to grazing impacts in this reach. THR 9-5 data were also slightly elevated, which may have been due to rural residential impacts.

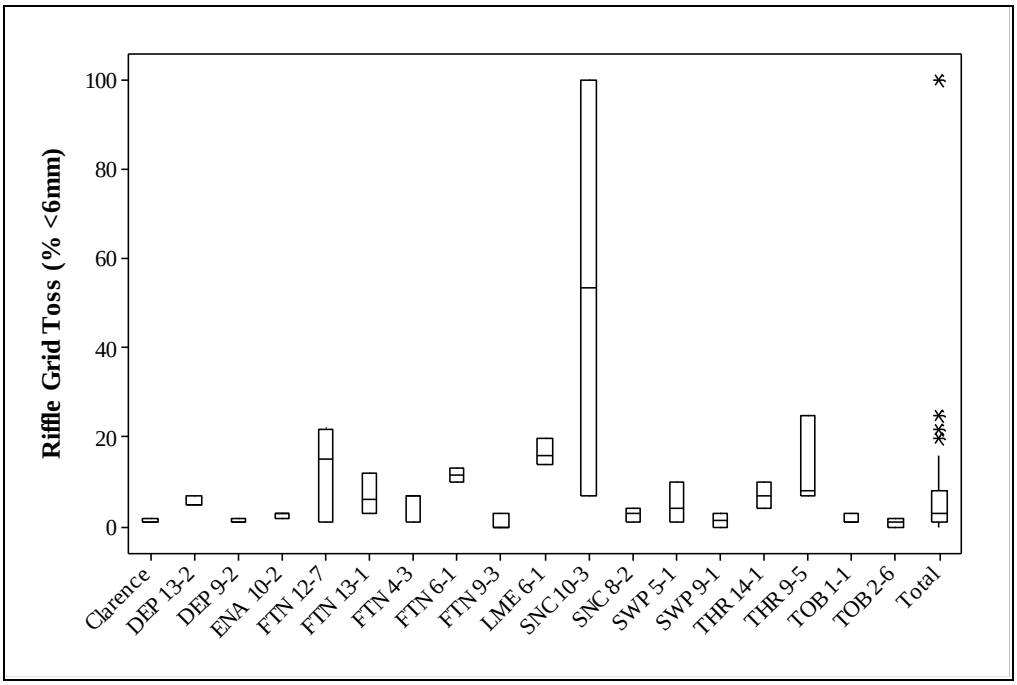

Figure D3-17. Riffle grid toss (% <6 mm) by reach

Table D3-19. Summary statistics of riffle grid toss (% < 6 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	3	1	1	1	2	2
DEP 13-2	3	5	5	5	7	7
DEP 9-2	3	1	1	1	2	2
ENA 10-2	3	2	2	3	3	3

Table D3-19. Summary statistics of riffle grid toss (% < 6 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
FTN 12-7	3	1	1	15	22	22
FTN 13-1	3	3	3	6	12	12
FTN 4-3	3	1	1	7	7	7
FTN 6-1	2	10		11.5		13
FTN 9-3	3	0	0	0	3	3
LME 6-1	3	14	14	16	20	20
SNC 10-3	2	7	*	53.5	*	100
SNC 8-2	3	1	1	3	4	4
SWP 5-1	3	1	1	4	10	10
SWP 9-1	3	0		1.5		3
THR 14-1	3	4	4	7	10	10
THR 9-5	3	7	7	8	25	25
TOB 1-1	3	1	1	1	3	3
TOB 2-6	3	0	0	1	2	2
Total	**52**	**0**	**1**	**3**	**8**	**100**

D3.4.7 Pool Grid Toss within Depositional Spawning Areas: Substrate Fines (% < 6mm)

Substrate fines less than 6 mm in pools exhibiting depositional spawning gravels for each site are displayed in **Figure D3-18** and **Table D3-20**. Some sites did not exhibit any suitable spawning gravels (Clarence, DEP 9-2, LME 6-1, SWP 9-1), and as a result are not included in this analysis. SNC 10-3 again exhibits high fines due to urban and transportation impacts.

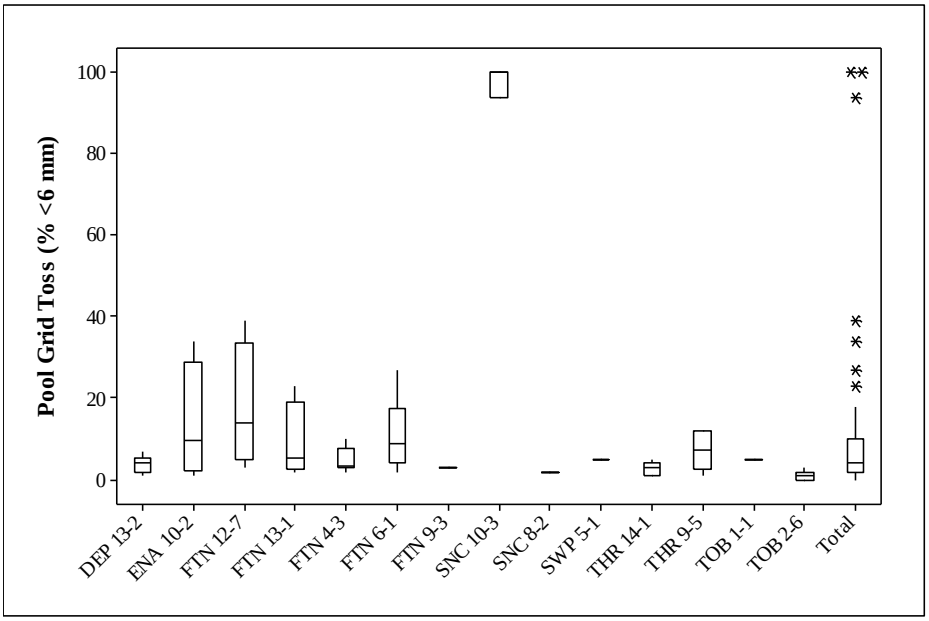

Figure D3-18. Pool grid toss (% <6 mm) by reach

Table D3-20. Summary statistics of pool grid toss (% <6 mm) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
DEP 13-2	10	1	1.75	4	5.5	7
ENA 10-2	4	1	2.25	9.5	28.75	34
FTN 12-7	4	3	5	14	33.5	39
FTN 13-1	4	2	2.5	5.5	19	23
FTN 4-3	8	2	3	3.5	7.75	10
FTN 6-1	8	2	4.25	9	17.5	27
FTN 9-3	1	3		3		3
SNC 10-3	3	94	94	100	100	100
SNC 8-2	1	2		2		2
SWP 5-1	1	5		5		5
THR 14-1	6	1	1	3	4.25	5
THR 9-5	6	1	2.5	7.5	12	12
TOB 1-1	1	5		5		5
TOB 2-6	8	0	0	1	1.75	3
Total	**65**	**0**	**2**	**4**	**10**	**100**

D3.4.8 Residual Pool Depth

Residual pool depth data for each site are displayed in **Figure D3-19** and **Table D3-21**. LME 6-1, SNC 10-3, and SWP 5-1 exhibited low residual pool depths.

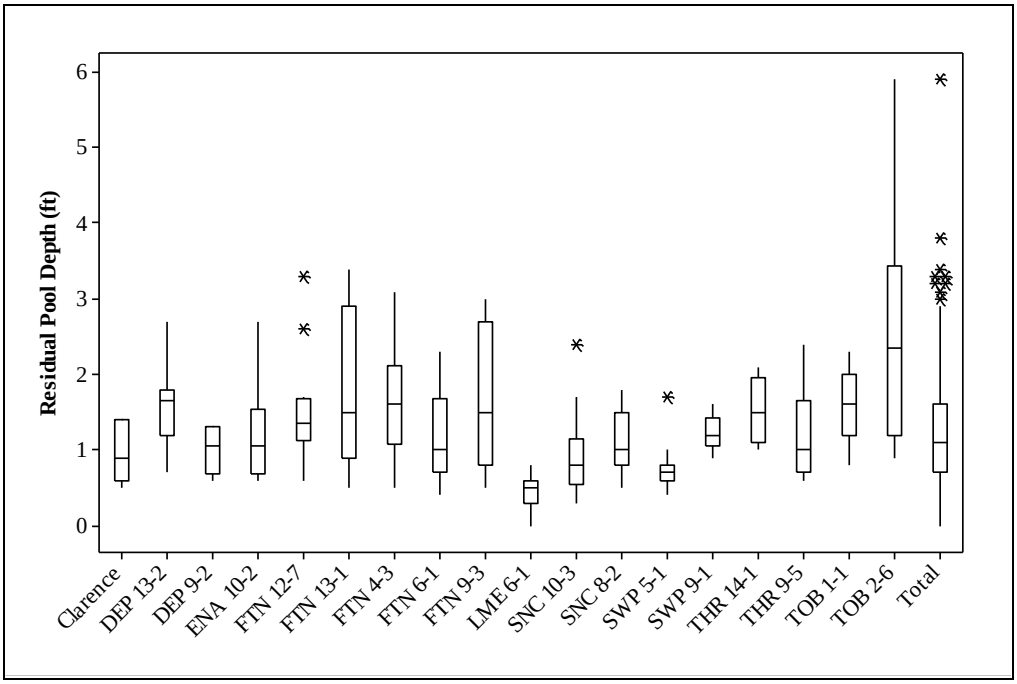

Figure D3-19. Residual pool depth (ft) by reach

Table D3-21. Summary statistics of residual pool depth (ft) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	7	0.5	0.6	0.9	1.4	1.4
DEP 13-2	16	0.7	1.2	1.7	1.8	2.7
DEP 9-2	6	0.6	0.7	1.1	1.3	1.3
ENA 10-2	14	0.6	0.7	1.1	1.6	2.7
FTN 12-7	12	0.6	1.1	1.4	1.7	3.3
FTN 13-1	11	0.5	0.9	1.5	2.9	3.4
FTN 4-3	10	0.5	1.1	1.6	2.1	3.1
FTN 6-1	10	0.4	0.7	1.0	1.7	2.3
FTN 9-3	7	0.5	0.8	1.5	2.7	3.0
LME 6-1	7	0.0	0.3	0.5	0.6	0.8
SNC 10-3	17	0.3	0.6	0.8	1.2	2.4
SNC 8-2	23	0.5	0.8	1.0	1.5	1.8
SWP 5-1	15	0.4	0.6	0.7	0.8	1.7
SWP 9-1	8	0.9	1.1	1.2	1.4	1.6
THR 14-1	9	1.0	1.1	1.5	2.0	2.1
THR 9-5	16	0.6	0.7	1.0	1.7	2.4
TOB 1-1	5	0.8	1.2	1.6	2.0	2.3
TOB 2-6	10	0.9	1.2	2.4	3.4	5.9
Total	**203**	**0.0**	**0.7**	**1.1**	**1.6**	**5.9**

D3.4.9 Greenline Inventory: Percent Understory Shrub Cover

Percent understory shrub cover data from the greenline survey for each site is displayed in **Figure D3-20** and **Table D3-22**.

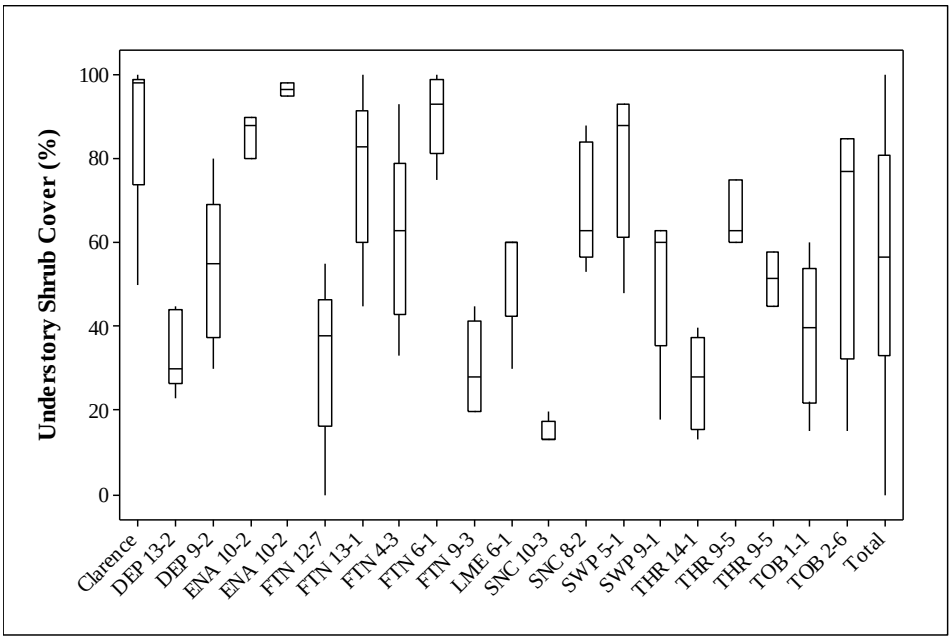

Figure D3-20. Greenline understory shrub cover (%) by reach

Table D3-22. Summary statistics of understory shrub cover (%) by reach

Reach ID	Count	Minimum	Q1	Median	Q3	Maximum
Clarence	5	50	74	98	99	100
DEP 13-2	5	23	26.5	30	44	45
DEP 9-2	5	30	37.5	55	69	80
ENA 10-2	3	80	80	88	90	90
ENA 10-2	2	95		96.5		98
FTN 12-7	5	0	16.5	38	46.5	55
FTN 13-1	5	45	60	83	91.5	100
FTN 4-3	5	33	43	63	79	93
FTN 6-1	5	75	81.5	93	99	100
FTN 9-3	5	20	20	28	41.5	45
LME 6-1	5	30	42.5	60	60	60
SNC 10-3	5	13	13	13	17.5	20
SNC 8-2	5	53	56.5	63	84	88
SWP 5-1	5	48	61.5	88	93	93
SWP 9-1	5	18	35.5	60	63	63
THR 14-1	5	13	15.5	28	37.5	40
THR 9-5	3	60	60	63	75	75
THR 9-5	2	45		51.5		58
TOB 1-1	5	15	22	40	54	60
TOB 2-6	5	15	32.5	77	85	85
Total	**90**	**0**	**33**	**56.5**	**80.75**	**100**

D4.0 STREAMBANK EROSION SOURCE 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 guidelines provided in *Watershed Assessment of River Stability and Sediment Supply* (Rosgen, 2006). These measurements were used in conjunction with streambank length and erosion source notes to determine sediment loads per 1,000 feet within each surveyed reach.

For sites within the Tobacco River TPA, eroding banks were identified as "actively eroding" or "slowly eroding". A number of eroding bank sites within each reach was evaluated based on the variability of streambank conditions within the reach. The banks selected for evaluation provide a representative sample of conditions throughout the reach, and banks which are similar to the evaluated banks are measured and recorded as "additional banks". At each eroding bank, photos were taken from locations perpendicular and upstream/downstream of the streambank. Photos were labeled according to the streambank site and position of the photograph. Photos of example streambanks are provided in **Attachment D**.

D4.1 FIELD MEASUREMENTS AND LOADING CALCULATIONS

D4.1.1 Field Measurements

Within each sampled reach, eroding streambanks were identified and supporting measurements were recorded for the following metrics:

- Bank condition (includes actively eroding or slowly eroding/undercut/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 (%): transportation, grazing, cropland, irrigation, natural, urban, railroad

D4.1.2 Determination of BEHI Scores

To determine the BEHI score for each eroding bank, the following parameters are used:

- Bank height/bankfull height
- Root depth/bank height
- Weighted root density (root density * root depth/bank height)

- Bank angle
- Surface protection

These five bank erosion parameters are used to determine a numerical BEHI index score that ranks erosion potential from very low to extreme based on relationships provided by Rosgen (2006) (**Table D4-1**).

Table D4-1. BEHI score and rating system for individual parameters

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 obtaining the BEHI index score for each individual parameter, the index scores are summed to produce a total BEHI score. Bank material factors are then considered, and total BEHI scores may be adjusted up or down. Banks comprised of bedrock, boulders, or cobble have very low erosion potential, and total BEHI scores for banks composed of these materials may be adjusted down by up to 10 points. Banks composed of cobble and/or gravel with a high fraction of sand have increased erosion potential, and total BEHI scores may be adjusted up by 5 to 10 points depending on the amount of sand present and whether the sandy material is exposed to erosion. Stratified banks containing layers of unstable material also have greater erosion potential, and total BEHI scores may be adjusted up by 5 to 10 points if stratified banks are present. After all material adjustments are made to the total BEHI score, the erosion potential is ranked from very low to extreme based on the scale provided below (**Table D4-2**). Photos of example streambanks with each BEHI rating are provided in **Attachment D**.

Table D4-2. Total BEHI score and rating system

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

D4.1.3 Near Bank Stress (NBS) Determination

To calculate Near Bank Stress (NBS) for each eroding bank, the following relationship is used:

NBS = Near Bank Maximum Bankfull Depth (ft) / Bankfull Mean Depth (ft)

As with the BEHI scores, the resulting NBS values correspond to a categorical rating that ranks the erosion potential from very low to extreme (**Table D4-3)**. If appropriate measurements are not recorded for NBS determination, the NBS rating is estimated in the field or from photos using best professional judgment.

Table D4-3. Near bank stress (NBS) rating system

NBS Value	Rating
< 1.0	very low
1.0 - 1.5	low
1.51 - 1.8	moderate
1.81 - 2.5	high
2.51 - 3.0	very high
> 3.0	extreme

D4.1.4 Retreat Rate

Once respective BEHI and NBS ratings are found for each eroding bank, the ratings are used to derive the average retreat rate of each streambank based on empirical relationships derived by Rosgen (2006). The average retreat rates (ft/yr) based on BEHI and NBS ratings are provided below in **Table D4-4**.

Table D4-4. Streambank retreat rate (ft/yr) based on BEHI and NBS rating

	Near Bank Stress					
BEHI	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

D4.1.5 Sediment Loading Calculation

Once retreat rate is determined from the BEHI and NBS ratings, the dimensions of the eroding streambank are used to find the total mass eroding from each bank per year. The total mass eroded from each streambank is calculated using the following equation:

$$\textit{mass eroded (tons/yr)} = \textit{bank length (ft)} * \textit{bank height (ft)} * \textit{retreat rate (ft/yr)} * \textit{material density (tons/ft}^3\textit{)}$$

The sediment load from each streambank is filtered into two bank erosion type categories including actively eroding banks or slowly eroding/undercut/vegetated banks. The total loads for each bank erosion type and for the entire reach are then calculated in tons of sediment per year per 1000 feet of reach.

D4.2 Sediment Loading Results by Assessment Reach

The following sections provide sediment loading results organized by waterbody. One data table is included for each sampled waterbody and includes data from each sampled reach which summarizes sediment loading for each bank erosion type (active or slowly eroding) and for the total reach. Information provided includes the number of banks present for each bank erosion type, the mean BEHI rating for each erosion type present, the percent of reach that is eroding, the percent contribution from each erosion source present, and the sediment load per 1000 feet for each erosion type and for the entire reach. Streambank erosion conditions are described for each reach.

D4.2.1 Sediment Loading Results for Clarence Creek

The sampled reach of Clarence Creek exhibited minimal streambank erosion, with only slowly eroding bank types. Two bank types with five total banks are slowly eroding, but a cobble layer at the base of the

banks limits the contribution of fine sediment to the stream channel. The stream may be downcutting to meet Grave Creek. Sediment loading results are provided below in **Table D4-5**.

Table D4-5. Sediment loading results for Clarence Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)	Sediment Load per 1000' (Tons/Year)
					Natural	
Clarence	Active	0	-	0	-	0.0
	Slow	5	moderate	12	100	14.1
	Total	5	-	12	100	14.1

D4.2.2 Sediment Loading Results for Deep Creek

Three reaches were sampled on Deep Creek, including full surveys on DEP 13-2 and DEP 9-2, and streambank erosion assessment only on DEP 7-1. Sediment loading results for Deep Creek sites are provided below in **Table D4-6**.

Reach 13-2 shows minimal erosion except on outside meanders and some erosion due to scour from wood. Overall, the streambank is well vegetated.

Within reach 9-2, a very large mass wasting site exists on river right, consisting of a tall (50-100') eroding bank with constructed rock barbs which are causing some erosion on river left. This feature creates extensive loading to Deep Creek, and the stream channel appears to be in disequilibrium with its sediment supply. One other bank erosion type exists within this reach with low NBS and a dense vegetation layer over cobble layer.

No streambank erosion was observed in reach 7-1. The site has extremely dense vegetation, with wood, moss and boulders covering the bank.

Table D4-6. Sediment loading results for Deep Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)		Sediment Load per 1000' (Tons/Year)
					Roads	Natural	
DEP 13-2	Active	0	-	0	-	-	0.0
	Slow	5	moderate	7	-	100	2.8
	Total	5	-	7	-	100	2.8
DEP 9-2	Active	2	extreme	10	100	-	117.1
	Slow	3	high	13	24	76	38.4
	Total	5	-	23	81	19	155.5
DEP 7-1	Active	0	-	0	-	-	0.0
	Slow	0	-	0	-	-	0.0
	Total	0	-	0	-	-	0.0

D4.2.3 Sediment Loading Results for Edna Creek

Four locations were sampled on Edna Creek, including reaches 10-2, 11-1, 7-2, and 8-1. Only reach 10-2 received a full site evaluation, while the other three sites were evaluated for bank erosion conditions only. Results of the sediment loading calculations are provided below in **Table D4-7**.

Reach 11-1 has minimal bank erosion with no actively eroding banks. There is evidence of recent beaver activity and numerous places where wildlife is accessing the stream. Reed canary grass armors the banks and prevents erosion. Adjacent cropland is actively mowed for hay.

Only one eroding bank type was noted within reach 10-2. The bank type is slowly eroding with well vegetated banks. Most banks are slightly undercut with low to very low NBS, and all bank erosion appears natural.

Reach 8-1 does not have much bank erosion, and has lots of cover and no actively eroding banks. A number of pieces of deadfall (10-15) are covering the stream with several 60 foot sections that were impossible to walk through.

Reach 7-2 has several slowly eroding banks and one actively eroding bank. Most banks were well covered throughout the reach.

Table D4-7. Sediment loading results for Edna Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)		Sediment Load per 1000' (Tons/Year)
					Cropland	Natural	
ENA 11-1	Active	0	-	0	-	-	0.0
	Slow	5	low	3	100	-	0.1
	Total	5	-	3	100	-	0.1
ENA 10-2	Active	0	-	0	-	-	0.0
	Slow	7	moderate	9	-	100	7.9
	Total	7	-	9	-	100	7.9
ENA 8-1	Active	0	-	0	-	-	0.0
	Slow	4	moderate	4	-	100	8.3
	Total	4	-	4	-	100	8.3
ENA 7-2	Active	1	moderate	2	-	100	0.9
	Slow	4	high	7	-	100	12.7
	Total	5	-	9	-	100	13.6

D4.2.4 Sediment Loading Results for Fortine Creek

Eleven sites were surveyed on Fortine Creek, including 5 full survey sites (4-3, 6-1, 9-3, 12-7, and 13-1) and 6 sites with streambank erosion assessments only (4-1, 7-2, 12-2, 12-9, 15-2, and 15-3). Sediment loading results for Fortine Creek are provided in **Table D4-8**.

Reach 15-3 has moderate erosion with one actively eroding bank, and all other banks were slowly eroding. Several game trails exit the forest and there was hoof shear at these locations.

Reach 15-2 has many slowly eroding banks, but no large actively eroding banks. The cover on the railroad side was surprisingly good.

Reach 13-1 has mostly slowly eroding banks with low to medium NBS. There is one location where a high bank (10') is actively eroding. Above the top of the reach there is massive bank erosion and failure with many adult trees in the stream channel. Eroding bank is approximately 15' high and more than 100’ long. Large banks have slumped into channel.

Reach 12-9 has minimal bank erosion, with only one actively eroding (and massive) bank at upper end of reach.

Within reach 12-7, heavy bank erosion and hoof shear exists due to grazing. The site has some evidence of past beaver activity. Most banks are actively eroding, with one vegetated slowly eroding bank.

Eroding banks within reach 12-2 includes one large long bank (actively eroding) and numerous slowly eroding banks. All streambank material is glacial till. Historic logging is noted along both banks, with trees cut right at bank edge.

Two bank types exist in reach 9-3. One is on outside meander bends with a cobble layer under fine sediments. This bank type has large conifers falling in the stream channel. The other bank type is a slowly eroding grassy bank, with fine material and some slumping into stream. Both bank types have medium NBS.

Reach 7-2 has some slowly eroding banks and only one actively eroding bank (downed tree next to stream and on a cliff).

Within reach 6-1, streambanks are eroding at top of reach due to beaver activity and railroad channelization which creates changes in stream energy. The “other” loading source in this reach is from railroad.

Two bank types exist within reach 4-3, including one due to cattle actively crossing stream, and one slowly eroding type on outside meander bends with good wood protection. Bank erosion is not severe considering cattle activity.

Reach 4-1 has many slowly eroding banks and two larger eroding banks due to log jams. All eroding banks appear to be natural.

Table D4-8. Sediment loading results for Fortine Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Roads	Grazing	Logging	Natural	Other	
FTN 15-3	Active	1	moderate	4	-	30	-	70	-	3.4
	Slow	3	low	6	-	16	-	84	-	1.5
	Total	4	-	10	-	26	-	74	-	4.9
FTN 15-2	Active	0	-	0	-	-	-	-	-	0.0
	Slow	6	moderate	22	48	-	-	52	-	11.9
	Total	6	-	22	48	-	-	52	-	11.9
FTN 13-1	Active	1	very high	2	-	-	-	100	-	17.0
	Slow	4	high	14	-	-	-	100	-	41.0
	Total	5	-	16	-	-	-	100	-	58.0

Table D4-8. Sediment loading results for Fortine Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)					Sediment Load per 1000' (Tons/Year)
					Roads	Grazing	Logging	Natural	Other	
FTN 12-9	Active	1	high	2	-	-	-	100	-	17.6
	Slow	4	low	8	-	46	14	40	-	1.8
	Total	5	-	10	-	4	1	94	-	19.4
FTN 12-7	Active	5	high	32	-	98	-	2	-	77.6
	Slow	1	moderate	5	-	-	-	100	-	0.2
	Total	6	-	37	-	98	-	2	-	77.8
FTN 12-2	Active	1	high	8	-	-	50	50	-	23.6
	Slow	8	moderate	15	-	-	15	85	-	11.9
	Total	9	-	23	-	-	38	62	-	35.5
FTN 9-3	Active	2	high	9	-	-	-	100	-	19.7
	Slow	1	moderate	14	-	-	-	100	-	1.6
	Total	3	-	23	-	-	-	100	-	21.3
FTN 7-2	Active	1	moderate	3	-	-	-	100	-	31.4
	Slow	5	moderate	7	-	-	-	100	-	6.4
	Total	6	-	10	-	-	-	100	-	37.7
FTN 6-1	Active	3	high	13	-	-	-	55	45	39.7
	Slow	2	moderate	11	-	-	-	100	-	3.8
	Total	5	-	24	-	-	-	59	41	43.4
FTN 4-3	Active	1	high	5	-	80	-	20	-	6.3
	Slow	7	moderate	30	-	-	-	100	-	15.0
	Total	8	-	35	-	24	-	76	-	21.3
FTN 4-1	Active	0	-	0	-	-	-	-	-	0.0
	Slow	11	high	20	-	-	-	100	-	46.5
	Total	11	-	20	-	-	-	100	-	46.5

D4.2.5 Sediment Loading Results for Lime Creek

One full site assessment was conducted on Lime Creek. Reach 6-1 has multiple eroding banks with three bank types present. Some bank erosion is due to game or livestock crossings, and some is due to tree failures into stream potentially due to historic logging activities. Due to fine material in banks, any bank disturbance results in erosion. Loading results for Lime Creek are provided below in **Table D4-9**.

Table D4-9. Sediment loading results for Lime Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)			Sediment Load per 1000' (Tons/Year)
					Roads	Logging	Natural	
LME 6-1	Active	1	high	2	-	20	80	6.2
	Slow	7	high	10	44	1	54	13.6
	Total	8	-	11	30	7	62	19.8

D4.2.6 Sediment Loading Results for Sinclair Creek

Three sites were sampled on Sinclair Creek, including full surveys on reaches 8-2 and 10-3, and streambank erosion assessment on 5-1. Results for Sinclair Creek are provided below in **Table D4-10**.

Reach 10-3 has two eroding bank types. Banks have high protection due to vegetation, but are stratified with a sand layer. Stream shows evidence of deposition. The "other" loading source within this reach is described as urban influence.

Reach 8-2 contains many eroding banks. Banks are bare on meander bends due to grazing, adding cobbles and large gravels to the stream. Stream appears to be recovering due to recent fencing of cattle.

Reach 5-1 has minimal erosion with large material and wood armoring banks. Two slowly eroding banks exist, although they are well protected. One actively eroding bank exists due to tree falling in stream channel.

Table D4-10. Sediment loading results for Sinclair Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)				Sediment Load per 1000' (Tons/Year)
					Roads	Grazing	Natural	Other	
SNC 10-3	Active	0	-	0	-	-	-	-	0.0
	Slow	4	moderate	11	50	-	20	30	53.5
	Total	4	-	11	50	-	20	30	53.5
SNC 8-2	Active	14	high	16	-	100	-	-	42.0
	Slow	0	-	0	-	-	-	-	0.0
	Total	14	-	16	-	100	-	-	42.0
SNC 5-1	Active	1	moderate	4	-	-	100	-	9.0
	Slow	2	moderate	3	-	-	100	-	2.7
	Total	3	-	7	-	-	100	-	11.7

D4.2.7 Sediment Loading Results for Swamp Creek

Three sites were sampled on Swamp Creek, including full surveys on reaches 5-1 and 9-1, and streambank erosion assessment on 3-1. Results for Swamp Creek are provided below in **Table D4-11**.

Reach 9-1 has seven long slowly eroding banks, including four that are undercut and overhanging. Mid-channel boulders are noted, but banks have good protection from large substrate and wood.

Reach 5-1 has multiple eroding banks. Some minor hoof shear is present at game crossings, and new pipe arch bridge upstream of reach may be causing erosion downstream. The natural loading source in this reach is from game crossings.

Only slowly eroding banks were found within reach 3-1. Site has good riparian corridor in lower portion of reach, but historic logging is evident in areas. Many eroding banks were due to trees that have fallen and exposed their roots. Reach has no large eroding banks.

Table D4-11. Sediment loading results for Swamp Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)		Sediment Load per 1000' (Tons/Year)
					Logging	Natural	
SWP 9-1	Active	0	-	0	-	-	0.0
	Slow	7	high	27	-	100	51.6
	Total	7	-	27	-	100	51.6
SWP 5-1	Active	2	high	5	90	10	9.8
	Slow	3	moderate	7	100	-	3.6
	Total	5	-	12	93	7	13.4
SWP 3-1	Active	0	-	0	-	-	0.0
	Slow	7	moderate	6	9	91	1.0
	Total	7	-	6	9	91	1.0

D4.2.8 Sediment Loading Results for Therriault Creek

Two full surveys were conducted on Therriault Creek at reaches 14-1 and 9-5. Sediment loading results are provided below in **Table D4-12**.

Reach 14-1 contains minimal bank erosion, with only two actively eroding banks. Several short slowly eroding occur on outside meander bends. The “other” loading source for this reach is rural residences.

Eroding banks in reach 9-5 are primarily slowly eroding banks on outside meander bends. A few high bank failures exist in short reaches, although they appear relatively stable. There is evidence of historic logging in the riparian area, and some active logging in the bench area above the sampled reach.

Table D4-12. Sediment loading results for Therriault Creek

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)				Sediment Load per 1000' (Tons/Year)
					Grazing	Logging	Natural	Other	
THR 14-1	Active	2	very high	2	14	-	86	-	2.8
	Slow	6	high	5	4	10	48	38	5.1
	Total	8	-	7	7	6	62	24	7.9
THR 9-5	Active	5	high	4	-	57	43	-	12.9
	Slow	8	moderate	10	-	63	37	-	8.5
	Total	13	-	14	-	60	40	-	21.4

D4.2.9 Sediment Loading Results for Tobacco River

Four sites were surveyed on the Tobacco River, including full surveys on reaches 1-1 and 2-6, and streambank erosion assessments on reaches 1-3 and 2-3. Sediment loading results for Tobacco River is provided below in **Table D4-13**.

Reach 2-6 has multiple eroding bank types including two big mass wasting sites. The bases of most banks were composed of gravel/cobble substrate. The “other” loading source for this reach was from railroad and rural residences.

Two bank types exist within reach 2-3, including one tall actively eroding bank type that occurs in three locations, and one slowly eroding bank type with good surface cover from cobbles. Some areas have riprap to control erosion, especially along outside meander bends. The "other" loading source for this reach is urban influence.

One massive glacial till bank exists just downstream of Therriault Creek within reach 1-3. Several slowly eroding grass banks also exist with cobble substrate at base.

Reach 1-1 has several eroding, unstable banks, with lots of cobbles, poor binding vegetation, and minimal bank protection.

Table D4-13. Sediment loading results for Tobacco River

Reach ID	Erosion Type	Number of Banks	Mean BEHI Rating	Percent Eroding Bank	Loading Source (%)				Sediment Load per 1000' (Tons/Year)
					Roads	Grazing	Natural	Other	
TOB 1-1	Active	6	moderate	32	-	1	99	-	47.6
	Slow	2	moderate	8	-	-	100	-	6.6
	Total	8	-	40	-	1	99	-	54.3
TOB 1-3	Active	1	very high	11	-	-	100	-	56.7
	Slow	4	moderate	15	7	7	87	-	11.7
	Total	5	-	26	1	1	98	-	68.4
TOB 2-3	Active	3	moderate	3	50	-	18	32	6.7
	Slow	3	low	8	35	-	65	-	2.7
	Total	6	-	11	46	-	31	23	9.4
TOB 2-6	Active	6	moderate	18	-	-	19	81	75.6
	Slow	2	high	7	-	-	100	-	7.6
	Total	8	-	25	-	-	27	73	83.2

D4.3 Sediment Loading Results by Reach Type

The following sections provide sediment loading results organized by reach type. Data provided includes sediment load per 1000 feet for each erosion type (active, slow, and total) and the percent contribution from each erosion source present. The adjacent land uses for left and right banks are also provided.

D4.3.1 Sediment Loading Results for Reach Type CR-0-2-U

Four sites were sampled of reach type CR-0-2-U. This reach type is in the Canadian Rockies Level IV Ecoregion, has low valley slope (<2%), and includes 2nd order streams within unconfined valleys. The "other" loading source within this reach type was urban influence within reach SNC 10-3, and rural residence within THR 14-1. Loading results are provided below in **Table D4-14**.

Table D4-14. Sediment loading results for reach type CR-0-2-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)					Adjacent Land Use	
	Active	Slow	Total	Roads	Grazing	Logging	Natural	Other	Left Bank	Right Bank
SNC 10-3	0.0	53.5	53.5	50	-	-	20	30	Urban	Urban
SNC 8-2	42.0	0.0	42.0	-	100	-	-	-	Rural/Farm	Hay/Pasture
THR 14-1	2.8	5.1	7.9	-	7	6	62	24	Forest	Rural/Farm
THR 9-5	12.9	8.5	21.4	-	-	60	40	-	Forest	Forest
Average	**14.4**	**16.7**	**31.2**	**13**	**27**	**17**	**31**	**14**		

D4.3.2 Sediment Loading Results for Reach Type CR-2-3-U

Only one site was sampled of reach type CR-2-3-U. This reach type is in the Canadian Rockies Level IV Ecoregion, has moderate valley slope (2-4%), and includes 3rd order streams within unconfined valleys. Loading results are provided below in **Table D4-15**.

Table D4-15. Sediment loading results for reach type CR-2-3-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)	Adjacent Land Use	
	Active	Slow	Total	Natural	Left Bank	Right Bank
DEP 13-2	0.0	2.8	2.8	100	Rural/Farm	Forest

D4.3.3 Sediment Loading Results for Reach Type CR-4-2-U

Three sites were sampled of reach type CR-4-2-U. This reach type is in the Canadian Rockies Level IV Ecoregion, has moderate valley slope (2-4%), and includes 2nd order streams within unconfined valleys. Loading results are provided below in **Table D4-16**.

Table D4-16. Sediment loading results for reach type CR-4-2-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)	Adjacent Land Use	
	Active	Slow	Total	Natural	Left Bank	Right Bank
Clarence	0.0	14.1	14.1	100	Forest	Forest
DEP 7-1	0.0	0.0	0.0	-	Forest	Harvest/Fire
SNC 5-1	9.0	2.7	11.7	100	Forest	Forest
Average	**3.0**	**5.6**	**8.6**	**100**		

D4.3.4 Sediment Loading Results for Reach Type CR-4-3-U

One site was sampled of reach type CR-4-3-U. This reach type is in the Canadian Rockies Level IV Ecoregion, has high valley slope (4-10%), and includes 3rd order streams within unconfined valleys. Loading results are provided below in **Table D4-17**.

Table D4-17. Sediment loading results for reach type CR-4-3-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)		Adjacent Land Use	
	Active	Slow	Total	Roads	Natural	Left Bank	Right Bank
DEP 9-2	117.1	38.4	155.5	81	19	Forest	Forest

D4.3.5 Sediment Loading Results for Reach Type NR-0-3-U

Five sites were sampled of reach type NR-0-3-U. This reach type is in the Northern Rockies Level IV Ecoregion, has low valley slope (<2%), and includes 3rd order streams within unconfined valleys. The "other" loading source within this reach type was from railroads within reach FTN 6-1. Loading results are provided below in **Table D4-18**.

Table D4-18. Sediment loading results for reach type NR-0-3-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)					Adjacent Land Use	
	Active	Slow	Total	Grazing	Crops	Logging	Natural	Other	Left Bank	Right Bank
ENA 11-1	0.0	0.1	0.1	-	100	-	-	-	Hay/Pasture	Hay/Pasture
FTN 4-1	0.0	46.5	46.5	-	-	-	100	-	Forest	Forest
FTN 4-3	6.3	15.0	21.3	24	-	-	76	-	Forest	Forest
FTN 6-1	39.7	3.8	43.4	-	-	-	59	41	Forest	Forest
SWP 5-1	9.8	3.6	13.4	-	-	93	7	-	Harvest/Fire	Harvest/Fire
Average	**11.1**	**13.8**	**24.9**	**5**	**20**	**19**	**48**	**8**		

D4.3.6 Sediment Loading Results for Reach Type NR-0-4-U

Seven sites were sampled of reach type NR-0-4-U, all on Fortine Creek. This reach type is in the Northern Rockies Level IV Ecoregion, has low valley slope (<2%), and includes 4th order streams within unconfined valleys. Loading results are provided below in **Table D4-19**.

Table D4-19. Sediment loading results for reach type NR-0-4-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)				Adjacent Land Use	
	Active	Slow	Total	Roads	Grazing	Logging	Natural	Left Bank	Right Bank
FTN 12-2	23.6	11.9	35.5	-	-	38	62	Forest	Forest
FTN 12-7	77.6	0.2	77.8	-	98	-	2	Forest	Hay/Pasture
FTN 12-9	17.6	1.8	19.4	-	4	1	94	Rural/Farm	Rural/Farm
FTN 13-1	17.0	41.0	58.0	-	-	-	100	Forest	Forest
FTN 15-2	0.0	11.9	11.9	48	-	-	52	Forest	Road
FTN 15-3	3.4	1.5	4.9	-	26	-	74	Rural/Farm	Rural/Farm
FTN 9-3	19.7	1.6	21.3	-	-	-	100	Forest	Forest
Average	**22.7**	**10.0**	**32.7**	**7**	**18**	**6**	**69**		

D4.3.7 Sediment Loading Results for Reach Type NR-0-5-U

Four sites were sampled of reach type NR-0-5-U, all of which were on the Tobacco River. This reach type is in the Northern Rockies Level IV Ecoregion, has low valley slope (<2%), and includes 5th order streams within unconfined valleys. The "other" loading source within this reach type was railroad and rural residences within reach TOB 2-6, and urban influence within reach TOB 2-3. Loading results are provided below in **Table D4-20**.

Table D4-20. Sediment loading results for reach type NR-0-5-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)				Adjacent Land Use	
	Active	Slow	Total	Roads	Grazing	Natural	Other	Left Bank	Right Bank
TOB 1-1	47.6	6.6	54.3	-	1	99	-	Forest	Forest
TOB 1-3	56.7	11.7	68.4	1	1	98	-	Hay/Pasture	Rural/Farm
TOB 2-3	6.7	2.7	9.4	46	-	31	23	Urban	Urban
TOB 2-6	75.6	7.6	83.2	-	-	27	73	Range	Hay/Pasture
Average	**46.6**	**7.2**	**53.8**	**12**	**1**	**63**	**24**		

D4.3.8 Sediment Loading Results for Reach Type NR-2-2-U

One site was sampled of reach type NR-2-2-U. This reach type is in the Northern Rockies Level IV Ecoregion, has moderate valley slope (2-4%), and includes 2nd order streams within unconfined valleys. Loading results are provided below in **Table D4-21**.

Table D4-21. Sediment loading results for reach type NR-2-2-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)	Adjacent Land Use	
	Active	Slow	Total	Natural	Left Bank	Right Bank
ENA 8-1	0.0	8.3	8.3	100	Forest	Road

4.3.9 Sediment Loading Results for Reach Type NR-2-3-U

Two sites were sampled of reach type NR-2-3-U. This reach type is in the Northern Rockies Level IV Ecoregion, has moderate valley slope (2-4%), and includes 3rd order streams within unconfined valleys. Loading results are provided below in **Table D4-22**.

Table D4-22. Sediment loading results for reach type NR-2-3-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)	Adjacent Land Use	
	Active	Slow	Total	Natural	Left Bank	Right Bank
FTN 7-2	31.4	6.4	37.7	100	Forest	Forest
SWP 9-1	0.0	51.6	51.6	100	Rural/Farm	Rural/Farm
Average	**15.7**	**29.0**	**44.6**	**100**		

D4.3.10 Sediment Loading Results for Reach Type NR-4-2-U

Two sites were sampled of reach type NR-4-2-U. This reach type is in the Northern Rockies Level IV Ecoregion, has high valley slope (4-10%), and includes 2nd order streams within unconfined valleys. Loading results are provided below in **Table D4-23**.

Table D4-23. Sediment loading results for reach type NR-4-2-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)		Adjacent Land Use	
	Active	Slow	Total	Logging	Natural	Left Bank	Right Bank
ENA 7-2	0.9	12.7	13.6	0	100	Forest	Forest
SWP 3-1	0.0	1.0	1.0	9	91	Forest	Forest
Average	**0.4**	**6.8**	**7.3**	**5**	**95**		

D4.3.11 Sediment Loading Results for Reach Type NR-4-3-U

Two sites were sampled of reach type NR-4-3-U. This reach type is in the Northern Rockies Level IV Ecoregion, has high valley slope (4-10%), and includes 3rd order streams within unconfined valleys. Loading results are provided below in **Table D4-24**.

Table D4-24. Sediment loading results for reach type NR-4-3-U

Reach ID	Sediment Load per 1000' (tons/year)			Loading Source (%)			Adjacent Land Use	
	Active	Slow	Total	Roads	Logging	Natural	Left Bank	Right Bank
ENA 10-2	0.0	7.9	7.9	-	-	100	Forest	Forest
LME 6-1	6.2	13.6	19.8	30	7	62	Forest	Forest
Average	**3.1**	**10.7**	**13.8**	**15**	**4**	**81**		

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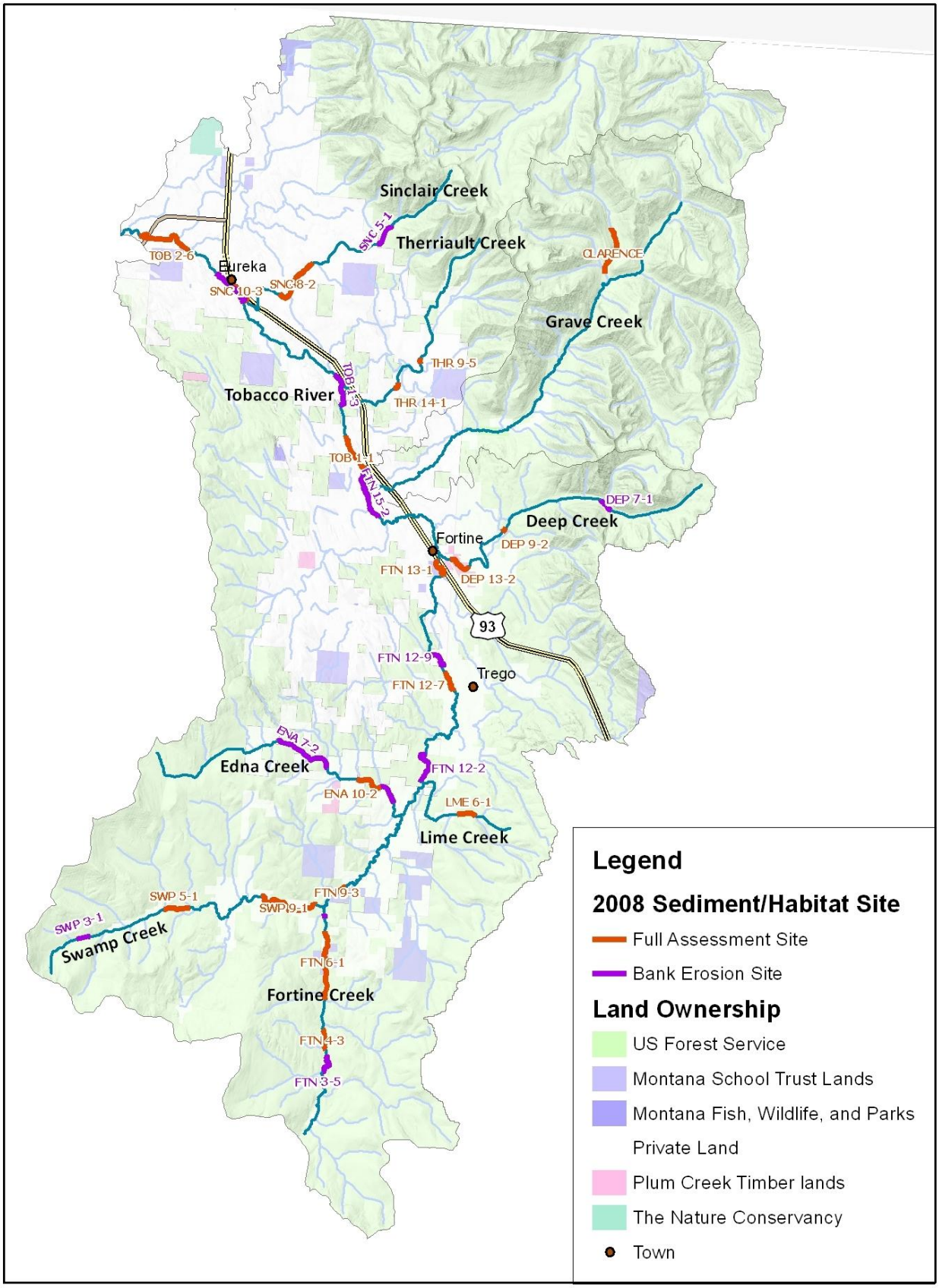
ATTACHMENT A – MONITORING SITE LOCATION MAP


Sinclair Creek
Therriault Creek
Eureka
Grave Creek
Tobacco River
Deep Creek
Fortine
Trego
Edna Creek
Lime Creek
Swamp Creek
Fortine Creek
93
TOB 2-6
SNC 5-1
SNC 8-2
SNC 10-3
CLARENCE
THR 9-5
THR 14-1
TOB 4-3
TOB 4-1
FTN 15-2
DEP 7-1
DEP 9-2
DEP 13-2
FTN 13-1
FTN 12-9
FTN 12-7
ENA 7-2
ENA 10-2
FTN 12-2
LME 6-1
SWP 5-1
SWP 9-1
FTN 9-3
SWP 3-1
FTN 6-1
FTN 4-3
FTN 3-5
Legend
2008 Sediment/Habitat Site
Full Assessment Site
Bank Erosion Site
Land Ownership
US Forest Service
Montana School Trust Lands
Montana Fish, Wildlife, and Parks
Private Land
Plum Creek Timber lands
The Nature Conservancy
Town

ATTACHMENT B – SEDIMENT AND HABITAT FIELD DATA

Table B-1. BEHI Sediment Load Data

Stream	Reach ID	Date	Reach Type	Erosion Type	Number of Banks	Mean BEHI Score	Mean BEHI Rating	Length of Eroding Bank (Feet)	Eroding Bank (% of reach)	Monitoring Site Sediment Load (Tons/Year)	Sediment Load per 1000 Feet (Tons/Year)	Road Load (tons /year)	Road Load (%)	Grazing Load (tons /year)	Grazing Load (%)	Cropland Load (tons /year)	Cropland Load (%)	Logging Load (tons /year)	Logging Load (%)	Natural Load (tons /year)	Natural Load (%)	"Other" Load (tons /year)	"Other" Load (%)
Clarence Creek	Clarence	8/26/08	CR-4-2-U	Active	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
	Clarence	8/26/08	CR-4-2-U	Slow	5	24.2	moderate	249	12.5	14.1	14.1	0.0	0	0.0	0	0.0	0	0.0	0	14.14	100	0.0	0
	Clarence	8/26/08	CR-4-2-U	Total	5			249	12.5	14.1	14.1	0.0	0	0.0	0	0.0	0	0.0	0	14.14	100	0.0	0
Deep Creek	DEP 13-2	8/27/08	CR-2-3-U	Active	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
	DEP 13-2	8/27/08	CR-2-3-U	Slow	5	26.9	moderate	131	6.6	2.8	2.8	0.0	0	0.0	0	0.0	0	0.0	0	2.79	100	0.0	0
	DEP 13-2	8/27/08	CR-2-3-U	Total	5			131	6.6	2.8	2.8	0.0	0	0.0	0	0.0	0	0.0	0	2.79	100	0.0	0
	DEP 7-1	9/9/08	CR-4-2-U	Active	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
	DEP 7-1	9/9/08	CR-4-2-U	Slow	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
	DEP 7-1	9/9/08	CR-4-2-U	Total	0			0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	100	0.0	0
	DEP 9-2	8/27/08	CR-4-3-U	Active	2	53.0	extreme	201	10.1	117.1	117.1	117.1	100	0.0	0	0.0	0	0.0	0	0.00	0	0.0	0
	DEP 9-2	8/27/08	CR-4-3-U	Slow	3	36.3	high	257	12.9	38.4	38.4	9.3	24	0.0	0	0.0	0	0.0	0	29.05	76	0.0	0
	DEP 9-2	8/27/08	CR-4-3-U	Total	5			458	22.9	155.5	155.5	126.4	81	0.0	0	0.0	0	0.0	0	29.05	19	0.0	0
Edna Creek	ENA 10-2	8/21/08	NR-4-3-U	Active	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
	ENA 10-2	8/21/08	NR-4-3-U	Slow	7	29.3	moderate	181	9.1	7.9	7.9	0.0	0	0.0	0	0.0	0	0.0	0	7.87	100	0.0	0
	ENA 10-2	8/21/08	NR-4-3-U	Total	7			181	9.1	7.9	7.9	0.0	0	0.0	0	0.0	0	0.0	0	7.87	100	0.0	0
	ENA 11-1	9/12/08	NR-0-3-U	Active	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
	ENA 11-1	9/12/08	NR-0-3-U	Slow	5	16.4	low	62	3.1	0.1	0.1	0.0	0	0.0	0	0.1	100	0.0	0	0.00	0	0.0	0
	ENA 11-1	9/12/08	NR-0-3-U	Total	5			62	3.1	0.1	0.1	0.0	0	0.0	0	0.1	100	0.0	0	0.00	0	0.0	0
	ENA 7-2	9/11/08	NR-4-2-U	Active	1	26.3	moderate	49	2.5	0.9	0.9	0.0	0	0.0	0	0.0	0	0.0	0	0.86	100	0.0	0
	ENA 7-2	9/11/08	NR-4-2-U	Slow	4	33.7	high	138	6.9	12.7	12.7	0.0	0	0.0	0	0.0	0	0.0	0	12.73	100	0.0	0
	ENA 7-2	9/11/08	NR-4-2-U	Total	5			187	9.4	13.6	13.6	0.0	0	0.0	0	0.0	0	0.0	0	13.59	100	0.0	0
	ENA 8-1	9/11/08	NR-2-2-U	Active	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
	ENA 8-1	9/11/08	NR-2-2-U	Slow	4	27.7	moderate	73	3.7	8.3	8.3	0.0	0	0.0	0	0.0	0	0.0	0	8.27	100	0.0	0
	ENA 8-1	9/11/08	NR-2-2-U	Total	4			73	3.7	8.3	8.3	0.0	0	0.0	0	0.0	0	0.0	0	8.27	100	0.0	0

Table B-1. BEHI Sediment Load Data

Stream	Reach ID	Date	Reach Type	Erosion Type	Number of Banks	Mean BEHI Score	Mean BEHI Rating	Length of Eroding Bank (Feet)	Eroding Bank (% of reach)	Monitoring Site Sediment Load (Tons/Year)	Sediment Load per 1000 Feet (Tons/Year)	Road Load (tons /year)	Road Load (%)	Grazing Load (tons /year)	Grazing Load (%)	Cropland Load (tons /year)	Cropland Load (%)	Logging Load (tons /year)	Logging Load (%)	Natural Load (tons /year)	Natural Load (%)	"Other" Load (tons /year)	"Other" Load (%)
Fortine Creek	FTN 12-2	9/10/08	NR-0-4-U	Active	1	35.2	high	159	8.0	23.6	23.6	0.0	0	0.0	0	0.0	0	11.8	50	11.79	50	0.0	0
	FTN 12-2	9/10/08	NR-0-4-U	Slow	8	26.0	moderate	308	15.4	11.9	11.9	0.0	0	0.0	0	0.0	0	1.8	15	10.10	85	0.0	0
	FTN 12-2	9/10/08	NR-0-4-U	Total	9			467	23.4	35.5	35.5	0.0	0	0.0	0	0.0	0	13.6	38	21.89	62	0.0	0
	FTN 12-7	8/23/08	NR-0-4-U	Active	5	36.3	high	634	31.7	77.6	77.6	0.0	0	75.9	98	0.0	0	0.0	0	1.66	2	0.0	0
	FTN 12-7	8/23/08	NR-0-4-U	Slow	1	22.8	moderate	100	5.0	0.2	0.2	0.0	0	0.0	0	0.0	0	0.0	0	0.22	100	0.0	0
	FTN 12-7	8/23/08	NR-0-4-U	Total	6			734	36.7	77.8	77.8	0.0	0	75.9	98	0.0	0	0.0	0	1.88	2	0.0	0
	FTN 12-9	9/11/08	NR-0-4-U	Active	1	38.0	high	48	2.4	17.6	17.6	0.0	0	0.0	0	0.0	0	0.0	0	17.63	100	0.0	0
	FTN 12-9	9/11/08	NR-0-4-U	Slow	4	19.5	low	150	7.5	1.8	1.8	0.0	0	0.8	46	0.0	0	0.3	14	0.71	40	0.0	0
	FTN 12-9	9/11/08	NR-0-4-U	Total	5			198	9.9	19.4	19.4	0.0	0	0.8	4	0.0	0	0.3	1	18.35	94	0.0	0
	FTN 13-1	8/23/08	NR-0-4-U	Active	1	44.7	very high	49	2.5	17.0	17.0	0.0	0	0.0	0	0.0	0	0.0	0	17.03	100	0.0	0
	FTN 13-1	8/23/08	NR-0-4-U	Slow	4	35.7	high	280	14.0	41.0	41.0	0.0	0	0.0	0	0.0	0	0.0	0	40.98	100	0.0	0
	FTN 13-1	8/23/08	NR-0-4-U	Total	5			329	16.5	58.0	58.0	0.0	0	0.0	0	0.0	0	0.0	0	58.01	100	0.0	0
	FTN 15-2	9/10/08	NR-0-4-U	Active	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
	FTN 15-2	9/10/08	NR-0-4-U	Slow	6	23.7	moderate	439	22.0	11.9	11.9	5.7	48	0.0	0	0.0	0	0.0	0	6.14	52	0.0	0
	FTN 15-2	9/10/08	NR-0-4-U	Total	6			439	22.0	11.9	11.9	5.7	48	0.0	0	0.0	0	0.0	0	6.14	52	0.0	0
	FTN 15-3	9/10/08	NR-0-4-U	Active	1	24.1	moderate	75	3.8	3.4	3.4	0.0	0	1.0	30	0.0	0	0.0	0	2.41	70	0.0	0
	FTN 15-3	9/10/08	NR-0-4-U	Slow	3	14.7	low	120	6.0	1.5	1.5	0.0	0	0.2	16	0.0	0	0.0	0	1.27	84	0.0	0
	FTN 15-3	9/10/08	NR-0-4-U	Total	4			195	9.8	4.9	4.9	0.0	0	1.3	26	0.0	0	0.0	0	3.67	74	0.0	0
	FTN 4-1	9/10/08	NR-0-3-U	Active	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
	FTN 4-1	9/10/08	NR-0-3-U	Slow	11	34.1	high	395	19.8	46.5	46.5	0.0	0	0.0	0	0.0	0	0.0	0	46.55	100	0.0	0
	FTN 4-1	9/10/08	NR-0-3-U	Total	11			395	19.8	46.5	46.5	0.0	0	0.0	0	0.0	0	0.0	0	46.55	100	0.0	0
	FTN 4-3	8/28/08	NR-0-3-U	Active	1	33.6	high	95	4.8	6.3	6.3	0.0	0	5.0	80	0.0	0	0.0	0	1.25	20	0.0	0
	FTN 4-3	8/28/08	NR-0-3-U	Slow	7	23.6	moderate	596	29.8	15.0	15.0	0.0	0	0.0	0	0.0	0	0.0	0	15.04	100	0.0	0
	FTN 4-3	8/28/08	NR-0-3-U	Total	8			691	34.6	21.3	21.3	0.0	0	5.0	24	0.0	0	0.0	0	16.30	76	0.0	0
	FTN 6-1	8/23/08	NR-0-3-U	Active	3	33.7	high	268	13.4	39.7	39.7	0.0	0	0.0	0	0.0	0	0.0	0	21.72	55	17.9	45
	FTN 6-1	8/23/08	NR-0-3-U	Slow	2	27.0	moderate	219	11.0	3.8	3.8	0.0	0	0.0	0	0.0	0	0.0	0	3.77	100	0.0	0
	FTN 6-1	8/23/08	NR-0-3-U	Total	5			487	24.4	43.4	43.4	0.0	0	0.0	0	0.0	0	0.0	0	25.50	59	17.9	41
	FTN 7-2	9/11/08	NR-2-3-U	Active	1	27.0	moderate	63	3.2	31.4	31.4	0.0	0	0.0	0	0.0	0	0.0	0	31.36	100	0.0	0
	FTN 7-2	9/11/08	NR-2-3-U	Slow	5	25.7	moderate	140	7.0	6.4	6.4	0.0	0	0.0	0	0.0	0	0.0	0	6.36	100	0.0	0
	FTN 7-2	9/11/08	NR-2-3-U	Total	6			203	10.2	37.7	37.7	0.0	0	0.0	0	0.0	0	0.0	0	37.72	100	0.0	0
	FTN 9-3	8/27/08	NR-0-4-U	Active	2	35.6	high	185	9.3	19.7	19.7	0.0	0	0.0	0	0.0	0	0.0	0	19.75	100	0.0	0
	FTN 9-3	8/27/08	NR-0-4-U	Slow	1	24.9	moderate	272	13.6	1.6	1.6	0.0	0	0.0	0	0.0	0	0.0	0	1.57	100	0.0	0
	FTN 9-3	8/27/08	NR-0-4-U	Total	3			457	22.9	21.3	21.3	0.0	0	0.0	0	0.0	0	0.0	0	21.32	100	0.0	0
Lime Creek	LME 6-1	8/26/08	NR-4-3-U	Active	1	30.5	high	16	1.6	3.1	6.2	0.0	0	0.0	0	0.0	0	0.6	20	2.49	80	0.0	0
	LME 6-1	8/26/08	NR-4-3-U	Slow	7	30.4	high	95	9.5	6.8	13.6	3.0	44	0.0	0	0.0	0	0.1	1	3.68	54	0.0	0
	LME 6-1	8/26/08	NR-4-3-U	Total	8			111	11.1	9.9	19.8	3.0	30	0.0	0	0.0	0	0.7	7	6.17	62	0.0	0

Table B-1. BEHI Sediment Load Data

Stream	Reach ID	Date	Reach Type	Erosion Type	Number of Banks	Mean BEHI Score	Mean BEHI Rating	Length of Eroding Bank (Feet)	Eroding Bank (% of reach)	Monitoring Site Sediment Load (Tons/Year)	Sediment Load per 1000 Feet (Tons/Year)	Road Load (tons /year)	Road Load (%)	Grazing Load (tons /year)	Grazing Load (%)	Cropland Load (tons /year)	Cropland Load (%)	Logging Load (tons /year)	Logging Load (%)	Natural Load (tons /year)	Natural Load (%)	"Other" Load (tons /year)	"Other" Load (%)
Sinclair Creek	SNC 10-3	8/26/08	CR-0-2-U	Active	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
	SNC 10-3	8/26/08	CR-0-2-U	Slow	4	28.7	moderate	228	11.4	53.5	53.5	26.7	50	0.0	0	0.0	0	0.0	0	10.69	20	16.0	30
	SNC 10-3	8/26/08	CR-0-2-U	Total	4			228	11.4	53.5	53.5	26.7	50	0.0	0	0.0	0	0.0	0	10.69	20	16.0	30
	SNC 5-1	9/9/08	CR-4-2-U	Active	1	21.4	moderate	72	3.6	9.0	9.0	0.0	0	0.0	0	0.0	0	0.0	0	8.96	100	0.0	0
	SNC 5-1	9/9/08	CR-4-2-U	Slow	2	22.2	moderate	68	3.4	2.7	2.7	0.0	0	0.0	0	0.0	0	0.0	0	2.72	100	0.0	0
	SNC 5-1	9/9/08	CR-4-2-U	Total	3			140	7.0	11.7	11.7	0.0	0	0.0	0	0.0	0	0.0	0	11.68	100	0.0	0
	SNC 8-2	8/25/08	CR-0-2-U	Active	14	35.0	high	321	16.1	42.0	42.0	0.0	0	42.0	100	0.0	0	0.0	0	0.00	0	0.0	0
	SNC 8-2	8/25/08	CR-0-2-U	Slow	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
	SNC 8-2	8/25/08	CR-0-2-U	Total	14			321	16.1	42.0	42.0	0.0	0	42.0	100	0.0	0	0.0	0	0.00	0	0.0	0
Swamp Creek	SWP 3-1	9/10/08	NR-4-2-U	Active	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
	SWP 3-1	9/10/08	NR-4-2-U	Slow	7	21.0	moderate	117	5.9	1.0	1.0	0.0	0	0.0	0	0.0	0	0.1	9	0.88	91	0.0	0
	SWP 3-1	9/10/08	NR-4-2-U	Total	7			117	5.9	1.0	1.0	0.0	0	0.0	0	0.0	0	0.1	9	0.88	91	0.0	0
	SWP 5-1	8/24/08	NR-0-3-U	Active	2	34.1	high	93	4.7	9.8	9.8	0.0	0	0.0	0	0.0	0	8.8	90	1.0	10	0.0	0
	SWP 5-1	8/24/08	NR-0-3-U	Slow	3	23.6	moderate	149	7.5	3.6	3.6	0.0	0	0.0	0	0.0	0	3.6	100	0.0	0	0.0	0
	SWP 5-1	8/24/08	NR-0-3-U	Total	5			242	12.1	13.4	13.4	0.0	0	0.0	0	0.0	0	12.4	93	1.0	7	0.0	0
	SWP 9-1	8/24/08	NR-2-3-U	Active	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
	SWP 9-1	8/24/08	NR-2-3-U	Slow	7	32.4	high	535	26.8	51.6	51.6	0.0	0	0.0	0	0.0	0	0.0	0	51.57	100	0.0	0
	SWP 9-1	8/24/08	NR-2-3-U	Total	7			535	26.8	51.6	51.6	0.0	0	0.0	0	0.0	0	0.0	0	51.57	100	0.0	0
Therriault Creek	THR 14-1	8/25/08	CR-0-2-U	Active	2	40.9	very high	43	2.2	2.8	2.8	0.0	0	0.4	14	0.0	0	0.0	0	2.44	86	0.0	0
	THR 14-1	8/25/08	CR-0-2-U	Slow	6	35.9	high	91	4.6	5.1	5.1	0.0	0	0.2	4	0.0	0	0.5	10	2.45	48	1.9	38
	THR 14-1	8/25/08	CR-0-2-U	Total	8			134	6.7	7.9	7.9	0.0	0	0.6	7	0.0	0	0.5	6	4.89	62	1.9	24
	THR 9-5	8/25/08	CR-0-2-U	Active	5	37.8	high	76	3.8	12.9	12.9	0.0	0	0.0	0	0.0	0	7.4	57	5.55	43	0.0	0
	THR 9-5	8/25/08	CR-0-2-U	Slow	8	27.6	moderate	198	9.9	8.5	8.5	0.0	0	0.0	0	0.0	0	5.4	63	3.09	37	0.0	0
	THR 9-5	8/25/08	CR-0-2-U	Total	13			274	13.7	21.4	21.4	0.0	0	0.0	0	0.0	0	12.7	60	8.64	40	0.0	0
Tobacco River	TOB 1-1	8/22/08	NR-0-5-U	Active	6	24.0	moderate	1281	32.0	95.2	47.6	0.0	0	1.3	1	0.0	0	0.0	0	93.90	99	0.0	0
	TOB 1-1	8/22/08	NR-0-5-U	Slow	2	27.1	moderate	306	7.7	13.3	6.6	0.0	0	0.0	0	0.0	0	0.0	0	13.27	100	0.0	0
	TOB 1-1	8/22/08	NR-0-5-U	Total	8			1587	39.7	108.5	54.3	0.0	0	1.3	1	0.0	0	0.0	0	107.17	99	0.0	0
	TOB 1-3	9/9/08	NR-0-5-U	Active	1	41.3	very high	450	11.3	113.4	56.7	0.0	0	0.0	0	0.0	0	0.0	0	113.36	100	0.0	0
	TOB 1-3	9/9/08	NR-0-5-U	Slow	4	21.6	moderate	585	14.6	23.4	11.7	1.6	7	1.6	7	0.0	0	0.0	0	20.24	87	0.0	0
	TOB 1-3	9/9/08	NR-0-5-U	Total	5			1035	25.9	136.7	68.4	1.6	1	1.6	1	0.0	0	0.0	0	133.60	98	0.0	0
	TOB 2-3	9/9/08	NR-0-5-U	Active	3	28.2	moderate	123	3.1	13.5	6.7	6.7	50	0.0	0	0.0	0	0.0	0	2.36	18	4.4	32
	TOB 2-3	9/9/08	NR-0-5-U	Slow	3	15.1	low	317	7.9	5.4	2.7	1.9	35	0.0	0	0.0	0	0.0	0	3.51	65	0.0	0
	TOB 2-3	9/9/08	NR-0-5-U	Total	6			440	11.0	18.8	9.4	8.6	46	0.0	0	0.0	0	0.0	0	5.86	31	4.4	23
	TOB 2-6	8/22/08	NR-0-5-U	Active	6	28.8	moderate	728	18.2	151.1	75.6	0.0	0	0.0	0	0.0	0	0.0	0	28.77	19	122.3	81
	TOB 2-6	8/22/08	NR-0-5-U	Slow	2	31.8	high	262	6.6	15.3	7.6	0.0	0	0.0	0	0.0	0	0.0	0	15.27	100	0.0	0
	TOB 2-6	8/22/08	NR-0-5-U	Total	8			990	24.8	166.4	83.2	0.0	0	0.0	0	0.0	0	0.0	0	44.04	26	122.3	74

Table B-2. Fine Sediment in Pool Tail-outs

Reach ID	Date	Cell	Pool Grid Toss Percent <6mm	Spawning Gravels Present?
CLARENCE	8/26/08	1	30	No
CLARENCE	8/26/08	2	0	No
CLARENCE	8/26/08	2	0	No
CLARENCE	8/26/08	3	1	No
DEP 13-2	8/27/08	1	1	Yes
DEP 13-2	8/27/08	1	5	Yes
DEP 13-2	8/27/08	2	4	Yes
DEP 13-2	8/27/08	2	4	Yes
DEP 13-2	8/27/08	3	5	Yes
DEP 13-2	8/27/08	3	2	Yes
DEP 13-2	8/27/08	4	7	Yes
DEP 13-2	8/27/08	4	3	Yes
DEP 13-2	8/27/08	5	1	Yes
DEP 13-2	8/27/08	5	7	Yes
DEP 9-2	8/27/08	1	7	No
DEP 9-2	8/27/08	3	3	No
DEP 9-2	8/27/08	4	1	No
DEP 9-2	8/27/08	4	0	No
ENA 10-2	8/21/08	1	34	Yes
ENA 10-2	8/21/08	1	9	No
ENA 10-2	8/21/08	2	5	No
ENA 10-2	8/21/08	2	6	Yes
ENA 10-2	8/21/08	3	5	No
ENA 10-2	8/21/08	3	7	No
ENA 10-2	8/21/08	4	13	Yes
ENA 10-2	8/21/08	4	3	No
ENA 10-2	8/21/08	5	3	No
ENA 10-2	8/21/08	5	1	Yes
FTN 12-7	8/23/08	1	3	Yes
FTN 12-7	8/23/08	1	3	No
FTN 12-7	8/23/08	2	10	No
FTN 12-7	8/23/08	2	8	No
FTN 12-7	8/23/08	3	15	No
FTN 12-7	8/23/08	3	44	No
FTN 12-7	8/23/08	4	11	Yes
FTN 12-7	8/23/08	4	39	Yes
FTN 12-7	8/23/08	5	17	Yes
FTN 12-7	8/23/08	5	18	No
FTN 13-1	8/23/08	1	6	No
FTN 13-1	8/23/08	1	5	No
FTN 13-1	8/23/08	2	7	Yes
FTN 13-1	8/23/08	2	1	No
FTN 13-1	8/23/08	3	2	Yes
FTN 13-1	8/23/08	4	4	Yes
FTN 13-1	8/23/08	5	23	Yes
FTN 4-3	8/28/08	1	10	Yes
FTN 4-3	8/28/08	1	4	Yes
FTN 4-3	8/28/08	2	8	Yes

Table B-2. Fine Sediment in Pool Tail-outs

Reach ID	Date	Cell	Pool Grid Toss Percent <6mm	Spawning Gravels Present?
FTN 4-3	8/28/08	2	4	No
FTN 4-3	8/28/08	3	3	Yes
FTN 4-3	8/28/08	3	3	Yes
FTN 4-3	8/28/08	4	2	Yes
FTN 4-3	8/28/08	4	3	Yes
FTN 4-3	8/28/08	5	7	Yes
FTN 6-1	8/23/08	1	18	Yes
FTN 6-1	8/23/08	1	5	No
FTN 6-1	8/23/08	2	7	Yes
FTN 6-1	8/23/08	2	25	No
FTN 6-1	8/23/08	3	5	Yes
FTN 6-1	8/23/08	3	4	Yes
FTN 6-1	8/23/08	4	11	Yes
FTN 6-1	8/23/08	4	2	Yes
FTN 6-1	8/23/08	5	16	Yes
FTN 6-1	8/23/08	5	27	Yes
FTN 9-3	8/27/08	1	1	No
FTN 9-3	8/27/08	1	3	Yes
FTN 9-3	8/27/08	2	4	No
FTN 9-3	8/27/08	2	0	No
FTN 9-3	8/27/08	3	0	No
LME 6-1	8/26/08	1	95	No
LME 6-1	8/26/08	1	100	No
LME 6-1	8/26/08	1	100	No
LME 6-1	8/26/08	2	72	No
LME 6-1	8/26/08	2	100	No
LME 6-1	8/26/08	3	89	No
LME 6-1	8/26/08	5	80	No
SNC 10-3	8/26/08	1	12	No
SNC 10-3	8/26/08	1	11	No
SNC 10-3	8/26/08	2	100	Yes
SNC 10-3	8/26/08	2	100	Yes
SNC 10-3	8/26/08	3	94	Yes
SNC 10-3	8/26/08	3	100	No
SNC 10-3	8/26/08	4	100	No
SNC 10-3	8/26/08	4	52	No
SNC 10-3	8/26/08	5	99	No
SNC 10-3	8/26/08	5	90	No
SNC 8-2	8/25/08	1	2	Yes
SNC 8-2	8/25/08	1	2	No
SNC 8-2	8/25/08	2	1	No
SNC 8-2	8/25/08	2	1	No
SNC 8-2	8/25/08	3	1	No
SNC 8-2	8/25/08	3	1	No
SNC 8-2	8/25/08	4	1	No
SNC 8-2	8/25/08	4	1	No
SNC 8-2	8/25/08	5	0	No
SNC 8-2	8/25/08	5	3	No

Table B-2. Fine Sediment in Pool Tail-outs

Reach ID	Date	Cell	Pool Grid Toss Percent <6mm	Spawning Gravels Present?
SWP 5-1	8/24/08	1	2	No
SWP 5-1	8/24/08	1	5	Yes
SWP 5-1	8/24/08	2	1	No
SWP 5-1	8/24/08	2	1	No
SWP 5-1	8/24/08	3	5	No
SWP 5-1	8/24/08	3	2	No
SWP 5-1	8/24/08	4	2	No
SWP 5-1	8/24/08	4	19	No
SWP 5-1	8/24/08	5	1	No
SWP 5-1	8/24/08	5	0	No
SWP 9-1	8/24/08	1	2	No
SWP 9-1	8/24/08	2	1	No
SWP 9-1	8/24/08	3	1	No
SWP 9-1	8/24/08	4	0	No
THR 14-1	8/25/08	1	3	Yes
THR 14-1	8/25/08	1	4	Yes
THR 14-1	8/25/08	2	5	Yes
THR 14-1	8/25/08	3	4	No
THR 14-1	8/25/08	4	7	No
THR 14-1	8/25/08	4	1	Yes
THR 14-1	8/25/08	4	3	Yes
THR 14-1	8/25/08	5	1	Yes
THR 9-5	8/25/08	1	6	No
THR 9-5	8/25/08	1	1	Yes
THR 9-5	8/25/08	2	10	Yes
THR 9-5	8/25/08	2	5	Yes
THR 9-5	8/25/08	3	7	No
THR 9-5	8/25/08	3	12	Yes
THR 9-5	8/25/08	4	3	Yes
THR 9-5	8/25/08	4	14	No
THR 9-5	8/25/08	5	12	Yes
TOB 1-1	8/22/08	2	5	Yes
TOB 1-1	8/22/08	3	0	No
TOB 1-1	8/22/08	4	1	No
TOB 1-1	8/22/08	4	0	No
TOB 1-1	8/22/08	5	0	No
TOB 2-6	8/22/08	1	1	No
TOB 2-6	8/22/08	1	2	Yes
TOB 2-6	8/22/08	2	3	Yes
TOB 2-6	8/22/08	3	1	Yes
TOB 2-6	8/22/08	3	0	Yes
TOB 2-6	8/22/08	4	1	Yes
TOB 2-6	8/22/08	4	0	Yes
TOB 2-6	8/22/08	5	0	No
TOB 2-6	8/22/08	5	0	Yes
TOB 2-6	8/22/08	5	1	Yes

Table B-3. Pool and Large Woody Debris Data

Reach ID	Date	Cell	Mean Residual Pool Depth (ft)	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
DEP 9-2	8/27/08	1-5	1.0	16	37	4	63
DEP 13-2	8/27/08	1-5	1.6	17	35	8	101
ENA 10-2	8/21/08	1-5	1.2	17	61	9	133
FTN 4-3	8/28/08	1-5	1.7	10	17	1	25
FTN 6-1	8/23/08	1-5	1.0	16	31	1	43
FTN 9-3	8/27/08	1-5	1.7	7	17	0	19
FTN 12-7	8/23/08	1-5	1.5	12	13	0	19
FTN 13-1	8/23/08	1-5	1.7	11	59	1	74
CLARENCE	8/26/08	1-5	1.0	7	28	1	34
LME 6-1	8/26/08	1-5	0.5	14	70	2	88
SNC 8-2	8/25/08	1-5	1.1	17	20	14	120
SNC 10-3	8/26/08	1-5	0.9	17	43	1	48
SWP 5-1	8/24/08	1-5	0.7	17	27	2	38
SWP 9-1	8/24/08	1-5	1.2	8	25	2	31
THR 9-5	8/25/08	1-5	1.2	16	92	7	153
THR 14-1	8/25/08	1-5	1.5	16	31	5	75
TOB 1-1	8/22/08	1-5	1.6	3	14	1	17
TOB 2-6	8/22/08	1-5	2.6	6	17	1	20

Table B-4. Riparian Greenline Data

Reach ID	Date	Cell	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width (ft)	Left Bank Mean Riparian Zone Width (ft)
DEP 9-2	8/27/08	1	30	10	0	73	>200	30
DEP 9-2	8/27/08	2	58	20	0	53	>200	8
DEP 9-2	8/27/08	3	80	10	0	53	>200	20
DEP 9-2	8/27/08	4	45	5	0	58	>200	70
DEP 9-2	8/27/08	5	55	0	0	78	>200	>200
DEP 13-2	8/27/08	1	23	0	0	3	113	63
DEP 13-2	8/27/08	2	30	0	0	3	63	34
DEP 13-2	8/27/08	3	30	0	0	33	88	64
DEP 13-2	8/27/08	4	43	0	0	18	100	>150
DEP 13-2	8/27/08	5	45	0	0	50	>200	>200
ENA 10-2	8/21/08	1	98	0	0	30	27	>30
ENA 10-2	8/21/08	2	95	0	0	8	40	34
ENA 10-2	8/21/08	3	88	0	0	3	29	39
ENA 10-2	8/21/08	4	90	0	0	8	26	32
ENA 10-2	8/21/08	5	80	0	0	5	11	15
FTN 4-3	8/28/08	1	93	0	0	30	0	0
FTN 4-3	8/28/08	2	63	0	0	3	0	0
FTN 4-3	8/28/08	3	53	0	0	0	0	0
FTN 4-3	8/28/08	4	33	0	0	3	>200	>200
FTN 4-3	8/28/08	5	65	0	0	13	>200	>200
FTN 6-1	8/23/08	1	88	0	0	43	>200	63
FTN 6-1	8/23/08	2	75	0	0	68	>200	>200
FTN 6-1	8/23/08	3	98	5	0	33	>200	>200
FTN 6-1	8/23/08	4	100	0	0	28	>200	>200
FTN 6-1	8/23/08	5	93	0	0	28	>200	>188
FTN 9-3	8/27/08	1	38	0	0	30	>200	>200
FTN 9-3	8/27/08	2	45	0	0	65	>200	>200
FTN 9-3	8/27/08	3	28	0	0	13	>200	>200
FTN 9-3	8/27/08	4	20	0	0	10	>200	>200
FTN 9-3	8/27/08	5	20	0	0	0	>200	>188
FTN 12-7	8/23/08	1	38	18	0	23	0	0
FTN 12-7	8/23/08	2	38	0	0	23	0	0

Table B-4. Riparian Greenline Data

Reach ID	Date	Cell	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width (ft)	Left Bank Mean Riparian Zone Width (ft)
FTN 12-7	8/23/08	3	33	0	0	28	0	0
FTN 12-7	8/23/08	4	0	10	0	0	0	0
FTN 12-7	8/23/08	5	55	0	0	3	0	79
FTN 13-1	8/23/08	1	100	0	0	38	>200	>200
FTN 13-1	8/23/08	2	83	0	0	65	>200	>200
FTN 13-1	8/23/08	3	75	0	0	58	>200	>200
FTN 13-1	8/23/08	4	83	0	0	43	>200	>200
FTN 13-1	8/23/08	5	45	0	0	40	>200	>200
CLARENCE	8/26/08	1	100	0	0	55	>200	>200
CLARENCE	8/26/08	2	98	0	0	28	>200	>200
CLARENCE	8/26/08	3	98	0	0	50	>200	>200
CLARENCE	8/26/08	4	50	0	0	33	>200	>200
CLARENCE	8/26/08	5	98	0	0	30	>200	>200
LME 6-1	8/26/08	1	60	0	0	75	>200	>200
LME 6-1	8/26/08	2	60	0	0	40	>200	>200
LME 6-1	8/26/08	3	30	0	0	65	>200	>200
LME 6-1	8/26/08	4	55	0	0	65	>200	>200
LME 6-1	8/26/08	5	60	0	0	50	65	65
SNC 8-2	8/25/08	1	80	0	0	80	15	20
SNC 8-2	8/25/08	2	63	0	0	43	30	13
SNC 8-2	8/25/08	3	53	0	0	85	23	15
SNC 8-2	8/25/08	4	88	0	0	75	25	35
SNC 8-2	8/25/08	5	60	0	0	53	20	10
SNC 10-3	8/26/08	1	13	10	0	10	18	26
SNC 10-3	8/26/08	2	20	0	0	5	11	21
SNC 10-3	8/26/08	3	13	0	0	18	19	30
SNC 10-3	8/26/08	4	15	0	0	5	30	38
SNC 10-3	8/26/08	5	13	0	0	0	28	30
SWP 5-1	8/24/08	1	88	0	0	0	>200	69
SWP 5-1	8/24/08	2	75	0	0	13	>200	150
SWP 5-1	8/24/08	3	48	0	0	20	>200	>200
SWP 5-1	8/24/08	4	93	0	0	15	>200	>200

Table B-4. Riparian Greenline Data

Reach ID	Date	Cell	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width (ft)	Left Bank Mean Riparian Zone Width (ft)
SWP 5-1	8/24/08	5	93	0	0	8	>200	>200
SWP 9-1	8/24/08	1	53	0	0	65	75	>200
SWP 9-1	8/24/08	2	18	0	0	45	>113	>200
SWP 9-1	8/24/08	3	63	0	0	50	>200	>200
SWP 9-1	8/24/08	4	63	0	0	80	>200	>200
SWP 9-1	8/24/08	5	60	0	0	45	>200	>200
THR 9-5	8/25/08	1	58	0	0	50	>200	>125
THR 9-5	8/25/08	2	45	0	0	55	>200	>200
THR 9-5	8/25/08	3	60	0	0	60	>200	>200
THR 9-5	8/25/08	4	75	0	0	55	>200	>200
THR 9-5	8/25/08	5	63	0	0	63	>150	>200
THR 14-1	8/26/08	1	35	0	0	55	18	19
THR 14-1	8/27/08	2	28	0	0	48	15	49
THR 14-1	8/28/08	3	13	0	0	63	34	>200
THR 14-1	8/29/08	4	40	0	0	80	30	125
THR 14-1	8/30/08	5	18	0	0	73	30	58
TOB 1-1	8/22/08	1	29	2	0	58	>74	14
TOB 1-1	8/22/08	2	48	4	0	52	15	9
TOB 1-1	8/22/08	3	40	0	0	40	16	20
TOB 1-1	8/22/08	4	15	0	0	21	6	40
TOB 1-1	8/22/08	5	60	0	0	67	15	34
TOB 2-6	8/22/08	1	85	0	0	54	>200	75
TOB 2-6	8/22/08	2	77	0	0	50	74	>200
TOB 2-6	8/22/08	3	15	0	0	2	>200	29
TOB 2-6	8/22/08	4	85	0	0	63	>200	>181
TOB 2-6	8/22/08	5	50	2	0	15	>58	>200

Table B-5. Channel Cross Section Data

Reach ID	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width (ft)	Cross-Sectional Area (ft^2)	Bankfull Mean Depth (ft)	Width / Depth Ratio	Maximum Depth (ft)	Floodprone Width (ft)	Entrenchment Ratio
DEP 9-2	8/27/08	1	48.77628	-114.85604	riffle	17.8	26.3	1.47	12.1	1.8	19.3	1.1
DEP 9-2	8/27/08	2	48.77657	-114.85565	riffle	25.2	38.8	1.54	16.4	2.0	57.7	2.3
DEP 9-2	8/27/08	3	48.77709	-114.85528	riffle	17.5	26.3	1.50	11.7	2.2	24.5	1.4
DEP 9-2	8/27/08	5	48.77816	-114.85435	riffle	19.0	30.4	1.60	6.4	2.3	62.0	3.3
DEP 13-2	8/27/08	1	48.76067	-114.88277	riffle	21.0	30.5	1.45	14.5	1.8	101.0	4.8
DEP 13-2	8/27/08	3	48.76012	-114.88113	riffle	19.0	26.6	1.40	13.6	2.2	126.5	6.7
DEP 13-2	8/27/08	4	48.75962	-114.88077	riffle	17.0	20.2	1.19	14.3	1.7	66.0	3.9
DEP 13-2	8/27/08	5	48.75941	-114.88075	riffle	20.7	26.3	1.27	16.3	2.1	95.7	4.6
ENA 10-2	8/21/08	1	48.66069	-114.93443	riffle	28.4	25.3	0.90	31.6	1.6	37.4	1.3
ENA 10-2	8/21/08	2	48.66088	-114.93542	riffle	21.5	21.5	1.00	21.5	1.8	61.5	2.9
ENA 10-2	8/21/08	3	48.66065	-114.93604	riffle	15.6	15.6	1.00	15.6	1.9	31.1	2.0
ENA 10-2	8/21/08	4	48.66075	-114.93642	riffle	16.4	17.0	1.04	15.8	1.5	24.4	1.5
ENA 10-2	8/21/08	5	48.66027	-114.93716	riffle	29.7	29.7	1.00	29.7	1.4	34.9	1.3
FTN 4-3	8/28/08	1	48.54107	-114.95274	riffle	21.3	26.3	1.23	17.3	1.8	42.8	2.0
FTN 4-3	8/28/08	2	48.54028	-114.95302	riffle	19.7	28.0	1.42	13.8	1.7	58.7	3.0
FTN 4-3	8/28/08	4	48.53973	-114.95251	riffle	26.0	21.4	0.82	31.7	1.5	78.0	3.0
FTN 6-1	8/23/08	1	48.57404	-114.95517	riffle	23.8	22.6	0.99	24.0	1.4	36.8	1.6
FTN 6-1	8/23/08	2	48.57355	-114.95463	riffle	22.7	20.4	0.90	25.2	1.6	24.7	1.1
FTN 6-1	8/23/08	4	48.57274	-114.95472	riffle	17.0	20.4	1.20	14.2	1.9	2.6	1.5
FTN 9-3	8/27/08	1	48.61608	-114.94911	riffle	32.0	44.4	1.38	23.2	1.9	41.5	1.3
FTN 9-3	8/27/08	2	48.61007	-114.94949	riffle	36.0	64.4	1.78	20.2	2.1	65.0	1.8
FTN 9-3	8/27/08	5	48.61016	-114.95115	riffle	20.5	37.6	1.83	11.2	2.2	94.5	4.6
FTN 12-7	8/23/08	1	48.70507	-114.88379	riffle	63.0	66.2	1.05	60.0	1.9	85.0	1.4
FTN 12-7	8/23/08	2	48.70451	-114.88431	riffle	48.7	55.0	1.13	43.1	1.9	192.7	4.0
FTN 12-7	8/23/08	3	48.70388	-114.88387	riffle	91.7	87.1	0.95	96.5	1.8	175.7	1.9
FTN 12-7	8/23/08	5	48.70322	-114.88239	riffle	46.5	65.1	1.40	33.2	2.0	66.5	1.4

Table B-5. Channel Cross Section Data

Reach ID	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width (ft)	Cross-Sectional Area (ft^2)	Bankfull Mean Depth (ft)	Width / Depth Ratio	Maximum Depth (ft)	Floodprone Width (ft)	Entrenchment Ratio
FTN 13-1	8/23/08	1	48.75771	-114.89907	riffle	32.9	47.7	1.45	22.7	2.0	42.9	1.3
FTN 13-1	8/23/08	2	48.75750	-114.89875	riffle	46.3	70.4	1.52	30.5	2.1	54.8	1.2
FTN 13-1	8/23/08	3	48.75727	-114.89815	riffle	32.3	37.5	1.16	27.8	1.9	58.3	1.8
FTN 13-1	8/23/08	5	48.75731	-114.89687	riffle	26.5	40.6	1.53	17.3	2.1	42.5	1.6
CLARENCE	8/26/08	1	48.89199	-114.79762	riffle	31.9	52.6	1.65	19.3	2.5	>250	7.8
CLARENCE	8/26/08	2	48.48208	-114.79797	riffle	27.0	51.0	1.88	14.4	3.9	>231	8.6
CLARENCE	8/26/08	3	48.89269	-114.79836	riffle	31.4	57.9	1.84	17.1	2.5	42.9	1.4
CLARENCE	8/26/08	4	48.89322	-114.79822	riffle	25.0	50.0	2.00	12.5	2.7	17.5	1.7
CLARENCE	8/26/08	5	48.89333	-114.79880	riffle	35.6	62.9	1.80	19.8	2.9	>238	6.7
LME 2-1	8/26/08	2	48.64851	-114.87065	riffle	7.7	7.4	0.96	8.0	1.4	29.7	3.9
LME 2-1	8/26/08	3	48.64834	-114.87058	riffle	6.2	6.5	1.05	5.9	1.9	21.7	3.5
LME 2-1	8/26/08	4	48.64854	-114.87017	riffle	7.6	8.4	1.10	6.9	1.8	17.6	2.3
LME 2-1	8/26/08	5	48.64853	-114.86967	riffle	8.3	10.8	1.30	6.4	2.0	17.3	2.1
SNC 8-2	8/25/08	1	48.88638	-115.00020	riffle	28.0	28.6	1.02	27.5	1.7	37.3	1.3
SNC 8-2	8/25/08	2	48.88681	-115.00156	riffle	17.0	21.4	1.26	13.5	1.5	27.6	1.6
SNC 8-2	8/25/08	3	48.88713	-115.00123	riffle	14.0	17.8	1.27	11.0	1.7	37.4	2.7
SNC 8-2	8/25/08	4	48.88725	-115.00053	riffle	22.3	24.5	1.10	20.3	1.5	30.8	4.3
SNC 8-2	8/25/08	5	48.88750	-115.00018	riffle	22.5	20.3	0.90	25.0	1.5	95.3	1.3
SNC 10-3	8/26/08	1	48.87679	-115.04916	riffle	19.3	23.0	1.19	16.2	1.5	25.3	1.3
SNC 10-3	8/26/08	2	48.87649	-115.04852	riffle	22.0	25.1	1.14	19.3	1.6	34.6	1.4
SNC 10-3	8/26/08	3	48.87632	-115.04777	riffle	22.0	22.7	1.13	17.7	1.5	35.0	1.7
SWP 5-1	8/24/08	1	48.59672	-115.05782	riffle	30.5	32.6	1.07	28.5	1.9	49.5	1.6
SWP 5-1	8/24/08	2	48.59711	-115.05901	riffle	23.2	21.1	0.90	25.5	1.7	39.7	1.7
SWP 5-1	8/24/08	3	48.59714	-115.05924	riffle	22.0	21.6	0.98	22.4	1.7	43.5	2.0
SWP 5-1	8/24/08	4	48.59729	-115.06017	riffle	23.0	22.3	0.97	23.7	1.5	30.0	1.3
SWP 5-1	8/24/08	5	48.59715	-115.06081	riffle	25.1	30.9	1.23	20.4	1.6	30.6	1.2
SWP 9-1	8/24/08	1	48.60279	-114.96725	riffle	38.0	41.8	1.10	34.6	2.5	78.0	2.1

Table B-5. Channel Cross Section Data

Reach ID	Date	Cell	Latitude	Longitude	Feature	Bankfull Channel Width (ft)	Cross-Sectional Area (ft^2)	Bankfull Mean Depth (ft)	Width / Depth Ratio	Maximum Depth (ft)	Floodprone Width (ft)	Entrenchment Ratio
SWP 9-1	8/24/08	2	48.60233	-114.96745	riffle	41.5	56.9	1.37	30.3	2.4	131.5	3.2
SWP 9-1	8/24/08	3	48.60209	-114.96777	riffle	38.0	62.5	1.64	23.2	1.9	58.0	1.5
SWP 9-1	8/24/08	4	48.60206	-114.96840	riffle	32.2	48.3	1.50	21.5	2.4	53.2	1.7
SWP 9-1	8/24/08	5	48.60153	-114.96926	riffle	30.0	47.1	1.57	19.1	2.5	98.0	3.3
THR 9-5	8/25/08	1	48.84865	-114.92039	riffle	15.5	23.6	1.50	10.2	1.9	59.3	3.8
THR 9-5	8/25/08	2	48.84912	-114.92059	riffle	16.0	23.5	1.46	11.0	1.7	38.0	2.4
THR 9-5	8/25/08	3	48.84964	-114.92064	riffle	13.3	19.4	1.45	9.2	1.7	24.3	1.8
THR 9-5	8/25/08	4	48.84989	-114.92025	riffle	17.6	26.8	1.52	11.6	2.2	25.2	1.4
THR 14-1	8/25/08	1	48.83928	-114.93488	riffle	19.0	28.3	1.48	12.8	2.2	124.0	6.5
THR 14-1	8/25/08	2	48.83981	-114.93499	riffle	18.0	23.9	1.33	13.5	1.8	52.0	2.9
THR 14-1	8/25/08	3	48.84013	-114.93456	riffle	17.0	28.7	1.68	13.5	2.0	26.5	1.6
THR 14-1	8/25/08	4	48.84044	-114.93462	riffle	16.3	29.2	1.79	9.1	2.5	37.3	2.3
THR 14-1	8/25/08	5	48.84091	-114.93479	riffle	16.5	24.4	1.47	11.2	2.0	58.5	3.5
TOB 1-1	8/22/08	1	48.80305	-114.95797	riffle	69.0	160.2	2.30	30.0	3.2	>284	4.1
TOB 1-1	8/22/08	2	48.80222	-114.95694	riffle	70.0	157.7	2.25	31.1	2.9	8.4	1.2
TOB 1-1	8/22/08	3	48.80104	-114.95586	riffle	83.0	172.6	2.08	20.0	2.9	>304	3.7
TOB 1-1	8/22/08	4	48.80056	-114.95496	riffle	77.0	155.5	2.02	38.1	3.4	>309	4.0
TOB 1-1	8/22/08	5	48.79984	-114.95361	riffle	78.5	194.7	2.48	31.7	3.3	>311	4.0
TOB 2-6	8/22/08	1	48.89653	-115.11347	riffle	55.0	137.5	2.50	22.0	3.5	67.5	1.2
TOB 2-6	8/22/08	2	48.89666	115.11205	riffle	96.0	223.7	2.33	41.2	2.8	135.0	1.4
TOB 2-6	8/22/08	4	48.89611	-115.11171	riffle	92.8	198.6	2.14	43.4	2.8	>352.8	3.8
TOB 2-6	8/22/08	5	48.89594	-115.11224	riffle	95.0	195.0	2.05	46.3	3.5	>303	2.2

ATTACHMENT C – QUALITY ASSURANCE/QUALITY CONTROL REVIEW

GENERAL DESCRIPTION OF FIELD ACTIVITIES

Sediment and habitat monitoring was conducted in the Tobacco River TMDL Planning Area in the summer/fall of 2008. Three separate field visits were conducted as part of this assessment:

On July 22-23, 2008, a field reconnaissance crew consisting of Banning Starr (DEQ) and Josh Vincent (Water & Environmental Technologies) conducted site visits of potential field assessment sites which were previously identified using aerial photography and GIS. Sites were inspected for their sampling feasibility and ability to gain access to private property.

On August 21-28, 2008, a sediment and habitat field crew consisting of Banning Starr, Steve Cook, and Christina Staten (DEQ), and Josh Vincent, John Trudnowski, John Babcock, and Ty DeBoo (Water & Environmental Technologies) conducted both longitudinal and Bank Erosion Hazard Index (BEHI) field assessments on 18 impaired stream reaches according to the Sampling and Analysis Plan prepared for this project (Sampling and Analysis Plan, Sediment and Habitat Assessment, Tobacco River TPA, July 2008).

On September 8-12, 2008, a field crew consisting of Steve Cook (DEQ) and Josh Vincent (Water & Environmental Technologies) conducted limited field assessments consisting of BEHI data only on an additional 14 impaired reaches.

Field Variance from SAP

During the field assessments, the following activities were noted as deviating from the approved SAP. It was determined during field activities that the assessment conducted on reach THR-14-1 extended upstream into reach 13-2. The reach location is noted correctly in the GIS database.

After completing field activities, it was determined that the assessment of GRV 2-1 was actually completed on Clarence Creek, a tributary of Grave Creek. The reach of Clarence Creek contained good reference data, and as a result, these data were used in the analysis.

BEHI Data Adjustments

Table C-1 provides adjustments made to the field data during sediment load calculations. In many cases, measurements for near bank stress (NBS), including near bank max depth or mean bankfull depth, were not provided, so NBS was estimated either in the field or from photos. The table provides both the original value determined in the field and the adjusted value used for sediment loading calculations. A rationale for why the value was adjusted is also provided.

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
DEP 9-2	2	bank height	50+	10	notes say 3-10' of bank is eroding
DEP 9-2	3	NBS	not calculated	low	used calculated value from bank 1
DEP 9-2	4	bank height	50+	10	notes say 3-10' of bank is eroding
DEP 9-2	4	NBS	not calculated	low	used calculated value from bank 2

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
DEP 9-2	5	NBS	not calculated	moderate	outside meander bend
DEP 13-2	2	NBS	not calculated	low	used calculated value from bank 1
DEP 13-2	4	NBS	not calculated	very low	used calculated value from bank 2
DEP 13-2	5	NBS	not calculated	very low	used calculated value from bank 2
ENA 10-2	2	NBS	not calculated	low	used calculated value from bank 1
ENA 10-2	3	NBS	not calculated	low	used calculated value from bank 1
ENA 10-2	4	NBS	not calculated	low	used calculated value from bank 1
ENA 10-2	5	NBS	not calculated	low	used calculated value from bank 1
ENA 10-2	6	NBS	not calculated	low	used calculated value from bank 1
ENA 10-2	7	NBS	not calculated	low	used calculated value from bank 1
LME 6-1	2	NBS	not calculated	low	used estimated value from field form
LME 6-1	3	NBS	not calculated	low	used estimated value from bank 2
LME 6-1	4	NBS	not calculated	low	used estimated value from bank 2
LME 6-1	5	NBS	not calculated	high	used estimated value from field form
LME 6-1	6	NBS	not calculated	high	used estimated value from field form
LME 6-1	7	NBS	not calculated	very low	used calculated value from bank 1
LME 6-1	8	NBS	not calculated	high	used estimated value from field form
SNC 8-2	6	bank length	not measured	10'	estimated from photo
SNC 8-2	2	NBS	not calculated	low	used estimated value from field form
SNC 8-2	3	NBS	not calculated	very low	used estimated value from field form
SNC 8-2	4	NBS	not calculated	very low	used estimated value from field form
SNC 8-2	5	NBS	not calculated	very low	used estimated value from field form
SNC 8-2	6	NBS	not calculated	very high	used estimated value from field form
SNC 8-2	7	NBS	not calculated	very high	used estimated value from field form
SNC 8-2	8	NBS	not calculated	low	used estimated value from field form
SNC 8-2	9	NBS	not calculated	high	used estimated value from field form
SNC 8-2	10	NBS	not calculated	high	used estimated value from field form
SNC 8-2	11	NBS	not calculated	very low	used calculated value from bank 1
SNC 8-2	12	NBS	not calculated	very high	used estimated value from bank 7
SNC 8-2	13	NBS	not calculated	low	used estimated value from field form
SNC 8-2	14	NBS	not calculated	high	used estimated value from field form
SNC 10-3	3	NBS	not calculated	very low	used calculated value from bank 1
SNC 10-3	4	NBS	not calculated	very low	used calculated value from bank 1
SNC 10-3	4	root depth	3.9	2.8	bank height is 2.8, adjusted so ratio is 1
THR 9-5	4	NBS	not calculated	very low	used calculated value from bank 1
THR 9-5	7	NBS	not calculated	very low	used calculated value from bank 1
THR 9-5	10	NBS	not calculated	moderate	used estimated value from field form
THR 9-5	3	NBS	not calculated	very low	used calculated value from bank 2
THR 9-5	6	NBS	not calculated	moderate	used estimated value from field form
THR 9-5	8	NBS	not calculated	very high	used estimated value from field form
THR 9-5	9	NBS	not calculated	moderate	used estimated value from field form
THR 9-5	11	NBS	not calculated	high	used estimated value from field form
THR 9-5	12	NBS	not calculated	low	used estimated value from field form
THR 9-5	13	NBS	not calculated	low	used estimated value from field form
THR 9-5	9	bankfull height	1.7	1.6	bank height is 1.6, adjusted so ratio is 1

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
THR 9-5	13	bankfull height	1.7	1.6	bank height is 1.6, adjusted so ratio is 1
TOB 2-6	3a	NBS	very low	extreme	extreme NBS from station 1172-1268
TOB 2-6	3b	NBS	very low	high	high NBS from station 1268-1483
TOB 2-6	6	BEHI	moderate	low	notes say low-very low load, protected
TOB 2-6	4	NBS	not calculated	very low	used estimated value from field form
TOB 2-6	6	NBS	not calculated	low	used estimated value from field form
TOB 2-6	7	NBS	not calculated	very low	used calculated value from bank 5
THR 14-1	5	bankfull height	2.2	1.8	bank height is 1.8, adjusted so ratio is 1
THR 14-1	6	bankfull height	2.2	1.1	bank height is 1.1, adjusted so ratio is 1
THR 14-1	4	NBS	not calculated	very low	used calculated value from bank 1
THR 14-1	5	NBS	not calculated	very low	used calculated value from bank 1
THR 14-1	6	NBS	not calculated	moderate	used estimated value from field form
THR 14-1	7	NBS	not calculated	very low	used calculated value from bank 1
THR 14-1	8	NBS	not calculated	high	used estimated value from field form
THR 14-1	3	NBS	not calculated	high	used estimated value from field form
SWP 5-1	3	NBS	not calculated	low	used estimated value from field form
SWP 5-1	3	bank length	not measured	15	estimated from photo
SWP 5-1	5	NBS	not calculated	moderate	used estimated value from field form
SWP 9-1	2	root depth	0.6 - 1.5	1.1	range given, used mean value
SWP 9-1	3	root depth	0.6 - 1.5	1.1	range given, used mean value
SWP 9-1	5	root depth	0.6 - 1.5	1.1	range given, used mean value
SWP 9-1	7	root depth	0.6 - 1.5	1.1	range given, used mean value
SWP 9-1	6	bankfull height	2.9	2.4	bank height is 2.4, adjusted so ratio is 1
SWP 9-1	7	bankfull height	2.3	1.8	bank height is 1.8, adjusted so ratio is 1
SWP 9-1	3	NBS	not calculated	moderate	mid-channel boulders
SWP 9-1	4	NBS	not calculated	moderate	mid-channel boulders
SWP 9-1	5	NBS	not calculated	moderate	mid-channel boulders
SWP 9-1	6	NBS	not calculated	moderate	mid-channel boulders
SWP 9-1	7	NBS	not calculated	moderate	mid-channel boulders
GRV 2-1	1-5	stratification	YES	5	recorded as "YES", given value of +5
GRV 2-1	2	NBS	not calculated	low	used estimated value from field form
GRV 2-1	3	NBS	not calculated	low	used estimated value from field form
GRV 2-1	4	NBS	not calculated	low	used estimated value from field form
GRV 2-1	5	NBS	not calculated	low	used estimated value from field form
FTN 6-1	2	bank length	88	172	bank on both sides, length doubled
FTN 6-1	2	NBS	not calculated	moderate	used calculated value from bank 1
FTN 6-1	4	NBS	not calculated	high	used estimated value from field form
FTN 6-1	3	NBS	not calculated	very low	used estimated value from field form
FTN 6-1	5	NBS	not calculated	low	used estimated value from field form
FTN 6-1	3	bank length	98	196	bank on both sides, length doubled
FTN 4-3	7	stratification	YES	5	recorded as "YES", given value of +5
FTN 4-3	7	NBS	extreme	moderate	photos show sloughing, used estimate
FTN 4-3	4	bankfull height	2.1	1.8	bank height is 1.8, adjusted so ratio is 1
FTN 4-3	5	bankfull height	2.1	1.8	bank height is 1.8, adjusted so ratio is 1
FTN 4-3	8	bankfull height	2.1	1.9	bank height is 1.9, adjusted so ratio is 1

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
FTN 4-3	2	NBS	not calculated	moderate	used calculated value from bank 1
FTN 4-3	3	NBS	not calculated	moderate	used calculated value from bank 1
FTN 4-3	4	NBS	not calculated	moderate	used calculated value from bank 1
FTN 4-3	5	NBS	not calculated	moderate	used calculated value from bank 1
FTN 4-3	6	NBS	not calculated	moderate	used calculated value from bank 1
FTN 4-3	8	NBS	not calculated	moderate	used calculated value from bank 1
FTN 9-3	2	NBS	not calculated	very low	used calculated value from bank 1
FTN 9-3	3	NBS	high	low	long bank next to pool, used estimate
FTN 9-3	3	BEHI	moderate	low	long vegetated bank, root depth is low
FTN 12-7	1	bankfull height	1.4	1.2	bank height is 1.2, adjusted so ratio is 1
FTN 12-7	4	bank angle	45-90	67	range given, used mean value
FTN 12-7	6	bank angle	45-90	67	range given, used mean value
FTN 12-7	4	NBS	very low	moderate	transverse bar w/ moderate NBS
FTN 12-7	5	NBS	not calculated	moderate	described as 1/2 low and 1/2 high NBS
FTN 12-7	6	NBS	not calculated	very low	used estimated value from field form
FTN 12-7	3	NBS	low	very low	heavy vegetated long bank, estimated
FTN 12-7	3	BEHI	moderate	low	heavily vegetated long bank
FTN 13-1	4	NBS	low	moderate	used estimated value
FTN 13-1	2	NBS	not calculated	moderate	used estimated value from field form
FTN 13-1	3	NBS	not calculated	moderate	used estimated value from field form
FTN 13-1	4	NBS	not calculated	moderate	used estimated value from field form
TOB 1-1	3	NBS	not calculated	very low	used calculated value from bank 2
TOB 1-1	4	NBS	not calculated	very low	used calculated value from bank 2
TOB 1-1	7	NBS	not calculated	very high	outside meander bend, estimated value
TOB 1-1	8	NBS	not calculated	high	outside meander bend, estimated value
TOB 1-1	6	bankfull height	2.3	2	bank height is 2.0, adjusted so ratio is 1
TOB 1-1	6	NBS	not calculated	low	used estimated value from field form
FTN 15-3	2	NBS	not calculated	very low	no bankfull mean depth, estimated value
FTN 15-3	3	NBS	not calculated	moderate	used estimated value from field form
FTN 15-3	4	NBS	not calculated	moderate	used estimated value from field form
FTN 4-1	1	NBS	not calculated	moderate	used estimated value from field form
FTN 4-1	2	NBS	not calculated	low	used estimated value from field form
FTN 4-1	3	NBS	not calculated	moderate	used estimated value from bank 1
FTN 4-1	4	NBS	not calculated	low	used estimated value from bank 2
FTN 4-1	5	NBS	not calculated	high	used estimated value from field form
FTN 4-1	6	NBS	not calculated	low	used estimated value from field form
FTN 4-1	7	NBS	not calculated	moderate	used estimated value from bank 1
FTN 4-1	8	NBS	not calculated	high	used estimated value from field form
FTN 4-1	9	NBS	not calculated	moderate	used estimated value from bank 1
FTN 4-1	10	NBS	not calculated	moderate	used estimated value from bank 1
FTN 4-1	11	NBS	not calculated	low	used estimated value from bank 2
ENA 7-2	4	bankfull height	1.7	1.3	bank height is 1.3, adjusted so ratio is 1
ENA 7-2	1	NBS	not calculated	moderate	used estimated value
ENA 7-2	2	NBS	not calculated	moderate	used estimated value
ENA 7-2	3	NBS	not calculated	moderate	used estimated value

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
ENA 7-2	4	NBS	not calculated	moderate	used estimated value
ENA 7-2	5	NBS	not calculated	moderate	used estimated value
FTN 12-2	1	NBS	not calculated	moderate	used estimated value from field form
FTN 12-2	1	BEHI	high	moderate	long bank, heavy veg below bankfull
FTN 12-2	2	NBS	not calculated	low	used estimated value from field form
FTN 12-2	3	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	4	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	5	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	6	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	7	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	8	NBS	not calculated	low	used estimated value from bank 2
FTN 12-2	9	NBS	not calculated	low	used estimated value from bank 2
ENA 11-1	2	bankfull height	1.0	0.6	bank height is 0.6, adjusted so ratio is 1
ENA 11-1	4	bankfull height	1.0	0.9	bank height is 0.9, adjusted so ratio is 1
ENA 11-1	1	NBS	not calculated	very low	estimated from photos
ENA 11-1	2	NBS	not calculated	very low	estimated from photos
ENA 11-1	3	NBS	not calculated	very low	estimated from photos
ENA 11-1	4	NBS	not calculated	very low	estimated from photos
ENA 11-1	5	NBS	not calculated	very low	estimated from photos
ENA 8-1	1	NBS	not calculated	moderate	used estimated value from field form
ENA 8-1	2	NBS	not calculated	very high	used estimated value from field form
ENA 8-1	3	NBS	not calculated	very high	used estimated value from bank 2
ENA 8-1	4	NBS	not calculated	moderate	used estimated value from bank 1
FTN 7-2	1	NBS	not calculated	moderate	used estimated value from field form
FTN 7-2	2	NBS	not calculated	low	estimated from photo
FTN 7-2	3	NBS	not calculated	high	used estimated value from field form
FTN 7-2	4	NBS	not calculated	low	used estimated value from bank 2
FTN 7-2	5	NBS	not calculated	low	used estimated value from field form
FTN 7-2	6	NBS	not calculated	low	used estimated value from bank 2
FTN 7-2	1	bankfull height	1.8	1.7	bank height is 1.7, adjusted so ratio is 1
FTN 12-9	5	NBS	not calculated	high	used estimated value from field form
FTN 12-9	1	NBS	not calculated	moderate	used estimated value from field form
FTN 12-9	2	bankfull height	2.0	1.3	bank height is 1.3, adjusted so ratio is 1
FTN 12-9	3	bankfull height	2.0	1.5	bank height is 1.5, adjusted so ratio is 1
FTN 12-9	4	bankfull height	2.0	1.6	bank height is 1.6, adjusted so ratio is 1
FTN 12-9	2	root depth	6.0	1.3	bank height is 1.3, adjusted so ratio is 1
FTN 12-9	3	root depth	6.0	1.5	bank height is 1.5, adjusted so ratio is 1
FTN 12-9	4	root depth	6.0	1.6	bank height is 1.6, adjusted so ratio is 1
FTN 12-9	4	material adjust.	0	10	erosion from hoof shear, in photo
FTN 12-9	4	BEHI	low	moderate	increase due to material adjustment
FTN 12-9	2	NBS	not calculated	low	used estimated value from field form
FTN 12-9	3	NBS	not calculated	low	used estimated value from field form
FTN 12-9	4	NBS	not calculated	low	used estimated value from bank 2
FTN 15-2	1	NBS	not calculated	moderate	used estimated value from field form
FTN 15-2	2	NBS	not calculated	moderate	used estimated value from field form

Table C-1. BEHI adjustments

Reach	Bank	Parameter	Original Value	Adjusted Value	Rationale
FTN 15-2	3	NBS	not calculated	moderate	used estimated value from field form
FTN 15-2	4	NBS	not calculated	moderate	used estimated value from field form
FTN 15-2	5	NBS	not calculated	low	used estimated value from field form
FTN 15-2	6	NBS	not calculated	low	used estimated value from field form
FTN 15-2	3	bankfull height	2.2	1.9	bank height is 1.9, adjusted so ratio is 1
FTN 15-2	5	bankfull height	2.2	1.9	bank height is 1.9, adjusted so ratio is 1
SWP 3-1	5	bankfull height	1.5	1.4	bank height is 1.4, adjusted so ratio is 1
SWP 3-1	6	bankfull height	1.5	1.0	bank height is 1.0, adjusted so ratio is 1
SWP 3-1	1	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	2	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	3	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	4	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	5	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	6	NBS	not calculated	low	photo estimate, woody debris in bank
SWP 3-1	7	NBS	not calculated	low	photo estimate, woody debris in bank
SNC 5-1	1	bankfull height	not measured	2.0	estimated from photos
SNC 5-1	2	bankfull height	not measured	2.0	estimated from photos
SNC 5-1	3	bankfull height	not measured	2.0	estimated from photos
SNC 5-1	1	NBS	not calculated	low	used estimated value from field form
SNC 5-1	2	NBS	not calculated	moderate	used estimated value from field form
SNC 5-1	3	NBS	not calculated	high	used estimated value from field form
TOB 2-3	1	NBS	not calculated	high	used estimated value from field form
TOB 2-3	2	NBS	not calculated	moderate	used estimated value from field form
TOB 2-3	4	NBS	not calculated	moderate	used estimated value from field form
TOB 2-3	3	NBS	not calculated	moderate	used estimated value from field form
TOB 2-3	5	NBS	not calculated	moderate	used estimated value from field form
TOB 2-3	6	NBS	not calculated	low	used estimated value from field form
TOB 1-3	1	NBS	not calculated	moderate	used estimated value from field form
TOB 1-3	3	NBS	not calculated	moderate	used estimated value from bank 1
TOB 1-3	4	NBS	not calculated	moderate	used estimated value from bank 1
TOB 1-3	5	NBS	not calculated	moderate	used estimated value from bank 1
TOB 1-3	2	NBS	not calculated	high	used estimated value from field form

ATTACHMENT D – EXAMPLE STREAMBANK PHOTOS

Very Low BEHI Rating: No banks were assessed with a "very low" BEHI rating.

Figure D-1. Low BEHI Rating: Sites ENA 11-1 (bank 1) and FTN 7-2 (bank 1)

Figure D-2. Moderate BEHI Rating: Sites LME 6-1 (bank 1) and TOB 1-1 (bank 2)

Figure D-3. High BEHI Rating: Sites FTN 13-1 (bank 1) and THR 14-1 (bank 1)

Figure D-4. Very High BEHI Rating: Sites THR 9-5 (bank 5) and THR 14-1 (bank 2)

Figure D-5. Extreme BEHI Rating: Sites TOB 2-6 (bank 3) and DEP 9-2 (bank 1)

APPENDIX E - STREAMBANK EROSION SOURCE ASSESSMENT

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E1.0 INTRODUCTION

This appendix presents an assessment of sediment loading due to streambank erosion in the Tobacco River TMDL Planning Area (TPA) located in Lincoln and Flathead Counties of Montana. Most of the information within this appendix is derived directly from an April, 2009 streambank erosion report prepared by Water & Environmental Technologies, PC (Water & Environmental Technologies, 2009; River Design Group, 2011; Water & Environmental Technologies, 2009). Sediment loads due to streambank erosion were estimated based on field data collected at 32 monitoring sites in August and September 2008. Streambank data collected at field monitoring sites were extrapolated to the stream reach, stream segment, and watershed scales based on reach type and land use characteristics identified in the aerial assessment database, which was compiled in a geographic information system (GIS) prior to field data collection. Detailed data from the GIS aerial assessment and other sediment and habitat parameters are presented in **Appendix D**. Streambank erosion data were also used to estimate potential sediment reductions to human influenced reaches through the application of all reasonable land, soil, and water conservation practices.

E2.0 METHODS

The streambank erosion assessment involved several procedures. First, streams were stratified into similar reaches using an aerial assessment performed in GIS. Streambank erosion data was then collected in the field at selected monitoring sites, and sediment loads were estimated based on field conditions. Sediment loads from field assessed monitoring sites were then extrapolated to the stream reach, stream segment, and watershed. Finally, the potential for reducing human influenced streambank erosion was evaluated. Detailed methods describing each procedure are provided in the following sections.

E2.1 AERIAL ASSESSMENT REACH STRATIFICATION

Prior to field data collection, an aerial assessment of streams in the Tobacco River TPA was conducted using GIS. Data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations(Montana Department of Environmental Quality, 2008)*.

The reach stratification process was completed for the mainstem segments of the following sediment-listed streams in the Tobacco River TPA: Deep Creek, Edna Creek, Fortine Creek, Grave Creek, Lime Creek, Swamp Creek, Theriault Creek, and Tobacco River. In addition to these streams, Sinclair Creek was included due to stakeholder and DEQ interest in evaluating this stream. A TMDL and water quality restoration plan has already been prepared for the Grave Creek watershed (Montana Department of Environmental Quality, et al., 2005), but the stream was included in the reach stratification effort for the purposes of consistency and extrapolation of sediment loads at the watershed scale. Stream segments stratified during the aerial assessment are considered “stratified”, while streams not stratified are considered “unstratified” for the purposes of this report. Meadow Creek and Indian Creek were not listed for sediment impairment, were not included in the stratification effort, and will be considered “unassessed” streams.

The aerial assessment reach stratification process involved dividing each stream into distinct reaches based on four watershed characteristics. A reach type is defined as a unique combination of EPA Ecoregion, valley gradient, Strahler stream order, and valley confinement, and is designated using the following naming convention based on the reach type identifiers provided in **Table E2-1**:

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

Table E2-1. Reach type identifiers.

Watershed Characteristic	Stratification Category	Reach Type Identifier
Level III Ecoregion	Northern Rockies	NR
	Canadian Rockies	CR
Valley Gradient	0-2%	0
	2-4%	2
	4-10%	4
	> 10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
	fifth order	5
Confinement	confined	C
	unconfined	U

For example, a reach identified as NR-0-3-U is in the Northern Rockies Level III Ecoregion, has a valley gradient of 0-2%, is a 3rd order stream, and is within an unconfined valley.

E2.2 Field Data Collection

Field data collection utilized the approach described the in *Longitudinal Field Methods for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007). Streambank erosion data was collected at each field assessed monitoring site, which was 500, 1000, or 2000 feet long based on bankfull width of the stream: the larger the bankfull width, the longer the monitored reach.

At each monitoring site, all streambanks were assessed for erosion severity and categorized as either “actively/visually eroding” or “slowly eroding/vegetated/undercut”. At each eroding bank, Bank Erosion Hazard Index (BEHI) measurements were performed and the Near Bank Stress (NBS) was estimated or determined based on field measurements (Rosgen, 2006). Bank erosion severity was rated from “very low” to “extreme” based on the BEHI score, which was determined by the following six parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. Near Bank Stress was rated from “very low” to “extreme” depending on the shape of the channel at the toe of the bank and the force of the water (i.e. “stream power”) along the bank.

In addition, the source or underlying cause of streambank erosion was evaluated based on current or observed human disturbances within the riparian corridor, as well as historic land-use practices in the surrounding landscape. The following near-stream source categories were used: transportation (roads), grazing, cropland, mining, logging, irrigation, natural, and “other”. Naturally eroding streambanks were considered those with no observed or known historic human impacts, while the “other” category was

chosen when streambank erosion resulted from a source not specifically identified in the list. If multiple sources were observed, then a percent of the total was estimated for each source.

E2.3 SEDIMENT LOAD CALCULATIONS

For each eroding streambank, the average annual sediment load was estimated based on the bank's length, mean height, and estimated annual retreat rate. The length and mean height were measured in the field, while the annual retreat rate was determined based on the BEHI and NBS ratings. Annual retreat rates were estimated based on those measured from the Lamar River in Yellowstone National Park (Rosgen, 1996) (**Table E2-2**).

Table E2-2. Streambank erosion retreat rates (ft/year), Lamar River, YNP.

BEHI	Near Bank Stress					
	very low	low	moderate	high	very high	extreme
very Low	0.002	0.004	0.009	0.021	0.050	0.12
low	0.02	0.04	0.10	0.24	0.57	1.37
moderate	0.10	0.17	0.28	0.47	0.79	1.33
high - very high	0.37	0.53	0.76	1.09	1.57	2.26
extreme	0.98	1.21	1.49	1.83	2.25	2.76

The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material. The bulk density of streambank material was assumed to average 1.3 tons/cubic yard as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (Rosgen, 2006). This process resulted in a sediment load from each eroding bank expressed in tons/year. Loads from each eroding bank were summed to produce a monitoring site sediment loading rate, expressed in tons/year/1000-feet of stream.

E2.4 SEDIMENT LOAD EXTRAPOLATION

Annual sediment loads from monitoring sites were extrapolated to the stream reach and stream segment scales based on similar reach type characteristics as identified in the aerial assessment database. Sediment load extrapolations were performed for monitoring sites, stream reaches, and stream segments, which are defined as follows:

Monitoring Site - *A 500, 1000, or 2000 foot section of a stream reach where field monitoring was conducted*

Stream Reach -*Subdivision of the stream segment based on Ecoregion, stream order, gradient and confinement as evaluated in GIS*

Stream Segment -*303(d) listed segment* (Note: several additional non-listed streams were included within this assessment)

The extrapolation of annual bank erosion sediment loads was completed according to the following criteria:

1. Monitoring site sediment loading rates were extrapolated directly to the stream reach in which the monitoring site was located.
2. For reaches not assessed in the field, the average sediment loading rate for all monitoring sites within a given reach type was applied, provided that a representative number of monitoring sites were assessed for that reach type.

3. All 1st order streams, both stratified and unstratified, were assigned a sediment load of zero due to their relatively small size, steep gradient and large substrate. These streams are not considered a significant source of controllable sediment load in this watershed. Therefore, they are excluded to focus on the controllable sediment loads.
4. Unstratified, non-1st order streams within the Northern Rockies Ecoregion were assigned the 25th percentile of sediment loading rates from all stratified streams in the NR Ecoregion (negating the Tobacco River due to its size). These streams were given a sediment loading rate of 11 tons/year/1000' of stream.
5. Unstratified, non-1st order streams within the Canadian Rockies Ecoregion were assigned the 25th percentile of sediment loading rates from all stratified streams in the CR Ecoregion (negating site DEP 9-2 due to its large non-typical sediment load). These streams were assigned a sediment loading rate of 5 tons/year/1000' of stream.
6. For reaches with field-assessed monitoring sites, the field-identified sources replaced the sources identified during the aerial assessment.

Exceptions to these criteria were made based on review of color aerial imagery and field experience within the Tobacco River watershed, including:

1. In select situations, the sediment loading rate derived for a specific reach was extrapolated directly to another reach, often when the two reaches were within close proximity or had similar land-use characteristics.
2. For reach types with confined valley types, the reach type average of the unconfined valley type may be applied.
3. If a certain reach type was not assessed within a major Ecoregion (Northern Rockies or Canadian Rockies), the reach type average from the other Ecoregion may be applied.
4. For steep reaches (valley gradient >10%), the 25th percentile loading rate from that Ecoregion was applied since no steep reaches were assessed in the field.

When human disturbances were evident at the stream reach scale but not observed at the monitoring site, the sources identified in the aerial assessment were retained.

E2.5 Sediment Load Reduction Potential

The sediment load reduction potential was evaluated for human influenced monitoring sites. This evaluation was performed by reducing all high, very high, and extreme BEHI ratings to the level of "moderate" at sites with human-caused sources of erosion. This provides an estimate of bank erosion reductions from the implementation of land, soil, and water conservation practices. Examples of these conservation practices may include riparian grazing management practices, physical adjustments to channel form via restoration projects, limiting harvest or removal of riparian vegetation or near-stream trees, or active revegetation efforts that improve riparian condition. Sediment load reductions at monitoring sites were extrapolated to the reach, segment, and watershed scales using the following methodology:

1. All field-assessed monitoring sites which had a human influenced sediment source were identified. Only sites with >5% human sources were considered for reduction.
2. For the monitoring sites identified in item 1, the load reduction potential was evaluated by reducing BEHI ratings of all streambanks down to "moderate", adjusting the bank erosion retreat rate, and calculating a reduced sediment loading rate for the reach. Only banks with a BEHI rating greater than "moderate" were adjusted. Though this approach may underestimate

potential load reductions in places, it focuses on the most likely and desirable locations for reducing bank erosion.

3. The potential load reduction percentage for each monitoring site was calculated by comparing the reduced sediment loading rate to the original sediment loading rate. All adjusted monitoring sites were then combined to calculate an average potential reduction percentage for human influenced sites.
4. The average potential reduction percentage calculated in item 3 was then multiplied by the existing human influenced load of all stratified reaches that had >5% human sources, thereby calculating the potential sediment load reduction in these reaches. The potential reduction to human influenced sediment load was then subtracted from the original reach load in these reaches.
5. The potential reduced sediment load was then calculated for each stream segment and for the entire watershed. All unstratified streams retained their original sediment load since land-use and erosion source information was unavailable for these streams. Sites with less than 5% human sediment sources also retained their existing sediment load.

E3.0 RESULTS

This section provides results of the aerial photo assessment, reach stratification process, a summary of field data collection sites, and the estimated average annual sediment loads due to streambank erosion at the monitoring site, stream segment and watershed scales. Potential sediment reductions were also examined by estimating reduced sediment loads for banks influenced by human activities.

E3.1 AERIAL ASSESSMENT REACH STRATIFICATION

During the aerial assessment, a total of 550 miles of stream were identified in the Tobacco River watershed, with 116 miles included in the aerial assessment reach stratification process. Of the remaining 434 miles of stream not included in the aerial assessment, 334 miles are 1st order headwater streams, and 100 miles are non-1st order streams. A total of 186 reaches were delineated in GIS and reach-specific data were compiled into a database. A total of 29 reach types were identified in the Tobacco River watershed, 11 of which were assessed in the field. Possible reach type combinations identified in the Tobacco River watershed are presented in **Table E3-1**, along with the number of reaches assessed in the field for each reach type.

Table E3-1. Reach types within the Tobacco River watershed

Reach Type	Number of Stratified Reaches	Number of Sampled Reaches	Percent Sampled
CR-0-2-U	17	4	24%
CR-0-3-U	1		
CR-0-4-C	1		
CR-0-4-U	9		
CR-2-1-U	3		
CR-2-2-C	1		
CR-2-2-U	7		
CR-2-3-U	6	1	17%
CR-2-4-U	2		
CR-4-1-U	6		

Table E3-1. Reach types within the Tobacco River watershed

Reach Type	Number of Stratified Reaches	Number of Sampled Reaches	Percent Sampled
CR-4-2-C	3		
CR-4-2-U	6	3	50%
CR-4-3-U	5	1	20%
CR-4-4-U	1		
CR-10-1-C	2		
CR-10-1-U	6		
CR-10-2-U	2		
NR-0-1-U	1		
NR-0-2-U	4		
NR-0-3-U	24	5	21%
NR-0-4-U	32	7	22%
NR-0-5-U	11	4	36%
NR-2-1-U	3		
NR-2-2-U	5	1	20%
NR-2-3-U	12	2	17%
NR-4-1-U	3		
NR-4-2-U	7	2	29%
NR-4-3-U	4	2	50%
NR-10-1-U	2		
Total	**186**	**32**	**17%**

E3.2 Field Data Collection

A total of 32 monitoring sites within the Tobacco River TPA were assessed in August and September 2008 (**Attachment A**). Monitoring sites were identified through an assessment of aerial images and field reconnaissance to capture the variability in land use and watershed characteristics that may be contributing to sediment impairment. At 18 of the monitoring sites, a complete sediment and habitat assessment was performed, while the remaining 14 monitoring sites were assessed only for streambank erosion. A total of 199 individual streambanks were assessed. The following streams were included in the Tobacco River TPA sediment assessment (specific reaches identified in parentheses):

- Deep Creek (13-2, 9-1, 7-1)
- Edna Creek (11-1, 10-2, 8-1, 7-2)
- Fortine Creek (15-3, 15-2, 13-1, 12-9, 12-7, 12-2, 9-3, 7-2, 6-1, 4-3, 4-1)
- Lime Creek (6-1)
- Sinclair Creek (10-3, 8-2, 5-1)
- Swamp Creek (9-1, 5-1, 3-1)
- Theriault Creek (14-1, 9-5)
- Tobacco (2-6, 2-3, 1-1)
- Clarence Creek (Clarence Creek is an unstratified Grave Creek tributary that was inadvertently sampled instead of the stratified Grave Creek mainstem)

E3.3 Sediment Load Calculations at Monitoring Sites

Sediment loads for each field-assessed eroding streambank were summed to provide a sediment load for each monitoring site. A total annual sediment load of 1,223 tons/year was attributed to the 199 eroding banks within the 32 field-assessed monitoring sites (**Table E3-2**). Approximately 41% of the bank erosion sediment load was attributed to historic or current human activities, while approximately 59% was attributed to natural erosion processes and sources. Monitoring site assessments indicate that roads (14%), riparian grazing (11%), cropland (<1%), recent logging (3%), and "other" (13%) are the main types of human activities in the Tobacco River TPA. The "other" category primarily describes impacts due to railroads and urban influences. Bank erosion impacts from mining and irrigation were not observed as sources during this assessment.

Table E3-2. Summary of monitoring site sediment loads.

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Roads	172	14
Riparian Grazing	129	11
Cropland	0.1	<1
Logging	40.3	3
Natural Sources	719	59
Other	163	13
Total	**1223**	**100%**
Anthropogenic	**504**	**41%**
Natural	**719**	**59%**

Average annual sediment loads from each monitoring site were normalized to a length of 1,000 feet for comparison and extrapolation purposes. Estimated annual sediment loads for each monitoring site are presented in **Table E3-3**, and estimated sediment loads by source are provided in **Table E3-4**.

Table E3-3. Estimated sediment loads by monitoring site.

Stream	Reach ID	Reach Type	Number of Eroding Banks	Length of Eroding Banks (Feet)	Monitoring Site Length (Feet)	Eroding Bank (% of reach)	Reach Sediment Load (Tons/Year)	Sediment Load per 1000 Feet (Tons/Year)
Clarence Creek	Clarence	CR-4-2-U	5	249	1000	12.5	14.1	14.1
Deep Creek	DEP 13-2	CR-2-3-U	5	131	1000	6.6	2.8	2.8
	DEP 7-1	CR-4-2-U	0	0	1000	0.0	0.0	0.0
	DEP 9-2	CR-4-3-U	5	458	1000	22.9	155.5	155.5
Edna Creek	ENA 10-2	NR-4-3-U	7	181	1000	9.1	7.9	7.9
	ENA 11-1	NR-0-3-U	5	62	1000	3.1	0.1	0.1
	ENA 7-2	NR-4-2-U	5	187	1000	9.4	13.6	13.6
	ENA 8-1	NR-2-2-U	4	73	1000	3.7	8.3	8.3

Table E3-3. Estimated sediment loads by monitoring site.

Stream	Reach ID	Reach Type	Number of Eroding Banks	Length of Eroding Banks (Feet)	Monitoring Site Length (Feet)	Eroding Bank (% of reach)	Reach Sediment Load (Tons/Year)	Sediment Load per 1000 Feet (Tons/Year)
Fortine Creek	FTN 12-2	NR-0-4-U	9	467	1000	23.4	35.5	35.5
	FTN 12-7	NR-0-4-U	6	734	1000	36.7	77.8	77.8
	FTN 12-9	NR-0-4-U	5	198	1000	9.9	19.4	19.4
	FTN 13-1	NR-0-4-U	5	329	1000	16.5	58.0	58.0
	FTN 15-2	NR-0-4-U	6	439	1000	22.0	11.9	11.9
	FTN 15-3	NR-0-4-U	4	195	1000	9.8	4.9	4.9
	FTN 4-1	NR-0-3-U	11	395	1000	19.8	46.5	46.5
	FTN 4-3	NR-0-3-U	8	691	1000	34.6	21.3	21.3
	FTN 6-1	NR-0-3-U	5	487	1000	24.4	43.4	43.4
	FTN 7-2	NR-2-3-U	6	203	1000	10.2	37.7	37.7
	FTN 9-3	NR-0-4-U	3	457	1000	22.9	21.3	21.3
Lime Creek	LME 6-1	NR-4-3-U	8	111	500	11.1	9.9	19.8
Sinclair Creek	SNC 10-3	CR-0-2-U	4	228	1000	11.4	53.5	53.5
	SNC 5-1	CR-4-2-U	3	140	1000	7.0	11.7	11.7
	SNC 8-2	CR-0-2-U	14	321	1000	16.1	42.0	42.0
Swamp Creek	SWP 3-1	NR-4-2-U	7	117	1000	5.9	1.0	1.0
	SWP 5-1	NR-0-3-U	5	242	1000	12.1	13.4	13.4
	SWP 9-1	NR-2-3-U	7	535	1000	26.8	51.6	51.6
Theriault Creek	THR 14-1	CR-0-2-U	8	134	1000	6.7	7.9	7.9
	THR 9-5	CR-0-2-U	13	274	1000	13.7	21.4	21.4
Tobacco River	TOB 1-1	NR-0-5-U	8	1587	2000	39.7	108.5	54.3
	TOB 1-3	NR-0-5-U	5	1035	2000	25.9	136.7	68.4
	TOB 2-3	NR-0-5-U	6	440	2000	11.0	18.8	9.4
	TOB 2-6	NR-0-5-U	8	990	2000	24.8	166.4	83.2

Table E3-4. Estimated sediment loads by individual source.

Stream	Reach ID	Monitoring Site Length (Feet)	Reach Sediment Load (Tons/Yr)	Road Load		Grazing Load		Cropland Load		Logging Load		Natural Load		"Other" Load	
				(Tons/ Yr)	(%)	(Tons / Yr)	(%)	(Tons / Yr)	(%)	(Tons / Yr)	(%)	(Tons/ Yr)	(%)	(Tons / Yr)	(%)
Clarence Creek	Clarence	1000	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.14	100.0	0.0	0.0
Deep Creek	DEP 13-2	1000	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.79	100.0	0.0	0.0
	DEP 7-1	1000	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
	DEP 9-2	1000	155.5	126.4	81.3	0.0	0.0	0.0	0.0	0.0	0.0	29.05	18.7	0.0	0.0
Edna Creek	ENA 10-2	1000	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.87	100.0	0.0	0.0
	ENA 11-1	1000	0.1	0.0	0.0	0.0	0.0	0.1	100.0	0.0	0.0	0.00	0.0	0.0	0.0
	ENA 7-2	1000	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.59	100.0	0.0	0.0
	ENA 8-1	1000	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.27	100.0	0.0	0.0
Fortine Creek	FTN 12-2	1000	35.5	0.0	0.0	0.0	0.0	0.0	0.0	13.6	38.3	21.89	61.7	0.0	0.0
	FTN 12-7	1000	77.8	0.0	0.0	75.9	97.6	0.0	0.0	0.0	0.0	1.88	2.4	0.0	0.0
	FTN 12-9	1000	19.4	0.0	0.0	0.8	4.3	0.0	0.0	0.3	1.3	18.35	94.4	0.0	0.0
	FTN 13-1	1000	58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.01	100.0	0.0	0.0
	FTN 15-2	1000	11.9	5.7	48.3	0.0	0.0	0.0	0.0	0.0	0.0	6.14	51.7	0.0	0.0
	FTN 15-3	1000	4.9	0.0	0.0	1.3	25.7	0.0	0.0	0.0	0.0	3.67	74.3	0.0	0.0
	FTN 4-1	1000	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.55	100.0	0.0	0.0
	FTN 4-3	1000	21.3	0.0	0.0	5.0	23.5	0.0	0.0	0.0	0.0	16.30	76.5	0.0	0.0
	FTN 6-1	1000	43.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.50	58.7	17.9	41.3
	FTN 7-2	1000	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.72	100.0	0.0	0.0
	FTN 9-3	1000	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.32	100.0	0.0	0.0
Lime Creek	LME 6-1	500	9.9	3.0	30.4	0.0	0.0	0.0	0.0	0.7	7.3	6.17	62.4	0.0	0.0
Sinclair Creek	SNC 10-3	1000	53.5	26.7	50.0	0.0	0.0	0.0	0.0	0.0	0.0	10.69	20.0	16.0	30.0
	SNC 5-1	1000	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.68	100.0	0.0	0.0
	SNC 8-2	1000	42.0	0.0	0.0	42.0	100.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
Swamp Creek	SWP 3-1	1000	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	9.2	0.88	90.8	0.0	0.0
	SWP 5-1	1000	13.4	0.0	0.0	0.0	0.0	0.0	0.0	12.4	92.9	1.0	7.1	0.0	0.0
	SWP 9-1	1000	51.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.57	100.0	0.0	0.0
Theriault Creek	THR 14-1	1000	7.9	0.0	0.0	0.6	7.3	0.0	0.0	0.5	6.5	4.89	61.8	1.9	24.4
	THR 9-5	1000	21.4	0.0	0.0	0.0	0.0	0.0	0.0	12.7	59.6	8.64	40.4	0.0	0.0

Table E3-4. Estimated sediment loads by individual source.

Stream	Reach ID	Monitoring Site Length (Feet)	Reach Sediment Load (Tons/Yr)	Road Load		Grazing Load		Cropland Load		Logging Load		Natural Load		"Other" Load	
				(Tons/ Yr)	(%)	(Tons / Yr)	(%)	(Tons / Yr)	(%)	(Tons / Yr)	(%)	(Tons/ Yr)	(%)	(Tons / Yr)	(%)
Tobacco River	TOB 1-1	2000	108.5	0.0	0.0	1.3	1.2	0.0	0.0	0.0	0.0	107.17	98.8	0.0	0.0
	TOB 1-3	2000	136.7	1.6	1.1	1.6	1.1	0.0	0.0	0.0	0.0	133.60	97.7	0.0	0.0
	TOB 2-3	2000	18.8	8.6	45.7	0.0	0.0	0.0	0.0	0.0	0.0	5.86	31.1	4.4	23.2
	TOB 2-6	2000	166.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.04	26.5	122.3	73.5

E3.4 Streambank Erosion Sediment Load Extrapolation

Sediment loading rates derived from the monitoring sites were extrapolated to the stream reach, stream segment and watershed scales based on the aerial assessment reach type analysis. Sediment loading rates were applied to each reach using the criteria provided in **Section E2.4**, and a total load was then calculated for each stream segment and subwatershed. The following sections provide summaries of sediment load extrapolation results by reach type, stream segment, and watershed.

E3.4.1 Reach Type Sediment Loads

Sediment loading rates from each monitoring site were averaged within each reach type to derive a reach type sediment loading rate. Overall, 11 reach types were identified in the Tobacco River TPA, including 4 in the Canadian Rockies Ecoregion (CR) and 7 in the Northern Rockies Ecoregion (NR). Reach type averages of sediment loading rates ranged from 3 to 155 tons/year/1000-feet; however, many reach type averages include only one assessed reach and may not be representative of conditions throughout the watershed. A summary of reach type sediment loading rates is provided in **Table E3-5**.

Table E3-5. Reach type sediment loading rates.

Reach Type	Description	Reach ID	Sediment Load per 1000 Feet (Tons/Year)	Average Reach Type Sediment Load per 1000 Feet (Tons/Year)
CR-0-2-U	Canadian Rockies, low gradient, 2nd order streams	SNC 10-3	53.5	31.2
		SNC 8-2	42.0	
		THR 14-1	7.9	
		THR 9-5	21.4	
CR-2-3-U	Canadian Rockies, moderate gradient, 3rd order streams	DEP 13-2	2.8	2.8
CR-4-2-U	Canadian Rockies, steep gradient, 2nd order streams	Clarence	14.1	8.6
		DEP 7-1	0.0	
		SNC 5-1	11.7	
CR-4-3-U	Canadian Rockies, steep gradient, 3rd order streams	DEP 9-2	155.5	155.5
NR-0-3-U	Northern Rockies, low gradient, 3rd order streams	ENA 11-1	0.1	24.9
		FTN 4-1	46.5	
		FTN 4-3	21.3	
		FTN 6-1	43.4	
		SWP 5-1	13.4	
NR-0-4-U	Northern Rockies, low gradient, 4th order streams	FTN 12-2	35.5	32.7
		FTN 12-7	77.8	
		FTN 12-9	19.4	
		FTN 13-1	58.0	
		FTN 15-2	11.9	
		FTN 15-3	4.9	
		FTN 9-3	21.3	
NR-0-5-U	Northern Rockies, low gradient, 5th order streams	TOB 1-1	54.3	53.8
		TOB 1-3	68.4	
		TOB 2-3	9.4	
		TOB 2-6	83.2	
NR-2-2-U	Northern Rockies, moderate gradient, 2nd order streams	ENA 8-1	8.3	8.3

Table E3-5. Reach type sediment loading rates.

Reach Type	Description	Reach ID	Sediment Load per 1000 Feet (Tons/Year)	Average Reach Type Sediment Load per 1000 Feet (Tons/Year)
NR-2-3-U	Northern Rockies, moderate gradient, 3rd order streams	FTN 7-2	37.7	44.6
		SWP 9-1	51.6	
NR-4-2-U	Northern Rockies, steep gradient, 2nd order streams	ENA 7-2	13.6	7.3
		SWP 3-1	1.0	
NR-4-3-U	Northern Rockies, steep gradient, 3rd order streams	ENA 10-2	7.9	13.8
		LME 6-1	19.8	

E3.4.2 Stream Segment Sediment Loads

Stream segment sediment loads were estimated for all Tobacco River TPA streams impaired for sediment per Montana's 2008 Integrated Report (reference), including Deep Creek, Edna Creek, Fortine Creek, Grave Creek, Lime Creek, Swamp Creek, Theriault Creek, and Tobacco River. Because of stakeholder interest, Sinclair Creek was fully evaluated for sediment TMDL development purposes including a bank erosion assessment. Although bank erosion loading were determined for the Grave Creek watershed during previous TMDL development (Montana Department of Environmental Quality, et al., 2005), DEQ decided to estimate bank erosion loading again for the Grave Creek watershed using the information presented in this appendix.

Overall, sediment loads were estimated for a total stratified length of 116 miles. A total annual sediment load of 15,423 tons/year was attributed to streambank erosion at the stream segment scale (**Table E3-6**). Approximately 34% of this sediment load was attributed to human sources, while approximately 66% was attributed to natural sources. This assessment indicates that roads (10%), riparian grazing (10%) and "other" (8%) are the greatest human related contributors of streambank sediment loading at the stream segment scale. The "other" category includes impacts from railroads and urban influences.

Table E3-6. Summary of stream segment sediment loads.

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Roads	1547	10
Grazing	1529	10
Cropland	693	4
Logging	264	2
Natural Sources	10,141	66
Other	1248	8
Total	**15,423**	**100**
Human Influenced	**5282**	**34**
Natural	**10,141**	**66**

Total stream segment loads were calculated by summing the cumulative sediment load of all reaches within each segment by using the sediment load extrapolation procedure detailed in **Section E2.4**. Stream segment sediment loads are discussed below for each stratified stream in the Tobacco River TPA. The total sediment load is provided for individual reaches, for the total stratified stream segment, for unstratified tributary streams, and for each subwatershed. The streambank erosion rate assigned to each reach during the extrapolation process is provided along with the bank erosion source. Any assumptions made in the selection of sediment loading rates are discussed on a reach by reach basis.

Reaches which were assessed in the field were assigned their measured sediment loading rate, and are shown on summary tables in **bold**.

E3.4.2.1 Deep Creek Sediment Loads

A total of 18 reaches were delineated for the mainstem of Deep Creek, and three monitoring sites were assessed in the field. Reach 9-2 was further broken into two sub-reaches (DEP 9-2a and DEP 9-2b) due to extreme erosion observed within the assessed monitoring site. The four upper reaches (1-1 to 4-1) were 1st order streams which were assigned a sediment load of zero. Reach 5-1 was reach type CR-4-2-U and received the reach type average as a loading rate. Reach 6-1 was a steep reach (>10%) and received the 25th percentile loading rate for Canadian Rockies Ecoregion since no other steep reaches were visited during the field assessment. Five reaches were reach type CR-4-3-U; however, the only field-assessed reach of this type was DEP 9-2a, which was determined to have an extreme load which was uncharacteristically high. As a result, the average sediment loading rate from reach type CR-4-2-U was applied to these reaches. The six reaches furthest downstream were all of reach type CR-2-3-U or CR-0-3-U, and received the field-assessed loading rate from adjacent reach DEP 13-2, which had similar land use characteristics.

The total estimated sediment load for the Deep Creek watershed was estimated to be 453 tons/year, including 405 tons/year from the mainstem, and 48 tons/year from unstratified non-1st order tributary streams. The estimated annual sediment loads for Deep Creek are provided below in **Table E3-7.**

Table E3-7. Estimated annual sediment loads for Deep Creek.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
DEP 1-1	CR-10-1-U	0	zero load (1st order)	0.5	0	0	0	0	0	100	0
DEP 2-1	CR-4-1-U	0	zero load (1st order)	1.1	0	0	0	0	0	100	0
DEP 3-1	CR-10-1-U	0	zero load (1st order)	0.3	0	0	0	0	0	100	0
DEP 4-1	CR-4-1-U	0	zero load (1st order)	0.1	0	0	0	0	0	100	0
DEP 5-1	CR-4-2-U	9	RT avg (N=3)	0.7	34	0	0	0	40	60	0
DEP 6-1	CR-10-2-U	5	CR 25th percentile	0.4	11	0	0	0	40	60	0
DEP 7-1	**CR-4-2-U**	**0**	**assessed value**	**0.5**	**0**	**0**	**0**	**0**	**0**	**100**	**0**
DEP 8-1	CR-4-3-U	9	CR-4-2-U avg (N=3)	0.3	14	0	0	0	50	50	0
DEP 8-2	CR-4-3-U	9	CR-4-2-U avg (N=3)	0.3	14	0	0	0	0	100	0
DEP 9-1	CR-4-3-U	9	CR-4-2-U avg (N=3)	0.6	29	0	0	0	20	80	0
DEP 9-2a	**CR-4-3-U**	**155**	**assessed value**	**0.2**	**156**	**81**	**0**	**0**	**0**	**19**	**0**
DEP 9-2b	CR-4-3-U	9	CR-4-2-U avg (N=3)	2.1	93	0	0	0	0	100	0
DEP 10-1	CR-4-3-U	9	CR-4-2-U avg (N=3)	0.1	5	0	0	0	0	100	0
DEP 11-1	CR-2-3-U	3	DEP 13-2 load	0.2	3	0	0	0	0	100	0
DEP 11-2	CR-2-3-U	3	DEP 13-2 load	0.3	4	0	0	0	0	100	0
DEP 12-1	CR-0-3-U	3	DEP 13-2 load	1.5	23	20	10	10	10	50	0
DEP 13-1	CR-2-3-U	3	DEP 13-2 load	0.3	4	40	20	0	0	40	0
DEP 13-2	**CR-2-3-U**	**3**	**assessed value**	**0.8**	**11**	**0**	**0**	**0**	**0**	**100**	**0**
DEP 13-3	CR-2-3-U	3	DEP 13-2 load	0.4	5	10	20	20	0	50	0
			Total Stream Segment	**10.6**	**405**	**33**	**1**	**1**	**8**	**57**	**0**
Unstratified 1st Order		0	no load (1st order)	12.6	0						
Unstratified non-1st Order		5	CR 25th percentile	1.7	48						
			Total Deep Creek Watershed	**24.9**	**453**						

E3.4.2.1 Edna Creek Sediment Loads

Eighteen reaches were delineated on the mainstem of Edna Creek, and 4 monitoring sites were evaluated in the field. The four 1st order reaches of Edna Creek were all assigned a sediment load of

zero. Reaches with types NR-4-2-U or NR-2-2-U received their reach type average sediment loading rate, which was comparable to assessed values found in Edna Creek. Sediment loading rates from field assessed reaches were applied to adjacent stream reaches since they were often a similar reach type or land use. The total estimated annual sediment load for the Edna Creek watershed was 452 tons/year, including 324 tons/year from the mainstem, and 128 tons/year from unstratified non-1st order streams. The estimated annual sediment loads for Edna Creek are provided below in **Table E3-8.**

Table E3-8. Estimated annual sediment loads for Edna Creek.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
ENA 1-1	NR-2-1-U	0	no load (1st order)	0.6	0	40	0	0	40	20	0
ENA 1-2	NR-2-1-U	0	no load (1st order)	0.5	0	30	0	0	30	40	0
ENA 2-1	NR-4-1-U	0	no load (1st order)	1.2	0	25	0	0	0	75	0
ENA 3-1	NR-4-2-U	7	RT avg (N=2)	0.2	6	0	0	0	0	100	0
ENA 3-2	NR-4-2-U	7	RT avg (N=2)	0.1	5	0	0	0	0	100	0
ENA 4-1	NR-2-2-U	8	RT avg (N=1)	0.8	34	0	0	0	0	100	0
ENA 5-1	NR-4-2-U	7	RT avg (N=2)	0.3	13	0	0	0	0	100	0
ENA 6-1	NR-2-2-U	8	RT avg (N=1)	0.2	10	0	0	0	0	100	0
ENA 6-2	NR-2-2-U	8	RT avg (N=1)	0.5	21	25	0	0	0	75	0
ENA 7-1	NR-4-2-U	14	ENA 7-2 load	0.3	25	20	0	0	0	80	0
ENA 7-2	**NR-4-2-U**	**14**	**assessed value**	**1.3**	**91**	**0**	**0**	**0**	**0**	**100**	**0**
ENA 8-1	**NR-2-2-U**	**8**	**assessed value**	**0.7**	**28**	**0**	**0**	**0**	**0**	**100**	**0**
ENA 9-1	NR-2-3-U	8	ENA 8-1 load	0.6	26	10	0	0	0	90	0
ENA 9-2	NR-2-3-U	8	ENA 10-2 load	0.4	16	10	0	0	20	70	0
ENA 10-1	NR-4-3-U	8	ENA 10-2 load	0.2	9	0	0	0	0	90	10
ENA 10-2	**NR-4-3-U**	**8**	**assessed value**	**0.9**	**38**	**0**	**0**	**0**	**0**	**100**	**0**
ENA 11-1	**NR-0-3-U**	**0**	**assessed value**	**0.7**	**0**	**0**	**0**	**100**	**0**	**0**	**0**
ENA 12-1	NR-0-3-U	0	ENA 11-1 load	0.7	0	0	60	0	0	40	0
			Total Stream Segment	**10.2**	**324**	**4**	**0**	**0**	**1**	**94**	**0**
Unstratified 1st Order		0	no load (1st order)	23.0	0						
Unstratified non-1st Order		11	NR 25th percentile	2.2	128						
			Total Edna Creek Watershed	**35.4**	**452**						

E3.4.2.3 Fortine Creek Sediment Loads

A total of 52 reaches were delineated on the mainstem of Fortine Creek, and 11 monitoring sites were assessed in the field. The one 1st order reach was assigned a sediment load of zero, and the two 2nd order reaches (reach type NR-0-2-U) received the 25th percentile rate of all assessed reaches within the Northern Rockies Ecoregion, since no sites in this reach type were evaluated in the field. The remaining reaches along Fortine Creek were reach type NR-0-3-U or NR-0-4-U, and received the average sediment loading rate for their respective reach type, most of which were derived from field assessments in Fortine Creek. Reach 7-1 was reach type NR-2-3-U, and received the sediment loading rate from adjacent reach 7-2, which was the same reach type.

The total estimated annual sediment load for the Fortine Creek watershed was 7287 tons/year, including 5175 tons/year from the mainstem, and 2112 tons/year from unstratified non-1st order streams. The estimated annual sediment loads for Fortine Creek are provided below in **Table E3-9.** Note that these results to not include all bank erosion loading from all watersheds contributing to Fortine Creek, but instead represent only those loads along Fortine Creek and from associated unstratified non-1st order streams.

Table E3-9. Estimated annual sediment loads for Fortine Creek.

Reach ID	Reach Type	Sediment Loading Rate (tons/yr /1000')	Loading Rate Source	Reach Length (miles)	Total Reach Load (tons /year)	Roads (%)	Grazing (%)	Cropland (%)	Logging (%)	Natural (%)	Other (%)
FTN 1-1	NR-0-1-U	0	no load (1st order)	0.3	0	20	0	0	0	80	0
FTN 2-1	NR-0-2-U	11	NR 25th percentile	0.1	6	0	0	0	0	100	0
FTN 2-2	NR-0-2-U	11	NR 25th percentile	1.2	72	10	0	0	0	90	0
FTN 3-1	NR-0-3-U	25	RT avg (N=5)	0.2	21	20	0	0	0	80	0
FTN 3-2	NR-0-3-U	25	RT avg (N=5)	0.2	30	10	0	0	0	90	0
FTN 3-3	NR-0-3-U	25	RT avg (N=5)	0.1	14	10	0	0	0	90	0
FTN 3-4	NR-0-3-U	25	RT avg (N=5)	0.1	12	40	0	0	0	60	0
FTN 3-5	NR-0-3-U	25	RT avg (N=5)	0.3	33	0	0	0	0	100	0
FTN 4-1	**NR-0-3-U**	**47**	**assessed value**	**0.6**	**154**	**0**	**0**	**0**	**0**	**100**	**0**
FTN 4-2	NR-0-3-U	25	RT avg (N=5)	0.2	32	0	0	0	0	100	0
FTN 4-3	**NR-0-3-U**	**21**	**assessed value**	**0.7**	**75**	**0**	**24**	**0**	**0**	**76**	**0**
FTN 4-4	NR-0-3-U	25	RT avg (N=5)	0.2	21	20	0	0	20	60	0
FTN 5-1	NR-0-3-U	25	RT avg (N=5)	0.3	42	60	0	0	0	20	20
FTN 5-2	NR-0-3-U	25	RT avg (N=5)	0.2	23	80	0	0	0	0	20
FTN 5-3	NR-0-3-U	25	RT avg (N=5)	0.1	17	20	0	0	40	40	0
FTN 5-4	NR-0-3-U	25	RT avg (N=5)	0.2	21	0	0	0	0	100	0
FTN 6-1	**NR-0-3-U**	**43**	**assessed value**	**2.3**	**517**	**0**	**0**	**0**	**0**	**59**	**41**
FTN 7-1	NR-2-3-U	38	FTN 7-2 load	0.4	80	40	0	0	0	60	0
FTN 7-2	**NR-2-3-U**	**38**	**assessed value**	**0.2**	**33**	**0**	**0**	**0**	**0**	**100**	**0**
FTN 8-1	NR-0-3-U	25	RT avg (N=5)	0.2	29	0	0	0	0	100	0
FTN 9-1	NR-0-4-U	33	RT avg (N=7)	0.3	44	0	0	0	0	0	100
FTN 9-2	NR-0-4-U	33	RT avg (N=7)	0.2	35	10	0	0	0	50	40
FTN 9-3	**NR-0-4-U**	**21**	**assessed value**	**0.7**	**74**	**0**	**0**	**0**	**0**	**100**	**0**
FTN 9-4	NR-0-4-U	33	RT avg (N=7)	0.9	159	20	0	0	0	80	0
FTN 9-5	NR-0-4-U	33	RT avg (N=7)	0.3	59	0	0	0	0	90	10
FTN 10-1	NR-0-4-U	33	RT avg (N=7)	2.1	365	20	0	0	0	80	0
FTN 10-2	NR-0-4-U	33	RT avg (N=7)	0.9	153	10	20	40	0	30	0
FTN 11-1	NR-0-4-U	33	RT avg (N=7)	0.3	58	10	0	0	0	90	0
FTN 11-2	NR-0-4-U	33	RT avg (N=7)	0.3	60	0	25	25	0	50	0
FTN 11-3	NR-0-4-U	33	RT avg (N=7)	0.8	143	10	0	0	0	70	20
FTN 12-1	NR-0-4-U	33	RT avg (N=7)	0.1	23	10	0	0	0	90	0
FTN 12-2	**NR-0-4-U**	**35**	**assessed value**	**1.2**	**230**	**0**	**0**	**0**	**38**	**62**	**0**
FTN 12-3	NR-0-4-U	33	RT avg (N=7)	0.6	102	10	0	0	0	80	10
FTN 12-4	NR-0-4-U	33	RT avg (N=7)	1.6	271	10	0	0	0	90	0
FTN 12-5	NR-0-4-U	33	RT avg (N=7)	0.4	67	0	0	40	0	60	0
FTN 12-6	NR-0-4-U	33	RT avg (N=7)	0.5	83	0	0	0	0	100	0
FTN 12-6	NR-0-4-U	33	RT avg (N=7)	0.4	66	10	0	20	0	70	0
FTN 12-7	**NR-0-4-U**	**78**	**assessed value**	**0.7**	**292**	**0**	**98**	**0**	**0**	**2**	**0**
FTN 12-8	NR-0-4-U	33	RT avg (N=7)	0.2	34	0	0	0	0	100	0
FTN 12-9	**NR-0-4-U**	**19**	**assessed value**	**0.7**	**73**	**0**	**4**	**0**	**1**	**94**	**0**
FTN 12-10	NR-0-4-U	33	RT avg (N=7)	1.4	246	0	0	0	0	100	0
FTN 12-11	NR-0-4-U	33	RT avg (N=7)	1.3	222	10	0	30	10	50	0
FTN 12-12	NR-0-4-U	33	RT avg (N=7)	0.6	101	30	0	40	0	30	0
FTN 13-1	**NR-0-4-U**	**58**	**assessed value**	**0.8**	**243**	**0**	**0**	**0**	**0**	**100**	**0**
FTN 13-2	NR-0-4-U	33	RT avg (N=7)	0.2	35	0	0	0	0	100	0
FTN 14-1	NR-0-4-U	33	RT avg (N=7)	0.1	22	10	0	0	0	90	0
FTN 14-2	NR-0-4-U	33	RT avg (N=7)	1.8	313	50	0	0	0	50	0
FTN 14-3	NR-0-4-U	33	RT avg (N=7)	0.7	129	10	0	0	0	70	20
FTN 14-4	NR-0-4-U	33	RT avg (N=7)	0.4	77	10	0	0	0	90	0
FTN 15-1	NR-0-4-U	33	RT avg (N=7)	0.4	70	10	0	0	0	80	10
FTN 15-2	**NR-0-4-U**	**12**	**assessed value**	**1.4**	**88**	**48**	**0**	**0**	**0**	**52**	**0**
FTN 15-3	**NR-0-4-U**	**5**	**assessed value**	**0.3**	**7**	**0**	**26**	**0**	**0**	**74**	**0**
			Total Stream Segment	**30.7**	**5175**	**11**	**7**	**4**	**2**	**68**	**7**
Unstratified 1st Order		0	no load (1st order)	105.9	0						
Unstratified non-1st Order		11	NR 25th percentile	36.7	2112						
Total Fortine Creek				**173.4**	**7287**						

E3.4.2.4 Grave Creek Sediment Loads

Sixteen reaches were stratified on the mainstem of Grave Creek, although no sites were assessed in the field. The upper mainstem reaches of Grave Creek above the confluence of Clarence Creek were assigned the sediment loading rate from the monitoring site on Clarence Creek, which was similar in size and land-use characteristics. Mainstem portions of Grave Creek downstream of Clarence Creek are primarily reach type CR-2-4-U or CR-0-4-U. These reaches were given the average loading rate from reach type NR-0-4-U (33 tons/year/1000'), which is similar in size and power to Grave Creek. All 1st order reaches in the Grave Creek watershed were assigned a sediment load of zero. Non-1st order tributaries to Grave Creek were assigned the 25th percentile loading rate from assessed reaches in the Canadian Rockies Ecoregion (negating site DEP 9-2). The estimated sediment load from the Grave Creek watershed was 2,730 tons/year, including 2,350 tons/year from the mainstem, and 380 tons/year from unstratified non-1st order streams (**Table E3-10**).

Table E3-10. Estimated annual sediment loads for Grave Creek.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
GRV 1-1	CR-2-2-U	14.1	Clarence Creek load	1.3	100	5	0	0	0	95	0
GRV 1-2	CR-2-2-U	14.1	Clarence Creek load	1.3	100	25	0	0	0	75	0
GRV 2-1	CR-2-3-U	14.1	Clarence Creek load	1.3	94	5	0	0	0	95	0
GRV 3-1	CR-2-4-U	32.7	NR-0-4-U RT avg (N=7)	1.6	278	10	0	0	0	90	0
GRV 3-2	CR-2-4-U	32.7	NR-0-4-U RT avg (N=7)	0.2	27	10	0	0	0	90	0
GRV 4-1	CR-4-4-U	32.7	NR-0-4-U RT avg (N=7)	0.5	94	0	0	0	0	100	0
GRV 5-1	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	1.6	278	0	0	0	0	100	0
GRV 6-1	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	0.4	63	0	0	0	0	100	0
GRV 6-2	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	0.7	119	10	0	0	0	90	0
GRV 6-3	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	1.4	237	10	0	0	0	90	0
GRV 7-1	CR-0-4-C	32.7	NR-0-4-U RT avg (N=7)	0.8	132	0	0	0	0	100	0
GRV 8-1	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	0.4	66	30	0	0	0	70	0
GRV 8-2	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	2.4	414	10	10	30	0	50	0
GRV 8-3	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	0.4	63	10	0	0	10	80	0
GRV 8-4	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	0.4	63	10	0	0	0	50	40
GRV 8-5	CR-0-4-U	32.7	NR-0-4-U RT avg (N=7)	1.3	223	10	20	30	0	30	10
			Total Stream Segment	**15.9**	**2350**	**8**	**4**	**8**	**0**	**78**	**2**
Unstratified 1st Order		0.0	no load (1st order)	57.9	0						
Unstratified non-1st Order		5.3	CR 25th percentile	13.6	380						
			Total Grave Creek Watershed	**87.4**	**2730**						

E3.4.2.5 Lime Creek Sediment Loads

Thirteen reaches were delineated on the mainstem of Lime Creek, and one monitoring site was assessed in the field. The three 1st order reaches on Lime Creek were assigned a sediment load of zero. Reaches 5-1 to 9-1 were assigned the sediment loading rate measured at adjacent site LME 6-1, which displayed similar land-use characteristics. The bottom two reaches were of reach type NR-0-3-U and were assigned the reach type average sediment loading rate. The total estimated annual sediment load for the Lime Creek watershed was 530 tons/year, including 383 tons/year from the mainstem, and 146 tons/year from unstratified non-1st order streams. Estimated annual sediment loads for Lime Creek are provided below in **Table E3-11.**

Table E3-11. Estimated annual sediment loads for Lime Creek.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
LME 1-1	NR-10-1-U	0	no load (1st order)	0.1	0	0	0	0	0	100	0
LME 2-1	NR-4-1-U	0	no load (1st order)	0.4	0	10	0	0	0	90	0
LME 3-1	NR-10-1-U	0	no load (1st order)	0.2	0	0	0	0	0	100	0
LME 4-1	NR-4-1-U	0	no load (1st order)	0.3	0	0	0	0	0	100	0
LME 5-1	NR-4-2-U	20	LME 6-1 load	0.2	19	0	0	0	0	100	0
LME 6-1	**NR-4-3-U**	**20**	**assessed value**	**0.6**	**64**	**30**	**0**	**0**	**7**	**62**	**0**
LME 7-1	NR-2-3-U	20	LME 6-1 load	0.1	12	0	0	0	0	100	0
LME 7-2	NR-2-3-U	20	LME 6-1 load	0.1	7	0	0	0	0	100	0
LME 8-1	NR-2-3-U	20	LME 6-1 load	0.6	61	0	30	0	0	70	0
LME 8-2	NR-2-3-U	20	LME 6-1 load	0.4	37	10	0	0	0	80	10
LME 9-1	NR-2-3-U	20	LME 6-1 load	0.1	11	0	0	0	0	100	0
LME 10-1	NR-0-3-U	25	RT avg (N=5)	0.7	95	20	40	0	0	40	0
LME 10-2	NR-0-3-U	25	RT avg (N=5)	0.6	78	10	20	0	0	70	0
			Total Stream Segment	**4.3**	**383**	**13**	**19**	**0**	**1**	**66**	**1**
Unstratified 1st Order		0	no load (1st order)	8.9	0						
Unstratified non-1st Order		11	NR 25th percentile	2.5	146						
			Total Lime Creek Watershed	**15.8**	**530**						

E3.4.2.6 Sinclair Creek Sediment Loads

Fourteen reaches were delineated for the mainstem of Sinclair Creek, and 3 monitoring sites were assessed in the field. The two 1st order streams received a load of zero, and the adjacent steep headwaters reach (3-1) received the 25th percentile loading rate for the Canadian Rockies Ecoregion. Reaches 4-1 to 6-1 were all similar reach type and land use, and received the field-assessed loading rate from reach 5-1. Reaches 7-1 and 8-1 were both forested reaches of type CR-0-2-U, and received the reach type average sediment loading rate. Reaches 8-2 to 10-2 were of similar reach type and land use (rural residential/hobby farm), so they received the field-assessed loading rate from reach 8-2. The total sediment load for the Sinclair Creek watershed was estimated to be 1381 tons/year, all from the mainstem. The watershed has 6.61 miles of unstratified 1st order streams, but no unstratified streams larger than 1st order. The estimated annual sediment loads for Sinclair Creek are provided below in **Table E3-12.**

Table E3-12. Estimated annual sediment loads for Sinclair Creek.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
SNC 1-1	CR-10-1-C	0	no load (1st order)	0.5	0	0	0	0	0	100	0
SNC 2-1	CR-10-1-U	0	no load (1st order)	0.6	0	0	0	0	0	100	0
SNC 3-1	CR-10-2-U	5	CR 25th percentile	1.0	27	0	0	0	0	100	0
SNC 4-1	CR-4-2-U	12	SNC 5-1 load	0.7	41	10	0	0	0	90	0
SNC 5-1	**CR-4-2-U**	**12**	**assessed value**	**0.8**	**47**	**0**	**0**	**0**	**0**	**100**	**0**
SNC 5-2	CR-4-2-U	12	SNC 5-1 load	1.3	80	10	0	0	0	80	10
SNC 6-1	CR-2-2-U	12	SNC 5-1 load	0.7	44	10	20	0	10	60	0
SNC 7-1	CR-0-2-U	31	RT avg (N=4)	0.4	67	10	0	0	0	90	0
SNC 8-1	CR-0-2-U	31	RT avg (N=4)	0.1	14	20	0	0	0	60	20
SNC 8-2	**CR-0-2-U**	**42**	**assessed value**	**1.7**	**378**	**0**	**100**	**0**	**0**	**0**	**0**
SNC 9-1	CR-2-2-U	42	SNC 8-2 load	0.5	105	20	40	0	0	20	20
SNC 10-1	CR-0-2-U	42	SNC 8-2 load	0.9	208	10	70	20	0	0	0
SNC 10-2	CR-0-2-U	42	SNC 8-2 load	0.5	109	20	50	10	0	0	20
SNC 10-3	**CR-0-2-U**	**53**	**assessed value**	**0.9**	**259**	**50**	**0**	**0**	**0**	**20**	**30**
			Total Stream Segment	**10.6**	**1381**	**16**	**46**	**4**	**0**	**25**	**10**
Unstratified 1st Order		0	no load (1st order)	6.6	0						
Unstratified non-1st Order		5	CR 25th percentile	0.0	0						
			Total Sinclair Creek Watershed	**17.2**	**1381**						

E3.4.2.7 Swamp Creek Sediment Loads

Fourteen reaches were delineated on the mainstem of Swamp Creek, and 3 monitoring sites were assessed in the field. The one 1st order reach was assigned a sediment load of zero, and the four 2nd order reaches (SWP 3-1 to 5-1) received the field-assessed sediment loading rate from reach 3-1. Reaches 6-1 and 6-2 received the field-assessed sediment loading rate from adjacent reach 5-1. Reaches 7-1 to 8-2 were all of reach type NR-0-3-U, and received the average reach type loading rate. The furthest downstream reach (SWP 10-1) was reach type NR-4-3-U, and also received its reach type average loading rate. The total estimated annual sediment load for the Swamp Creek watershed was 1408 tons/year, including 1080 tons/year from the mainstem, and 329 tons/year from unstratified non-1st order streams. The estimated annual sediment loads for Swamp Creek are provided below in **Table E3-13.**

Table E3-13. Estimated annual sediment loads for Swamp Creek.

Reach ID	Reach Type	Sediment Loading Rate (tons/yr /1000')	Loading Rate Source	Reach Length (miles)	Total Reach Load (tons /year)	Roads (%)	Grazing (%)	Cropland (%)	Logging (%)	Natural (%)	Other (%)
SWP 1-1	NR-2-1-U	0	no load (1st order)	1.4	0	10	0	0	40	50	0
SWP 2-1	NR-2-2-U	1	SWP 3-1 load	0.1	1	0	0	0	0	100	0
SWP 3-1	**NR-4-2-U**	**1**	**assessed value**	**0.5**	**2**	**0**	**0**	**0**	**9**	**91**	**0**
SWP 4-1	NR-0-2-U	1	SWP 3-1 load	2.4	12	30	0	0	0	70	0
SWP 4-2	NR-0-2-U	1	SWP 3-1 load	0.1	1	0	0	0	0	100	0
SWP 5-1	**NR-0-3-U**	**13**	**assessed value**	**0.9**	**60**	**0**	**0**	**0**	**93**	**7**	**0**
SWP 6-1	NR-2-3-U	13	SWP 5-1 load	0.2	13	0	0	0	50	50	0
SWP 6-2	NR-2-3-U	13	SWP 5-1 load	0.5	38	0	0	0	10	90	0
SWP 7-1	NR-0-3-U	25	RT avg (N=5)	0.1	12	10	0	0	0	80	10
SWP 7-2	NR-0-3-U	25	RT avg (N=5)	0.9	118	20	20	40	0	20	0
SWP 8-1	NR-0-3-U	25	RT avg (N=5)	1.0	131	10	20	50	0	20	0
SWP 8-2	NR-0-3-U	25	RT avg (N=5)	0.6	80	10	0	0	0	90	0
SWP 9-1	**NR-2-3-U**	**52**	**assessed value**	**2.2**	**590**	**0**	**0**	**0**	**0**	**100**	**0**
SWP 10-1	NR-4-3-U	14	RT avg (N=2)	0.3	20	0	0	0	0	80	20
			Total Stream Segment	**11.1**	**1080**	**5**	**5**	**10**	**6**	**74**	**0**
Unstratified 1st Order		0	no load (1st order)	29.7	0						
Unstratified non-1st Order		11	NR 25th percentile	5.7	329						
			Total Swamp Creek Watershed	**46.5**	**1408**						

E3.4.2.8 Theriault Creek Sediment Loads

A total of 31 reaches were delineated for Theriault Creek, and 2 monitoring sites were assessed in the field. The upper 12 reaches were 1st order streams or lake sections and were assigned zero load. Thirteen reaches were reach type CR-0-2-U or CR-2-2-U. These reaches received the average of the 2 reaches assessed on Theriault Creek, since stream conditions observed for Theriault Creek indicated a lower loading rate than the average for streams of type CR-0-2-U. Reaches of type CR-4-2-U or CR-4-2-C received the CR-4-2-U reach type average sediment loading rate. The total sediment load for Theriault Creek was estimated to be 433 tons/year, including 375 tons/year from the mainstem, and 57 tons/year from unstratified non-1st order streams. The estimated annual sediment loads for Theriault Creek are provided below in **Table E3-14.**

Table E3-14. Estimated annual sediment loads for Theriault Creek.

Reach ID	Reach Type	Sediment Loading Rate (tons/yr /1000')	Loading Rate Source	Reach Length (miles)	Total Reach Load (tons /year)	Roads (%)	Grazing (%)	Cropland (%)	Logging (%)	Natural (%)	Other (%)
THR 1-1	CR-10-1-C	0	no load (1st order)	0.5	0	5	0	0	0	95	0
THR 2-1	CR-10-1-U	0	no load (1st order)	0.9	0	5	0	0	0	95	0
THR 3-1	CR-4-1-U	0	no load (1st order)	0.6	0	0	0	0	0	100	0
THR 3-2	CR-4-1-U	0	no load (1st order)	0.2	0	5	0	0	0	95	0
THR 4-1	lake	0	no load (lake segment)	0.2	0	10	0	0	30	60	0
THR 5-1	CR-4-1-U	0	no load (1st order)	0.4	0	5	0	0	0	95	0
THR 5-2	CR-4-1-U	0	no load (1st order)	0.3	0	30	0	0	0	70	0
THR 6-1	CR-10-1-U	0	no load (1st order)	0.1	0	25	0	0	0	75	0
THR 6-2	CR-10-1-U	0	no load (1st order)	0.1	0	0	0	0	0	100	0
THR 7-1	CR-2-1-U	0	no load (1st order)	0.6	0	10	0	0	0	90	0
THR 7-2	CR-2-1-U	0	no load (1st order)	0.2	0	0	0	0	0	100	0
THR 7-3	CR-2-1-U	0	no load (1st order)	0.1	0	0	0	0	0	100	0
THR 8-1	CR-2-2-U	15	avg of THR reaches (N=2)	0.1	4	0	0	0	30	70	0
THR 9-1	CR-0-2-U	15	avg of THR reaches (N=2)	0.1	5	0	0	0	20	80	0
THR 9-2	CR-0-2-U	15	avg of THR reaches (N=2)	0.1	12	20	0	0	0	80	0
THR 9-3	CR-0-2-U	15	avg of THR reaches (N=2)	0.4	32	10	10	30	0	50	0
THR 9-4	CR-0-2-U	15	avg of THR reaches (N=2)	0.2	18	20	0	0	0	80	0
THR 9-5	**CR-0-2-U**	**21**	**assessed value**	**0.2**	**24**	**0**	**0**	**0**	**60**	**40**	**0**
THR 10-1	CR-4-2-U	9	RT avg (N=3)	0.3	14	10	0	0	50	40	0
THR 11-1	CR-4-2-C	9	CR-4-2-U avg (N=3)	0.0	2	0	0	0	0	100	0
THR 11-2	CR-4-2-C	9	CR-4-2-U avg (N=3)	0.1	5	10	0	0	0	90	0
THR 12-1	CR-2-2-C	15	avg of THR reaches (N=2)	0.2	19	10	0	0	0	90	0
THR 13-1	CR-2-2-U	15	avg of THR reaches (N=2)	0.5	38	0	0	0	0	90	10
THR 13-2	CR-2-2-U	15	avg of THR reaches (N=2)	0.2	15	0	0	0	0	100	0
THR 14-1	**CR-0-2-U**	**8**	**assessed value**	**0.3**	**12**	**0**	**7**	**0**	**6**	**62**	**24**
THR 14-2	CR-0-2-U	15	avg of THR reaches (N=2)	0.7	51	10	20	20	0	50	0
THR 14-3	CR-0-2-U	15	avg of THR reaches (N=2)	0.1	11	10	0	0	0	90	0
THR 14-4	CR-0-2-U	15	avg of THR reaches (N=2)	0.2	14	25	0	0	0	75	0
THR 15-1	CR-4-2-C	9	CR-4-2-U avg (N=3)	0.3	13	25	0	0	0	75	0
THR 16-1	CR-0-2-U	15	avg of THR reaches (N=2)	0.1	8	25	0	0	0	75	0
THR 16-2	CR-0-2-U	15	avg of THR reaches (N=2)	1.0	80	10	25	25	0	40	0
			Total Stream Segment	**9.0**	**375**	**10**	**9**	**11**	**6**	**63**	**2**
Unstratified 1st Order		0	no load (1st order)	20.6	0						
Unstratified non-1st Order		5	CR 25th percentile	2.1	57						
			Total Theriault Creek Watershed	**31.7**	**433**						

E3.4.2.9 Tobacco River Sediment Loads

A total of 11 reaches were delineated on the mainstem of the Tobacco River, and 4 monitoring sites were assessed in the field. All reaches on the Tobacco River were reach type NR-0-5-U. All field-assessed were assigned their measured sediment loading rate, while the remaining six reaches received the NR-0-5-U reach type average loading rate, all of which were on the Tobacco River. The total estimated annual sediment load for the Tobacco River watershed was 4,830 tons/year, including 3,949 tons/year from the mainstem, and 880 tons/year from unstratified non-1st order streams. The estimated annual sediment loads for Tobacco River are provided below in **Table E3-15.** Note that these results to not include all bank erosion loading from all watersheds contributing to the Tobacco River, but instead represent only those loads along the Tobacco River and from associated unstratified non-1st order streams.

Table E3-15. Estimated annual sediment loads for Tobacco River.

Reach ID	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load	Roads	Grazing	Cropland	Logging	Natural	Other
		(tons/yr /1000')		(miles)	(tons /year)	(%)	(%)	(%)	(%)	(%)	(%)
TOB 1-1	**NR-0-5-U**	**54**	**assessed value**	**1.3**	**372**	**0**	**1**	**0**	**0**	**99**	**0**
TOB 1-2	NR-0-5-U	54	RT avg (N=4)	1.0	283	15	0	0	0	85	0
TOB 1-3	**NR-0-5-U**	**68**	**assessed value**	**1.2**	**429**	**1**	**1**	**0**	**0**	**98**	**0**
TOB 1-4	NR-0-5-U	54	RT avg (N=4)	3.2	918	10	0	0	0	90	0
TOB 2-1	NR-0-5-U	54	RT avg (N=4)	0.3	78	10	0	0	0	90	0
TOB 2-2	NR-0-5-U	54	RT avg (N=4)	1.0	280	10	25	25	0	40	0
TOB 2-3	**NR-0-5-U**	**9**	**assessed value**	**1.4**	**71**	**46**	**0**	**0**	**0**	**31**	**23**
TOB 2-4	NR-0-5-U	54	RT avg (N=4)	0.4	108	15	0	0	0	85	0
TOB 2-5	NR-0-5-U	54	RT avg (N=4)	0.8	240	10	50	0	0	40	0
TOB 2-6	**NR-0-5-U**	**83**	**assessed value**	**2.1**	**916**	**0**	**0**	**0**	**0**	**26**	**74**
TOB 2-7	NR-0-5-U	54	RT avg (N=4)	0.9	253	10	40	0	0	50	0
			Total Stream Segment	**13.6**	**3949**	**7**	**8**	**2**	**0**	**66**	**17**
Unstratified 1st Order		0	no load (1st order)	33.5	0						
Unstratified non-1st Order		11	NR 25th percentile	15.3	880						
Total Tobacco River				**62.4**	**4830**						

E3.4.3 Sediment Loads from Meadow Creek and Indian Creek

This section presents the approach used to estimate bank erosion for two major streams in the Tobacco River watershed not listed as impaired and not otherwise included in the above analyses: Meadow Creek and Indian Creek. All of Meadow Creek is within the Northern Rockies Ecoregion. The upper portions of the Indian Creek watershed are in the Canadian Rockies Ecoregion; however, the watershed will be considered part of the Northern Rockies Ecoregion for the extrapolation process since the majority falls in the Northern Rockies Ecoregion and the watershed is bracketed by the lower portions of the Tobacco River watershed.

All 1st order streams were assigned a sediment loading rate of zero. Non-1st order streams on Meadow Creek and Indian Creek were assigned the 25th percentile loading rate from all assessed reaches in the Northern Rockies Ecoregion (negating the Tobacco River due to its size). Overall, the estimated annual sediment load from unassessed streams was 1,181 tons/year, including 719 tons/year from the Meadow Creek watershed and 462 tons/year from the Indian Creek watershed. A summary of sediment loads from unassessed streams is provided below in **Table E3-16**.

Table E3-16. Estimated annual sediment loads from unassessed streams.

Watershed	Reach Type	Sediment Loading Rate	Loading Rate Source	Reach Length	Total Reach Load
		(tons/yr /1000')		(miles)	(tons /year)
Meadow Creek	1st order	0	no load (1st order)	22.5	0
	non-1st order	11	NR 25th percentile	12.5	719
	Total Stream Length			**35.0**	**719**
Indian Creek	1st order	0	no load (1st order)	12.3	0
	non-1st order	11	NR 25th percentile	8.0	462
	Total Stream Length			**20.4**	**462**
Total of Unassessed Streams				**55.4**	**1181**

E3.4.4 Watershed Sediment Loads

Streambank sediment loads were calculated for the entire Tobacco River watershed based on estimated loads from each subwatershed, including both stratified and unstratified streams. Overall, 550 miles of streams were evaluated, including 116 miles of stratified mainstem streams, 334 miles of unstratified 1st order streams, and 100 miles of unstratified non-1st order streams. The total estimated annual sediment load due to streambank erosion in the Tobacco River watershed was 20,685 tons/year, including 15,423 tons/year from listed mainstem streams, and 5,261 tons/year from unstratified non-1st order streams. As previously discussed, all 1st order streams were assigned a sediment loading rate of zero since they are not considered a significant source of controllable sediment load. A summary of estimated annual sediment loads are provided below for each sub-watershed and for the entire Tobacco River watershed (**Table E3-17**).

Note that the total load for Fortine Creek watershed is not identified within **Table E3-17**. The total watershed load would include the load from Fortine Creek plus the loads from Deep, Edna, Lime, Swamp, and Meadow Creeks for a total Fortine Creek watershed load of 10,849 tons/year.

Table E3-17. Estimated annual sediment loads for the entire Tobacco River watershed.

Stream	Reach Type	Stream Length	Total Sediment Load	Average Sediment Loading Rate	
		(miles)	(tons /year)	(tons/year/mile)	(tons/year/1000')
Deep Creek	Mainstem	10.6	405	38	7
	Unstratified 1st Order	12.6	0	0	0
	Unstratified Non-1st Order	1.7	48	28	5
	Total Deep Creek Watershed	**24.9**	**453**	**18**	**3**
Edna Creek	Mainstem	10.2	324	32	6
	Unstratified 1st Order	23.0	0	0	0
	Unstratified Non-1st Order	2.2	128	58	11
	Total Edna Creek Watershed	**35.4**	**452**	**13**	**2**
Fortine Creek	Mainstem	30.7	5175	168	32
	Unstratified 1st Order	105.9	0	0	0
	Unstratified Non-1st Order	36.7	2112	58	11
	Total Fortine Creek *	**173.4**	**7287**	**42**	**8**
Lime Creek	Mainstem	4.3	383	88	17
	Unstratified 1st Order	8.9	0	0	0
	Unstratified Non-1st Order	2.5	146	58	11
	Total Lime Creek Watershed	**15.8**	**530**	**33**	**6**
Sinclair Creek	Mainstem	10.6	1381	131	25
	Unstratified 1st Order	6.6	0	0	0
	Unstratified Non-1st Order	0.0	0	NA	NA
	Total Sinclair Creek Watershed	**17.2**	**1381**	**80**	**15**
Swamp Creek	Mainstem	11.1	1080	97	18
	Unstratified 1st Order	29.7	0	0	0
	Unstratified Non-1st Order	5.7	329	58	11
	Total Swamp Creek Watershed	**46.5**	**1408**	**30**	**6**
Theriault Creek	Mainstem	9.0	375	42	8
	Unstratified 1st Order	20.6	0	0	0
	Unstratified Non-1st Order	2.1	57	28	5
	Total Theriault Creek Watershed	**31.7**	**433**	**14**	**3**
Tobacco River	Mainstem	13.6	3949	290	55
	Unstratified 1st Order	33.5	0	0	0
	Unstratified Non-1st Order	15.3	880	58	11
	Total Tobacco River	**62.4**	**4830**	**77**	**15**
Grave Creek	Mainstem	15.9	2350	148	28
	Unstratified 1st Order	57.9	0	0	0
	Unstratified Non-1st Order	13.6	380	28	5
	Total Grave Creek Watershed	**87.4**	**2730**	**31**	**6**
Meadow Creek	Unstratified 1st Order	22.5	0	0	0
	Unstratified Non-1st Order	12.5	719	58	11
	Total Meadow Creek Watershed	**35.0**	**719**	**21**	**4**
Indian Creek	Unstratified 1st Order	12.3	0	0	0
	Unstratified Non-1st Order	8.0	462	58	11
	Total Indian Creek Watershed	**20.4**	**462**	**23**	**4**
Entire Tobacco River Watershed	Total Listed Mainstem Sites	116.1	15423	133	25
	Total Unstratified 1st Order	333.6	0	0	0
	Total Unstratified Non-1st Order	100.3	5261	52	10
	Total Tobacco River Watershed	**550.1**	**20684**	**38**	**7**

E3.5 Streambank Erosion Sediment Load Reductions

The potential to reduce sediment loads from streambanks with identified human impacts was evaluated to simulate the implementation of Best Management Practices (BMPs) and other reasonable land, soil, and water conservation practices. This evaluation was performed by adjusting BEHI values in reaches with identified human sources using methods described in **Section E2.5**. Results are presented in **Table E3-18** for individual monitoring sites.

Overall, the average potential reduction to the human related sediment load was 33% for all monitoring sites. Five monitoring sites with observed sources had low BEHI scores which could not be reduced, resulting in no potential reduction from these sites. The greatest potential reduction was seen in sites SNC 10-3 (87%) and DEP 9-2a (83%), both of which had extreme BEHI ratings in at least one eroding bank.

Table E3-18. Potential sediment load reductions at monitoring sites.

Reach ID	Reach Type	Human Related Sources (%)	Number of Eroding Banks	Number of Adjusted Banks	Original Sediment Loading Rate (tons/year /1000')	Reduced Sediment Loading Rate (tons/year /1000')	Potential Reduction to Human Sediment Load
SNC 10-3	CR-0-2-U	80%	4	1	53	7	87%
SNC 8-2	CR-0-2-U	100%	14	11	42	22	48%
THR 14-1	CR-0-2-U	38%	8	7	8	3	63%
THR 9-5	CR-0-2-U	60%	13	7	21	10	56%
DEP 9-2a	CR-4-3-U	81%	5	4	155	27	83%
ENA 11-1	NR-0-3-U	100%	5	0	0	0	0%
FTN 4-3	NR-0-3-U	24%	8	1	21	20	8%
FTN 6-1	NR-0-3-U	41%	5	3	43	19	57%
SWP 5-1	NR-0-3-U	93%	5	1	13	13	5%
FTN 12-2	NR-0-4-U	38%	9	2	35	30	15%
FTN 12-7	NR-0-4-U	98%	6	5	78	30	61%
FTN 12-9	NR-0-4-U	6%	5	1	19	9	52%
FTN 15-2	NR-0-4-U	48%	6	0	12	12	0%
FTN 15-3	NR-0-4-U	26%	4	0	5	5	0%
TOB 2-3	NR-0-5-U	69%	6	0	9	9	0%
TOB 2-6	NR-0-5-U	74%	8	4	83	44	47%
SWP 3-1	NR-4-2-U	9%	7	0	1	1	0%
LME 6-1	NR-4-3-U	38%	8	5	20	16	18%
Average Potential Reduction for all Human Influenced Sites							**33%**

The average potential reduction from human influenced monitoring sites (33%) was used to calculate sediment load reductions throughout the watershed. This reduction percentage was applied to the existing human load of all reaches identified in the aerial assessment process with >5% human load source. These reduced reach loads were then extrapolated to the stream segment and watershed scales (**Table E3-19)**. It is estimated that the total Tobacco River TPA sediment load can be reduced by approximately 1,700 tons/year through implementation of conservation practices and BMPs.

Not included in **Table E3-19** is the cumulative summary information applicable to the whole Fortine Creek watershed. Of the 10,849 tons/year within the Fortine Creek watershed, 2,243 tons/year were

linked to human loading. Application of a 33% reduction results in a total potential load reduction of 740 tons. This equates to a 10,109 tons/year load after reductions were applied, or a 7% total reduction for the whole Fortine Creek watershed consistent with the results for Fortine Creek only.

Table E3-19. Potential sediment load reductions by stream segment and watershed.

Stream	Reach Type	Reach Length (miles)	Original Reach Load (tons/year)	Original Human-Related Reach Load (tons/year)	Potential Reduction to Human-Related Reach Load (tons/year)	Reach Load w/ Human-Related Sources Reduced (tons/year)	Potential Reduction to Original Load (%)
Deep Creek	Total Stream Segment	10.6	405	174	57	348	14
	Unstratified 1st Order Streams	12.6	0	0	0	0	0
	Unstratified non-1st Order Streams	1.7	48	0	0	48	0
	Total Watershed	**24.9**	**453**	**174**	**57**	**396**	**13**
Edna Creek	Total Stream Segment	10.2	324	19	6	317	2
	Unstratified 1st Order Streams	23.0	0	0	0	0	0
	Unstratified non-1st Order Streams	2.2	128	0	0	128	0
	Total Watershed	**35.4**	**452**	**19**	**6**	**446**	**1**
Fortine Creek	Total Stream Segment	30.7	5175	1635	540	4636	10
	Unstratified 1st Order Streams	105.9	0	0	0	0	0
	Unstratified non-1st Order Streams	36.7	2112	0	0	2112	0
	Total Fortine Creek	**173.4**	**7287**	**1635**	**540**	**6748**	**7**
Lime Creek	Total Stream Segment	4.3	383	130	43	340	11
	Unstratified 1st Order Streams	8.9	0	0	0	0	0
	Unstratified non-1st Order Streams	2.5	146	0	0	146	0
	Total Watershed	**15.8**	**530**	**130**	**43**	**487**	**8**
Sinclair Creek	Total Stream Segment	10.6	1381	1037	342	1039	25
	Unstratified 1st Order Streams	6.6	0	0	0	0	0
	Unstratified non-1st Order Streams	0.0	0	0	0	0	0
	Total Watershed	**17.2**	**1381**	**1037**	**342**	**1039**	**25**
Swamp Creek	Total Stream Segment	11.1	1080	285	94	986	9
	Unstratified 1st Order Streams	29.7	0	0	0	0	0
	Unstratified non-1st Order Streams	5.7	329	0	0	329	0
	Total Watershed	**46.5**	**1408**	**285**	**94**	**1314**	**7**
Theriault Creek	Total Stream Segment	9.0	375	141	46	329	12
	Unstratified 1st Order Streams	20.6	0	0	0	0	0
	Unstratified non-1st Order Streams	2.1	57	0	0	57	0
	Total Watershed	**31.7**	**433**	**141**	**46**	**386**	**11**
Tobacco River	Total Stream Segment	13.6	3949	1334	435	3514	11
	Unstratified 1st Order Streams	33.5	0	0	0	0	0
	Unstratified non-1st Order Streams	15.3	880	0	0	880	0
	Total Tobacco River	**62.4**	**4830**	**1334**	**435**	**4394**	**9**
Grave Creek	Total Stream Segment	15.9	2350	528	174	2176	7
	Unstratified 1st Order Streams	57.9	0	0	0	0	0
	Unstratified non-1st Order Streams	13.6	380	0	0	380	0
	Total Watershed	**87.4**	**2730**	**528**	**174**	**2555**	**6**
Meadow Creek	Unstratified 1st Order Streams	22.5	0	**0**	**0**	0	0
	Unstratified non-1st Order Streams	12.5	719	0	0	719	0
	Total Watershed	**35.0**	**719**	**0**	**0**	**719**	**0**
Indian Creek	Unstratified 1st Order Streams	12.3	0	**0**	**0**	0	0
	Unstratified non-1st Order Streams	8.0	462	0	0	462	0
	Total Watershed	**20.4**	**462**	**0**	**0**	**462**	**0**
Entire Tobacco River Watershed	Total Stream Segment	116.1	15423	5282	1738	13685	11
	Unstratified 1st Order Streams	333.6	0	0	0	0	0
	Unstratified non-1st Order Streams	100.3	5261	0	0	5261	0
	Total Watershed	**550.1**	**20684**	**5282**	**1738**	**18946**	**8**

E4.0 Discussion And Conclusions

The streambank erosion source assessment included a combination of GIS analysis, aerial photograph assessment, field data collection, and detailed extrapolation procedures. Results of the assessment identify roads, riparian grazing, railroad encroachment, and urban influences as the primary sources of sediment loading in the Tobacco River TPA, with logging and crop production identified as minor sources. However, it should be noted that significant historic logging activities took place in the watershed that have likely impacted streambank erosion processes. Due to the historic nature of these activities, residual impacts may not have been difficult to identify through this assessment process.

It is estimated that 15,423 tons/year of sediment are delivered at the stream segment scale, which includes the stratified reaches of all listed streams within the Tobacco River TPA, in addition to Sinclair Creek. Approximately 5,282 tons/year (34%) of this sediment load is attributed to human sources. An additional 5,261 tons/year is delivered from unstratified and/or unassessed portions of the watershed, including 719 tons/year from Meadow Creek and 462 tons/year from Indian Creek.

For the entire Tobacco River TPA, it is estimated that 20,684 tons/year of sediment are delivered to the stream network from bank erosion. Through the implementation of all reasonable land, soil, and water conservation practices on sites with observed non-natural sources, it is estimated that the total human related sediment load be reduced by 1,738 tons/year (33%), which represents an 8% reduction in streambank sediment erosion for the entire watershed.

E5.0 Comparison Between Grave Creek Bank Erosion Studies

Bank erosion was previously estimated for the 2005 Grave Creek sediment TMDL (Montana Department of Environmental Quality, et al., 2005) using a similar BEHI method applied to data collected during the 2003 summer field season. The results within the 2005 document show that most of the bank erosion in the Grave Creek watershed was along the lower mainstem portion of Grave Creek. **Table E3-10** of this appendix also shows a similar conclusion when looking at the 0-2% valley slope reaches where the lower Grave Creek mainstem is located. The lower Grave Creek mainstem results from both analyses, along with human impact and potential load reduction information, are presented in **Table E5-1**.

Table E5-1. Lower Grave Creek Mainstem Bank Erosion Loading Analyses

Measure	2005 Grave Creek TMDL Bank Erosion Analysis (using 2003 field data)	Tobacco Watershed TMDL Bank Erosion Analysis (using 2008 field data)
Bank Erosion Load	9,433 tons/yr	1,658 tons/yr (**Table E3-10** reaches with 0-2% valley slope)
Human Caused Percentage	99%	22% (**Table E3-10**)
Potential Load Reduction	63%	7% (**Table E3-19**)
Load after Reduction	3,475 tons/yr (based on 63% reduction from 9,433 tons/yr)	1,541 tons/yr (based on 7% reduction from 1,658 tons/year)

The **Table E5-1** results vary for several reasons:

- Lower Grave Creek mainstem has a history of instability linked to historical channelization and associated high levels of bank erosion. Field crews evaluated a significant portion of lower Grave Creek in 2003 and documented many highly erodible banks with an equivalent of high, very high

and extreme BEHI ratings. These erodible banks were primarily linked to human activity because of the human caused channelization. The more recent results from 2008 are based on an aerial assessment which probably did not capture human impacts from channelization as well as a field assessment.

- Significant restoration work was completed for about 8000 feet of the lower Grave Creek mainstem since the 2003 BEHI field work. Bank erosion rates have significantly decreased along many of the reaches where highly erodible banks were documented in 2003 (River Design Group, 2011). The more recent assessment likely captures some of this reduced bank erosion.
- The 63% reduction potential value for the 2003 Grave Creek work was based on bank erosion from a reference reach within Grave Creek and an estimate of achievable loading reduction. The extrapolation approach within this appendix resulted in a much lower percent reduction (7%) because of the lower estimate of human caused bank erosion in lower Grave Creek mainstem combined with a lower bank erosion reduction potential applied throughout the Tobacco watershed.

The resulting bank erosion values for lower Grave Creek mainstem, after applying reductions, are 3,475 tons/year based on the 2003 analysis, and 1,541 tons/year based on the 2008 analyses. These values compare favorably given the level of uncertainty associated with determining total loading, percent human influence, and reduction potential. The 3,475 tons/year value reported in the 2005 Grave Creek TMDL document is perhaps the more accurate achievable sediment loading values since it is based more on field data collection versus aerial assessment and extrapolation.

For the recent 2008 analysis, the resulting bank erosion load estimate in the upper portions of Grave Creek watershed is 1,072 tons/year. For the upper portions of the Grave Creek watershed, the 2005 sediment load estimate was 2,299 tons/year based on a combination of sediment loading from bank erosion and mass wasting along stream channels. The mass wasting was included in the Grave Creek sediment assessment because of the susceptibility of mass wasting within the Grave Creek watershed, and it was combined with bank erosion since it was difficult to separate mass wasting from bank erosion when it occurred along stream channels. The resulting load values after applying reductions are 1,526 tons/year from the 2005 analysis versus 997 tons/year based on the more recent 2008 information. Since the 1,526 tons/year also includes mass wasting, it may reflect a more accurate total achievable load, but cannot be compared directly to the 997 tons/year value since the 997 tons/year is based more on extrapolated bank erosion values and associated aerial assessment of human impact.

E6.0 REFERENCES

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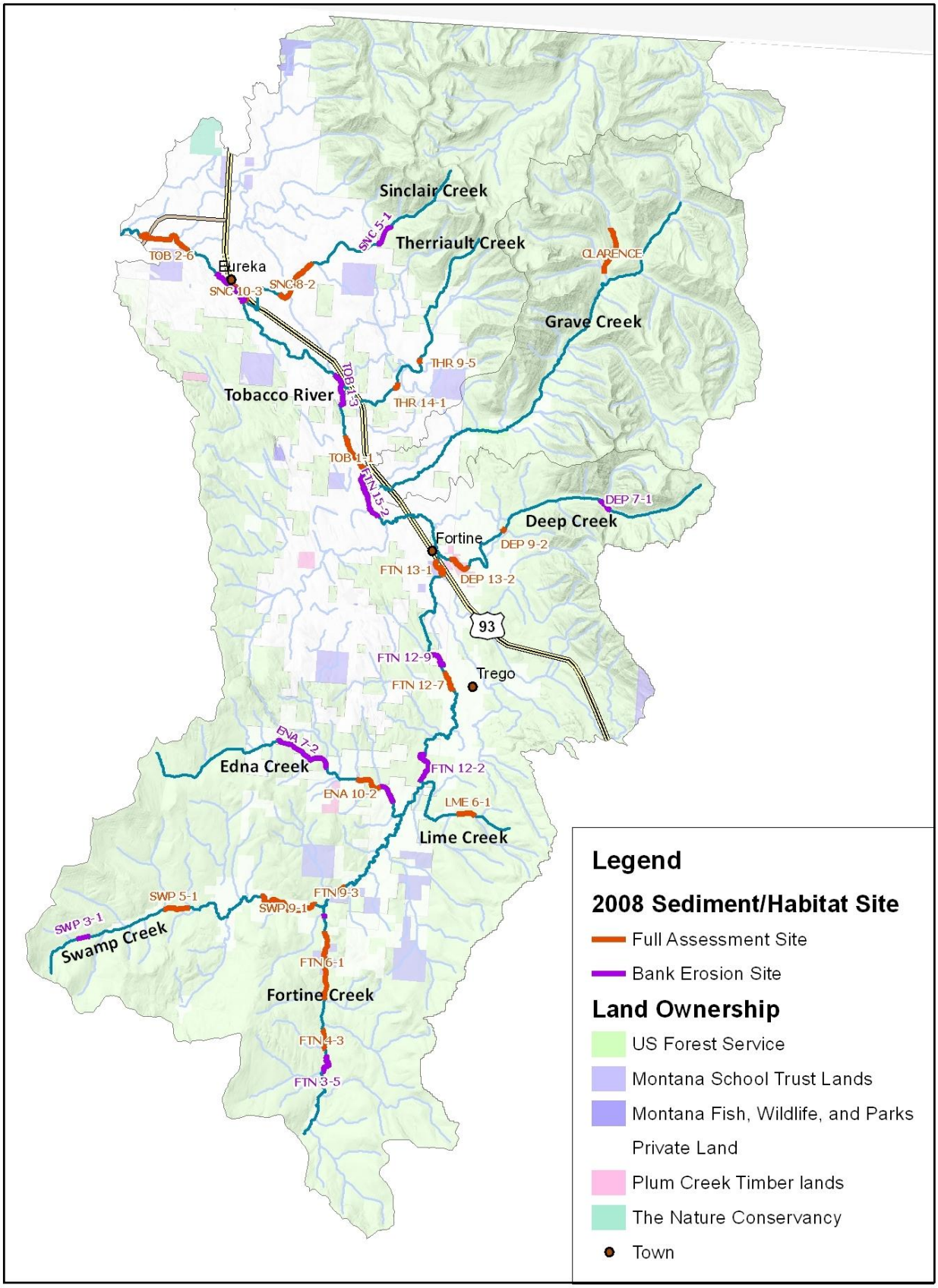
ATTACHMENT A – MONITORING SITE LOCATION MAP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Therriault Creek
Grave Creek
Tobacco River
Deep Creek
Edna Creek
Lime Creek
Swamp Creek
Fortine Creek
Eureka
Fortine
Trego
93
SNC 5-1
TOB 2-6
SNC 8-2
SNC 10-3
CLARENCE
THR 9-5
THR 14-1
TOB 4-3
TOB 4-1
FTN 15-2
DEP 7-1
DEP 9-2
FTN 13-1
DEP 13-2
FTN 12-9
FTN 12-7
ENA 7-2
FTN 12-2
ENA 10-2
LME 6-1
SWP 5-1
SWP 9-1
FTN 9-3
SWP 3-1
FTN 6-1
FTN 4-3
FTN 3-5
Legend
2008 Sediment/Habitat Site
Full Assessment Site
Bank Erosion Site
Land Ownership
US Forest Service
Montana School Trust Lands
Montana Fish, Wildlife, and Parks
Private Land
Plum Creek Timber lands
The Nature Conservancy
Town

APPENDIX F - TOBACCO RIVER WATERSHED UPLAND SEDIMENT SOURCE ASSESSMENT

This upland sediment modeling appendix is derived from the Tobacco River Watershed Upland Sediment Modeling Final Report (Confluence Incorporated, 2009) prepared by Confluence Consulting for the Kootenai River Network and the Montana Department of Environmental Quality

F1.0 SEDIMENT CONTRIBUTION FROM HILLSLOPE EROSION

F1.1 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 and a riparian health assessment sediment delivery reduction. This model provided an assessment of existing sediment loading from upland sources and an assessment of potential sediment loading through the application of Best Management Practices (BMPs). For this evaluation the primary BMP evaluated includes the modification in upland management practices and the secondary BMP evaluated includes the modification in riparian health 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 assessment methodology did not differentiate between sediment loads with all reasonable BMPs and "natural" loads.

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 Tobacco River 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, et al., 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, et al., 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 Tobacco River 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.

F1.2 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 based sediment delivery ratio (SDR) and a riparian health assessment 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, and (3) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of upland management BMPs. 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.

F1.3 MODELING SCENARIOS

Three management scenarios were evaluated for the Tobacco River watershed. They include: (1) an existing condition scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) an improved grazing and cover management scenario with existing riparian health; and (3) an improved grazing and cover management scenario with improved riparian health management.

Erosion was differentiated into two source categories for each scenario: (1) natural erosion that occurs on the time scale of geologic processes and (2) human caused erosion that is accelerated by human-caused activity. A similar classification is presented as part of the National Engineering Handbook Chapter 3 – Sedimentation (United States Department of Agriculture, 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 Tobacco River watershed were 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. MT DEQ completed a riparian health assessment in the Tobacco River watershed, encompassing the Tobacco River mainstem and its primary tributary streams. This information is used 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.

F1.4 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 with 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 Tobacco River watershed.

The **P-factor** was set to one, as per previous communication with NRCS State Agronomist who suggested that this value is the most appropriate representation of current management practices in the Tobacco River 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 Dube, Megahan & McCalmon in their development of the WARSEM road sediment model for the State of Washington.

The **riparian health factor** was derived from a riparian health assessment completed by MT DEQ in the Tobacco River watershed, encompassing the Tobacco River mainstem and its primary tributary streams. Ratings of poor, fair, and good were assigned by the riparian health assessment to the left and right bank of multiple reaches on each surveyed stream.

F2.0 Modeling Methods

A grid was created for each data source, giving 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. The estimated sediment delivered to the stream network was further reduced by using a riparian health factor. Additional details about each model factor are provided in the sections that follow.

F2.1 Tobacco DEM

The digital elevation model (DEM) for the Tobacco River watershed (**Figure F2-1**) is the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area (the Tobacco River watershed and Grave Creek watershed), 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 Tobacco River 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 Tobacco River 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.

F2.2 R-Factor

The rainfall and runoff factor (i.e. R-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 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 Tobacco River watershed, to match the project's standard grid definition (**Figure F2-1**).

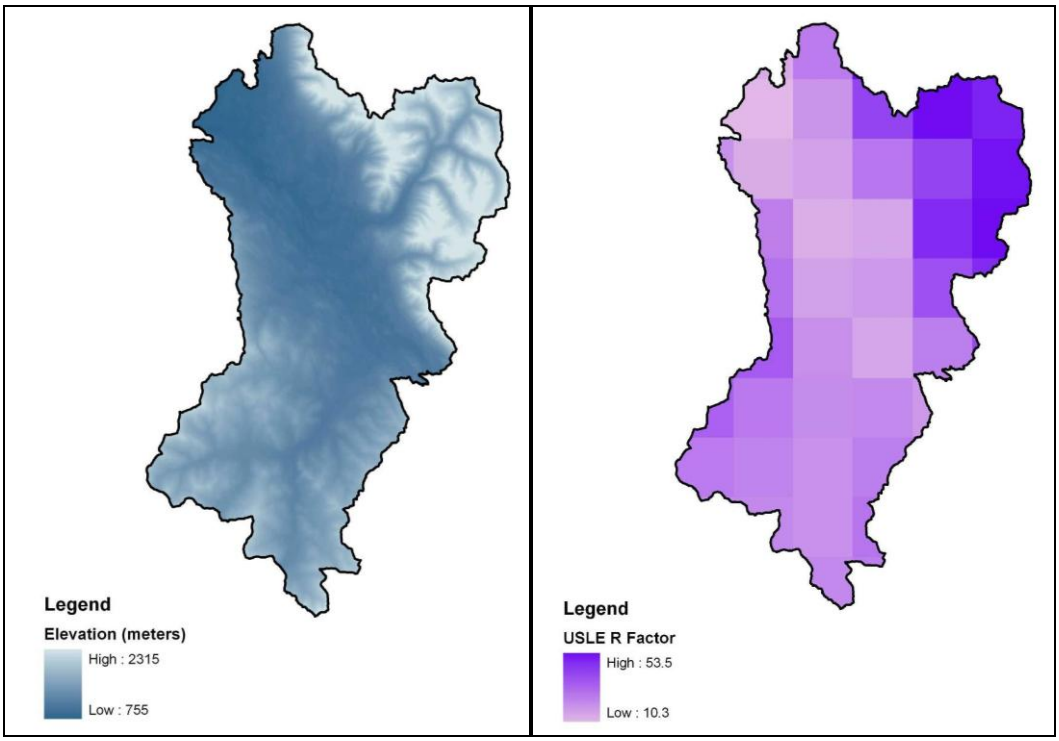


Figure F2-1 Digital Elevation Model (DEM) and R-factor of the Tobacco River Watershed

F2.3 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 units, and the polygon coverage was converted to a 10m analytic grid for use in this analysis (**Figure F2-2**). SSURGO data were considered for use, due to the higher resolution and age of the SSURGO datasets but were not used because they did not contain the required K-factor.

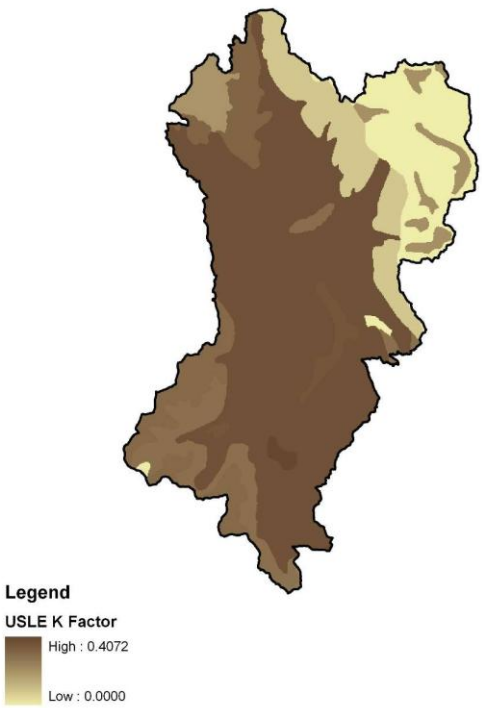


Figure F2-2 ULSE K-factor for the Tobacco River Watershed

F2.4 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 Tobacco River 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 Tobacco River 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.

F2.5 NLCD

The 2001 National Land Cover Dataset (NLCD) was obtained from USGS for use in establishing USLE C-factors for the Tobacco watershed. The 2001 NLCD is a categorized 30 meter Landsat Thematic Mapper image shot in 2001 (**Figure F2-3**). 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 Tobacco watershed are described in **Table F2-1**.

Table F2-1. NLCD Land Cover Classification Codes for Areas Present in the Tobacco Watershed

Code	Description
11	Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.
21	Developed, Open Space - Includes areas with a mixture of constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.
23	Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.
24	Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100 percent of the total cover.
31	Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.
41	Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
42	Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
52	Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

Table F2-1. NLCD Land Cover Classification Codes for Areas Present in the Tobacco Watershed

Code	Description
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.

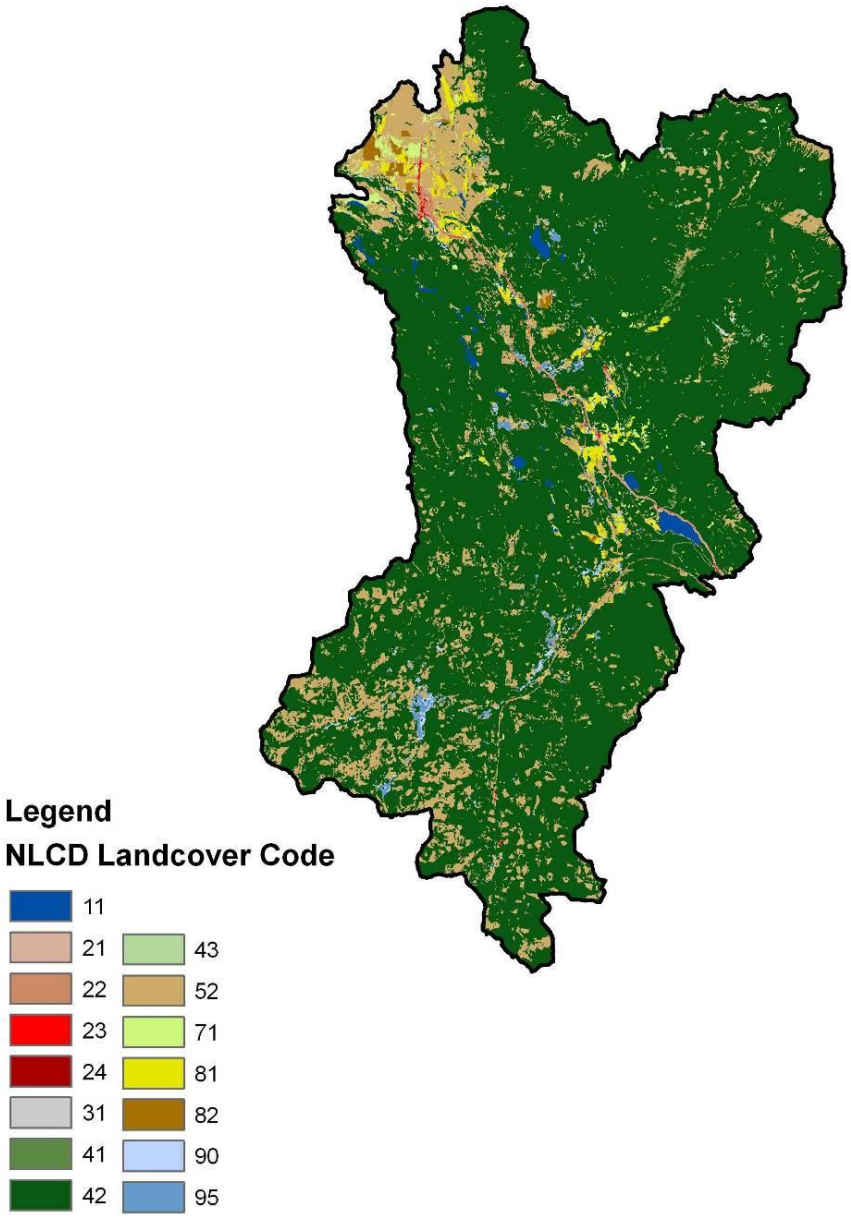


Figure F2-3 NLCD Landcover for the Tobacco River Watershed

F2.6 Logging 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 Tobacco River watershed, and the relative stability of that land use over the 7 years since the Landsat image was taken that the NLCD is based on, this was considered to be a reasonable assumption. However, The NLCD was modified (**Figure F2-4**) to incorporate logging that has occurred since 2001 and to identify 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.

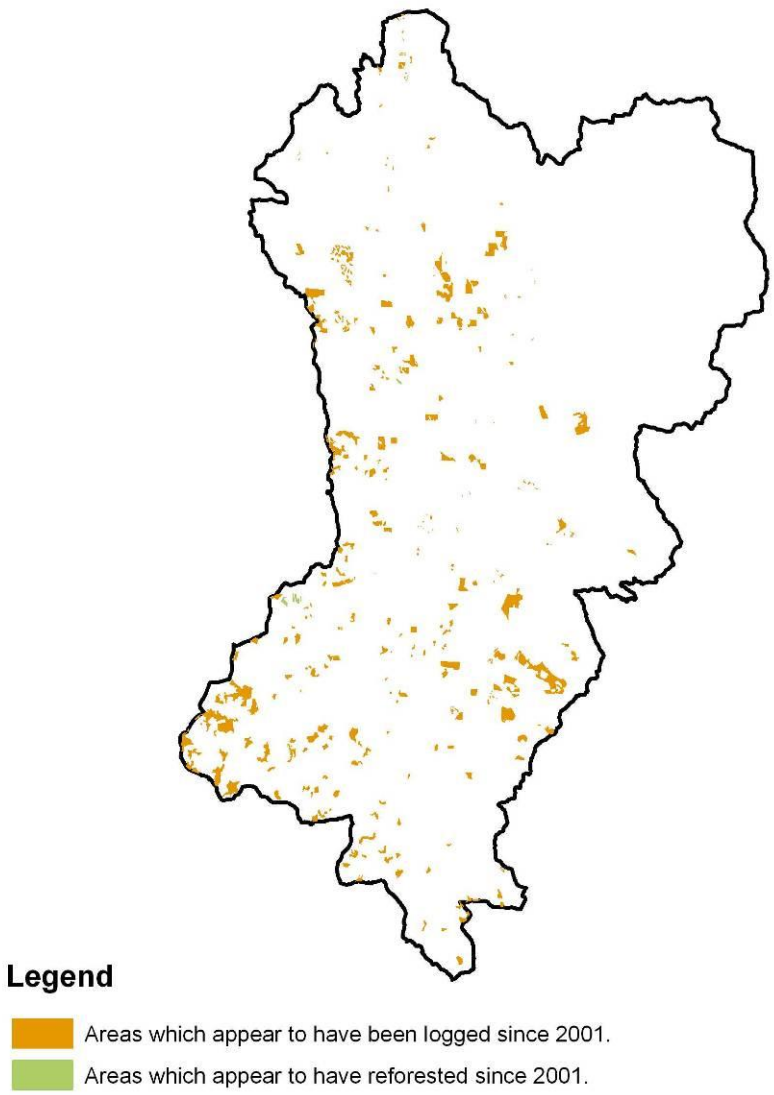


Figure F2-4 Logging areas for the Tobacco River Watershed

Adjustment for logging was accomplished by using harvest record polygons provided by the U.S. Forest Service. Polygons with a harvest date of 2001 or later were selected. Additionally, adjustment for logging on non-USFS property was accomplished by comparing the 2001 NLCD grid for the Tobacco River 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, there were indications of logging activity (proximity to forest or logging roads, appearance of stands, etc), and they were on non-USFS land.

Adjustment for reforestation was also accomplished by comparing the 2001 NLCD grid for the Tobacco River 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). For the purposes of sediment generation estimation, both Type 1

(logging) and Type 2 (reforesting) adjustment areas were treated as 'transitional' and classified with the corresponding C-factor. A C-factor slightly higher than a deciduous/evergreen forest was used for logged areas (i.e. transitional) because logging intensity within the watershed is generally low and because practices, such as riparian clear-cutting, that tend to produce high sediment yields have not been used since at least 1991, when the MT Streamside Management Zone (SMZ) law was enacted. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines (Elliot and Robichaud, 2001; Elliot, 2006; Rice, et al., 1972). The logging C-factor is the same for both management scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities.

F2.7 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 Tobacco River watershed.

Per **Table F2-2** a C-factor slightly higher than a deciduous/evergreen forest was used for logged areas (i.e. transitional) because logging intensity within the watershed is generally low and because practices, such as riparian clear-cutting, that tend to produce high sediment yields have not been used since at least 1991, when the MT Streamside Management Zone (SMZ) law was enacted. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines. The logging C-factor is the same for both management scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities. The other land use categories were reclassified based on the NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland", which 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 **Appendix F, Attachment A**.

To estimate the potential reduction in sediment production that might be accomplished under a best management practices scenario, 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 Tobacco River 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. These changes result in a C-factor matrix for BMP conditions shown in **Table F2-3**.

Table F2-2. C-factors in the Tobacco River watershed.

NLCD Code	Description	C-Factor Existing Condition	C-Factor Improved Management Condition
21	Developed, Open Space	0.003	0.003
22	Developed, Low Intensity	0.001	0.001
42	Evergreen Forest	0.003	0.003
52	Shrub/Scrub	0.008	0.008
71	Grasslands/Herbaceous	0.020	0.013
81	Pasture/Hay	0.020	0.013
82	Cultivated Crops	0.240	0.150
90	Woody Wetlands	0.013	0.013
95	Emergent Herbaceous Wetlands	0.003	0.003
N/A	Transitional	0.006	0.006
Other	Represents < 1% of watershed area: includes barren land, medium and high intensity development, and deciduous and mixed forest.	Varies	Varies

Table F2-3. 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

F2.8 Sediment Delivery Ratio Factor

A sediment delivery ratio factor 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 Dube, Megahan & McCalmon (2004) in their development of the WARSEM road sediment model for the State of Washington. This relationship was developed by integrating the results of several previous studies (principally those of Megehan and Ketchison) which examined sediment delivery to streams downslope of forest roads. They found that the proportion of sediment production that is ultimately delivered to streams declines with distance from the stream as shown in **Table F2-4**.

Table F2-4. Sediment Delivery vs. Distance

Distance fromCulvert (ft)	Percent of Total Eroded Sediment Delivered
0	100
35	70
70	50
105	35
140	25
175	18
210	10
245	4
280	3
315	2
350	1

We believe the use of this relationship to develop a sediment delivery ratio for a USLE based model is a conservative (i.e. tending toward the high end of the range of reasonable values) estimate of sediment delivery from hillslope erosion, especially in light of the fact that the USLE methodology does not account for gully erosion.

This factor was applied to the results of the USLE model to estimate sediment delivered from hillslope sources, by calculating the flow distance from each cell to the nearest stream channel, and multiplying the sediment production of that cell by the corresponding distance based percentage of delivery.

F2.9 Riparian Health Assessment Based Sediment Delivery Ratio Factor

Well vegetated riparian buffers have been shown to act as filters that help to 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.

DEQ completed a riparian health assessment in the Tobacco River watershed, encompassing the Tobacco River mainstem and its primary tributary streams. Ratings of poor, fair, and good were assigned by the riparian health assessment to the left and right bank of multiple reaches on each surveyed stream. The results of this assessment are shown in **Figure 2-5**. This information can be used to estimate further reduction in the quantity of eroded sediment that is ultimately delivered to the streams.

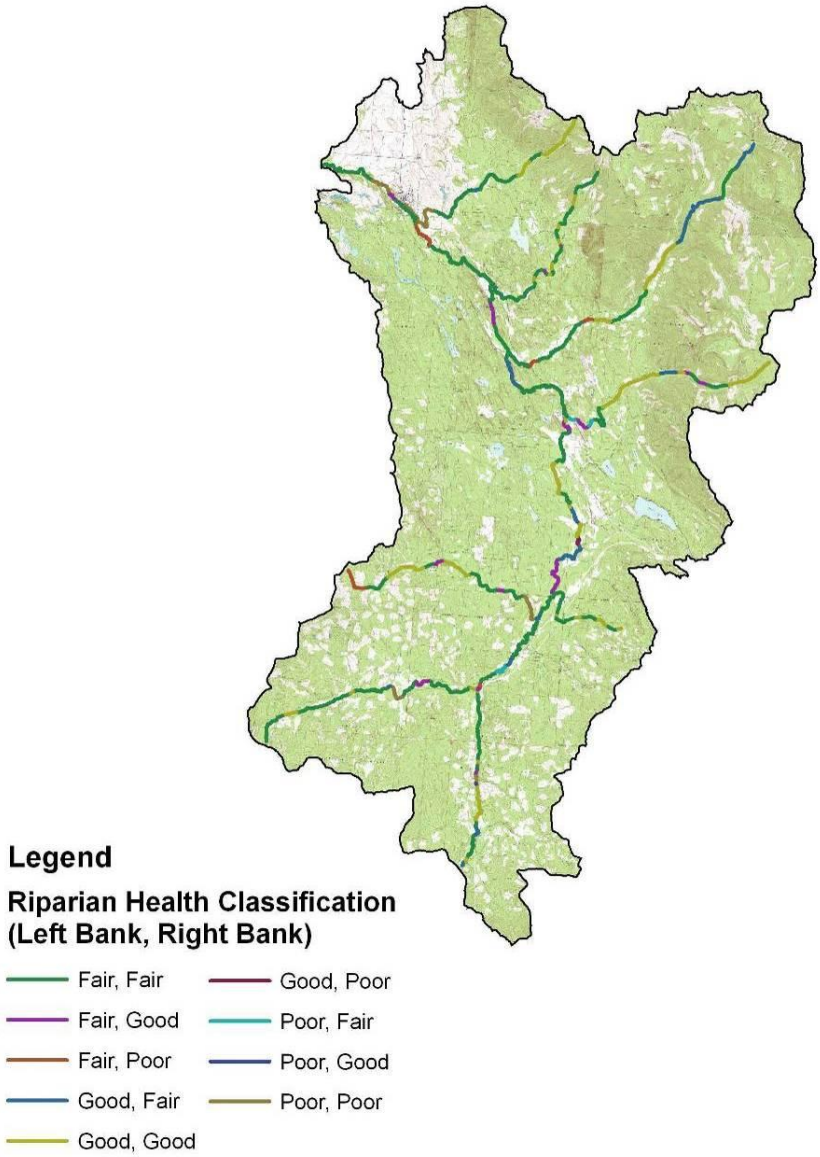
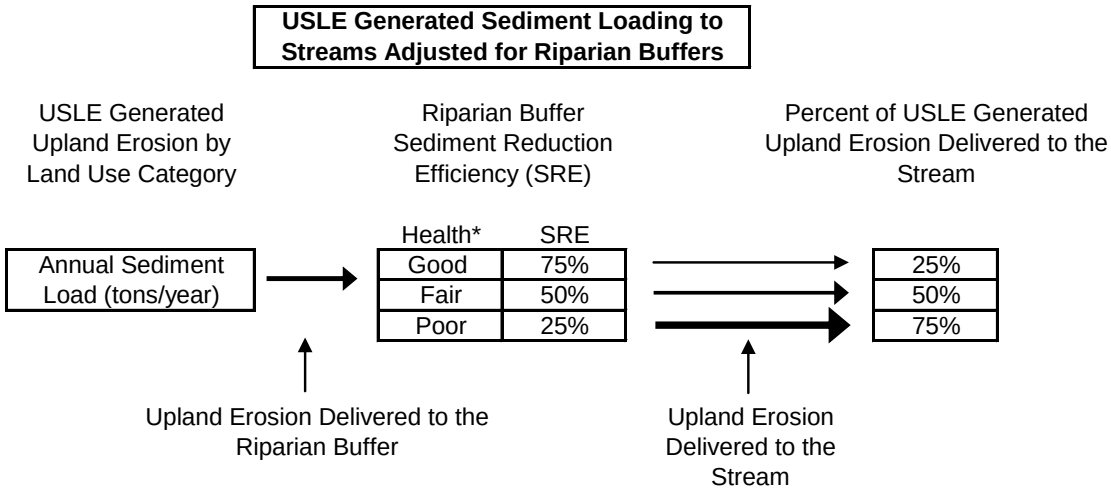


Figure F2-5. Riparian Health Assessment for the Tobacco River and its Primary Tributaries

For this analysis, a sediment reduction efficiency of 75% was assumed to represent the loading condition for a healthy (good) vegetated riparian buffer. With 75% removal, 25% of the USLE generated upland hillslope load is delivered to the stream. As the condition of the riparian buffer declines or is degraded, sediment reduction efficiencies of 50% and 25% are assumed to represent the loading condition for moderately (fair) and heavily (poor) disturbed conditions. That is, as the overall health of the vegetated riparian buffer is degraded, hence reducing its buffering capacity, sediment loading delivered to the stream from upland sources increases (**Figure F2-6**).



*Average health condition of the vegetated riparian buffer

Figure F2-6. USLE Upland Sediment Load Adjusted for Riparian Buffer Capacity

Using these data we computed a length-weighted riparian health score based SDR for each surveyed sub-basin. This was accomplished by tallying the percent of the total bank length of each stream that was rated in each of the three riparian health classes, multiplying by the assumed sediment delivery efficiency reduction for each class (75% for a good buffer condition, 50% for a fair buffer condition, and 25% for a poor buffer condition) and summing for each stream. An example of how this calculation was performed is shown in **Table F2-5**. The riparian health assessment based SDR computed for each surveyed sub-basin for the existing conditions scenario is visually presented via **Figure F2-7**, and all results are presented in **Table F2-6.**

Table F2-5. Example of Calculation of Riparian Health SDR Factor for Upper Fortine Creek

Existing Buffer Condition	Stream Length (mi)	Percent of Total Length	Weighted Sediment Reduction Percentage Existing Conditions
Good	5.6	5.6 / 15.9 = 0.35	0.35 * 0.75 = 0.27
Fair	9.5	9.5 / 15.9 = 0.60	0.60 * 0.50 = 0.30
Poor	0.8	0.8 / 15.9 = 0.05	0.05 * 0.25 = 0.01
Total	5.6 + 9.5 + 0.8 = 15.9	0.35 + 0.60 + 0.05 = 1	0.27 + 0.30 + 0.01 = 0.58

Therefore the sediment delivered to the stream is 1 – 0.58 = 0.42 or 42% of the total calculated sediment load.

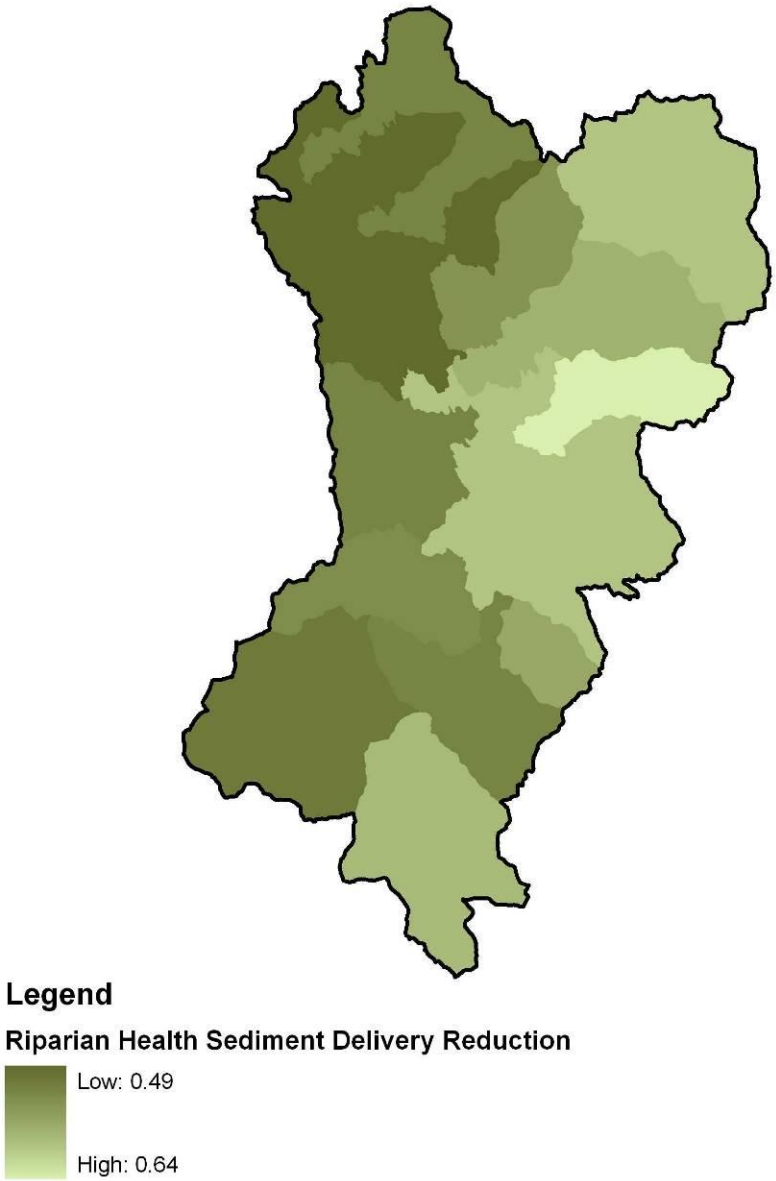


Figure F2-7. Riparian Health Sediment Delivery Reduction for the Tobacco River Watershed

Table F2-6. Sediment reduction percentage based on riparian health assessment.

Sub-basin	Existing Buffer Condition	Stream Length (mi)	Percent of Total Length	Weighted Sediment Reduction Percentage Existing Conditions	Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage
Upper Fortine Creek	Good	5.6	35	27		
	Fair	9.5	60	30		
	Poor	0.8	5	1		
	Total	15.9	100	**58**	**69**	**11**

Table F2-6. Sediment reduction percentage based on riparian health assessment.

Sub-basin	Existing Buffer Condition	Stream Length (mi)	Percent of Total Length	Weighted Sediment Reduction Percentage Existing Conditions	Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage
Swamp Creek – Lake Creek	Good	2.7	12	9		
	Fair	17.8	80	40		
	Poor	1.8	8	2		
	Total	22.2	100	**51**	**69**	**18**
Middle Fortine Creek	Good	2.2	13	10		
	Fair	13.2	80	40		
	Poor	1.1	7	2		
	Total	16.5	100	**52**	**69**	**17**
Edna Creek	Good	6.4	31	23		
	Fair	10.1	49	25		
	Poor	4.0	19	5		
	Total	20.5	100	**53**	**69**	**17**
Lower Fortine Creek	Good	10.8	37	28		
	Fair	17.8	61	31		
	Poor	0.4	1	0		
	Total	29.0	100	**59**	**69**	**10**
Deep Creek	Good	12.4	58	44		
	Fair	8.2	39	19		
	Poor	0.7	3	1		
	Total	21.3	100	**64**	**69**	**5**
Upper Grave Creek	Good	4.2	38	28		
	Fair	6.9	62	31		
	Poor	0.0	0	0		
	Total	11.1	100	**59**	**69**	**10**
Lower Grave Creek	Good	6.7	33	24		
	Fair	13.1	64	32		
	Poor	0.7	4	1		
	Total	20.6	100	**57**	**69**	**12**
Therriault Creek	Good	3.1	17	13		
	Fair	15.0	83	41		
	Poor	0.0	0	0		
	Total	18.1	100	**54**	**69**	**15**
Tobacco River	Good	1.4	5	4		
	Fair	22.9	84	42		
	Poor	2.9	11	3		
	Total	27.2	100	**49**	**69**	**20**
Sinclair Creek	Good	6.1	29	22		
	Fair	10.3	49	24		
	Poor	4.7	22	6		
	Total	21.1	100	**52**	**69**	**17**
Lime Creek	Good	2.1	24	18		
	Fair	6.6	76	38		
	Poor	0.0	0	0		
	Total	8.7	100	**56**	**69**	**13**

Additionally, a BMP condition of the riparian buffer was estimated. Under this condition, it is assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer increases the watershed scale riparian health condition from its existing condition to 75% of the total stream length with a 'good' riparian health condition and 25% of the total stream length with a 'fair' condition. The concept is that through the application of BMPs, the general health of the vegetated riparian buffer will increase, hence increasing its sediment reduction efficiency. The BMP riparian health assessment based SDR computed for each sub-basin is also presented in **Table F2-6** along with the difference from the existing to the improved condition.

The riparian health assessment was not completed for the Meadow Creek and Indian Creek sub-watersheds. The Indian Creek sub-watershed was assumed to be similar to the Sinclair Creek sub-watershed and assigned a sediment delivery reduction of 52%. The Meadow Creek sub-watershed was assumed to be similar to the Middle Fortine Creek sub-watershed and therefore a sediment reduction of 52% was used.

F2.10 Sub-basins

The Tobacco River watershed boundary and the sub-basin boundaries were defined using the USGS 6th code Hydrologic Unit Codes (HUC) (**Figure F2-8**). Lime Creek is the only 303(d) listed stream that was not represented in the 6th code HUCs. The Lime Creek sub-basin was cut from the Middle Fortine Creek sub-basin using USGS topography as a guide to drainage divides.

Figure F2-8. Sub-basin polygons for the Tobacco River Watershed

F3.0 RESULTS

Figures F3-1, F3-2 and F3-3 present the USLE based hillslope model's prediction of existing and potential conditions graphically. **Table F3-1** presents 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.

Table F3-2 presents the delivered sediment load totals for the sub-basins and the cumulative totals within the watershed. In **Table F3-1**, the cumulative results for a sub-basin are a sum of the results for that sub-basin plus the sub-basins upstream of it. For example, Middle Fortine Creek is a sum of the results for that sub-basin plus the results for Edna Creek, Lime Creek, Upper Fortine Creek, and

SwampCreek/Lake Creek. The results for Tobacco River represent the total sediment load delivered from the entire watershed.

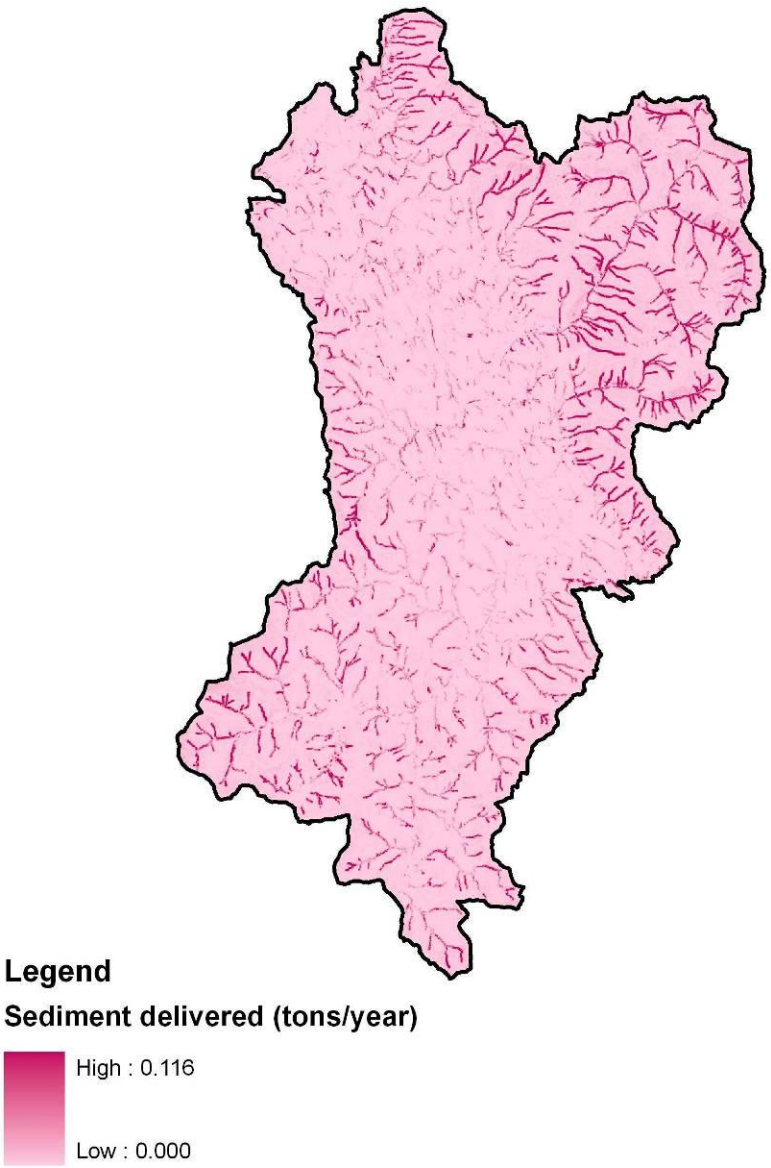


Figure F3-1. Upland Erosion USLE Existing Load Corrected for Existing Riparian Health Condition

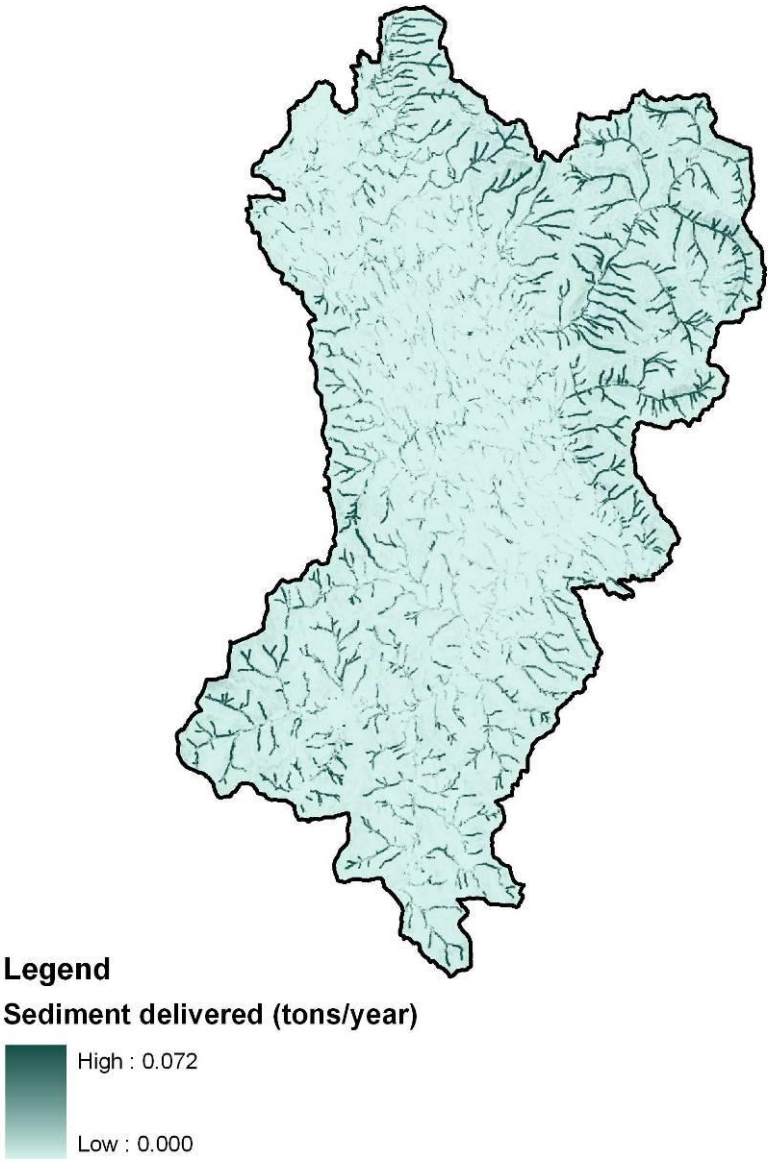


Figure F3-2. Upland Erosion USLE BMP Load Corrected for Existing Riparian Health Condition

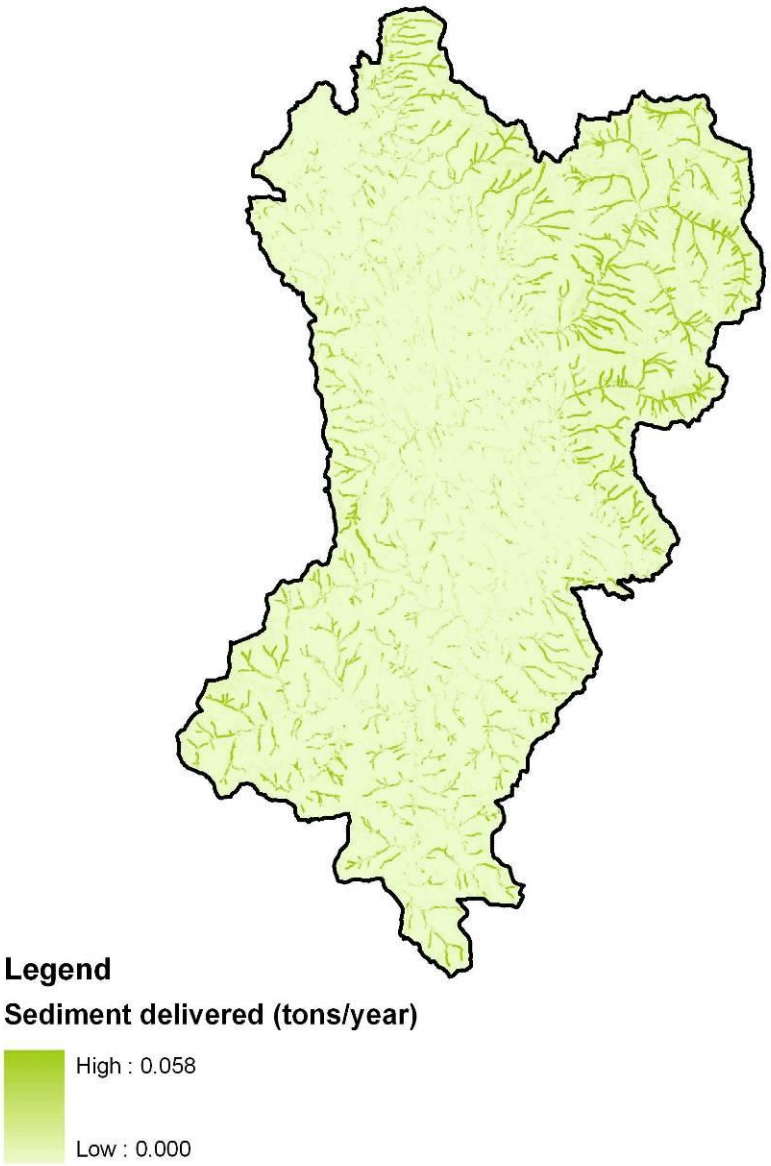


Figure F3-3. Upland Erosion USLE BMP Load Corrected for BMP Riparian Health Condition

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Upper Fortine Creek	Developed, Open Space	15.6	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	32.9	<1	<1	0%	<1	0%	0%
	Evergreen Forest	18,697.5	92.4	92.4	0%	68.2	26%	26%
	Shrub/Scrub	5,256.3	53.6	53.6	0%	39.5	26%	26%
	Grasslands/Herbaceous	33.9	<1	<1	0%	<1	0%	0%
	Pasture/Hay	13.6	<1	<1	0%	<1	0%	0%
	Cultivated Crops	2.0	<1	<1	0%	<1	0%	0%
	Woody Wetlands	89.4	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	72.9	<1	<1	0%	<1	0%	0%
	Transitional	602.5	1.6	1.6	0%	1.2	26%	26%
	Other	17.6	<1	<1	0%	<1	0%	0%
	Total	**24,834**	**150**	**150**	**0%**	**111**	**26%**	**26%**
Swamp Creek – Lake Creek	Developed, Open Space	2.9	<1	<1	0%	<1	0%	0%
	Evergreen Forest	17,900.7	131.4	131.4	0%	83.2	37%	37%
	Shrub/Scrub	7,456.5	102.8	102.8	0%	65.0	37%	37%
	Grasslands/Herbaceous	51.3	<1	<1	0%	<1	0%	0%
	Pasture/Hay	13.4	<1	<1	0%	<1	0%	0%
	Cultivated Crops	4.9	<1	<1	0%	<1	0%	0%
	Woody Wetlands	370.2	3.5	3.5	0%	2.2	37%	37%
	Emergent Herbaceous Wetlands	562.4	<1	<1	0%	<1	0%	0%
	Transitional	2,258.1	14.5	14.5	0%	9.1	37%	37%
	Total	**28,620**	**252**	**252**	**0%**	**160**	**37%**	**37%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Lime Creek	Developed, Open Space	4.7	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	25.5	<1	<1	0%	<1	0%	0%
	Evergreen Forest	4,986.9	28.4	28.4	0%	20.0	30%	30%
	Shrub/Scrub	515.5	2.1	2.1	0%	1.5	30%	30%
	Grasslands/Herbaceous	8.6	<1	<1	0%	<1	0%	0%
	Pasture/Hay	47.4	<1	<1	0%	<1	0%	0%
	Cultivated Crops	3.4	<1	<1	0%	<1	0%	0%
	Woody Wetlands	22.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	66.6	<1	<1	0%	<1	0%	0%
	Transitional	645.2	4.9	4.9	0%	3.4	30%	30%
	Other	3.8	<1	<1	0%	<1	0%	0%
	Total	**6,330**	**35**	**35**	**0%**	**25**	**29%**	**29%**
Edna Creek	Evergreen Forest	12,040.4	66.3	66.3	0%	43.7	34%	34%
	Shrub/Scrub	1,848.1	25.2	25.2	0%	16.6	34%	34%
	Grasslands/Herbaceous	31.4	1.1	0.7	35%	0.5	34%	57%
	Pasture/Hay	13.5	<1	<1	0%	<1	0%	0%
	Cultivated Crops	3.4	<1	<1	0%	<1	0%	0%
	Woody Wetlands	45.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	149.1	<1	<1	0%	<1	0%	0%
	Transitional	582.5	4.3	4.3	0%	2.8	34%	34%
	Total	**14,714**	**99**	**98**	**1%**	**64**	**34%**	**35%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Middle Fortine Creek	Developed, Open Space	23.5	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	53.0	<1	<1	0%	<1	0%	0%
	Evergreen Forest	13,315.3	60.7	60.7	0%	39.2	35%	35%
	Shrub/Scrub	2,139.1	19.3	19.3	0%	12.4	35%	35%
	Grasslands/Herbaceous	40.3	<1	<1	0%	<1	0%	0%
	Pasture/Hay	55.9	<1	<1	0%	<1	0%	0%
	Cultivated Crops	4.0	<1	<1	0%	<1	0%	0%
	Woody Wetlands	166.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	161.3	<1	<1	0%	<1	0%	0%
	Transitional	976.6	7.1	7.1	0%	4.6	35%	35%
	Other	4.0	<1	<1	0%	<1	0%	0%
	Total	**16,939**	**90**	**90**	**0%**	**57**	**35%**	**37%**
Deep Creek	Developed, Open Space	54.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	48.3	<1	<1	0%	<1	0%	0%
	Evergreen Forest	10,814.6	133.3	133.3	0%	114.8	14%	14%
	Shrub/Scrub	463.1	22.5	22.5	0%	19.4	14%	14%
	Grasslands/Herbaceous	263.8	5.1	3.3	35%	2.9	14%	44%
	Pasture/Hay	261.4	2.3	1.5	35%	1.3	14%	44%
	Woody Wetlands	8.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	2.0	<1	<1	0%	<1	0%	0%
	Transitional	191.1	<1	<1	0%	<1	0%	0%
	Other	125.1	<1	<1	0%	<1	0%	0%
	Total	**12,232**	**168**	**163**	**3%**	**141**	**14%**	**16%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Meadow Creek	Developed, Open Space	2.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	3.8	<1	<1	0%	<1	0%	0%
	Evergreen Forest	14,542.4	79.3	79.3	0%	51.2	35%	35%
	Shrub/Scrub	1,393.6	18.6	18.6	0%	12.0	35%	35%
	Grasslands/Herbaceous	69.4	2.0	1.3	35%	0.8	35%	58%
	Pasture/Hay	79.2	1.5	1.0	35%	0.6	35%	58%
	Cultivated Crops	3.0	<1	<1	0%	<1	0%	0%
	Woody Wetlands	67.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	227.6	<1	<1	0%	<1	0%	0%
	Transitional	746.8	5.0	5.0	0%	3.3	35%	35%
	Other	3.8	<1	<1	0%	<1	0%	0%
	Total	**17,139**	**108**	**107**	**1%**	**69**	**35%**	**36%**
Lower Fortine Creek	Developed, Open Space	733.3	2.4	2.4	0%	1.8	24%	24%
	Developed, Low Intensity	533.7	<1	<1	0%	<1	0%	0%
	Evergreen Forest	30,507.0	158.6	158.6	0%	119.9	24%	24%
	Shrub/Scrub	2,757.3	21.1	21.1	0%	15.9	24%	24%
	Grasslands/Herbaceous	396.9	7.0	4.5	35%	3.4	24%	51%
	Pasture/Hay	1,263.4	6.7	4.4	35%	3.3	24%	51%
	Cultivated Crops	82.4	2.5	1.6	38%	1.2	24%	53%
	Woody Wetlands	278.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	329.6	<1	<1	0%	<1	0%	0%
	Transitional	463.5	1.1	1.1	0%	0.8	24%	24%
	Other	295.0	1.3	1.3	0%	1.0	24%	24%
	Total	**37,640**	**202**	**196**	**3%**	**148**	**24%**	**27%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Upper Grave Creek	Evergreen Forest	24,727.2	297.3	297.3	0%	224.8	24%	24%
	Shrub/Scrub	2,838.1	73.0	73.0	0%	55.2	24%	24%
	Grasslands/Herbaceous	58.0	11.7	7.6	35%	5.8	24%	51%
	Pasture/Hay	4.4	<1	<1	0%	<1	0%	0%
	Other	274.3	2.0	2.0	0%	1.5	24%	24%
	Total	**27,902**	**384**	**380**	**1%**	**287**	**24%**	**25%**
Lower Grave Creek	Developed, Open Space	68.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	72.0	<1	<1	0%	<1	0%	0%
	Evergreen Forest	17,419.8	252.2	252.2	0%	181.8	28%	28%
	Shrub/Scrub	784.6	20.0	20.0	0%	14.4	28%	28%
	Grasslands/Herbaceous	124.3	3.6	2.3	35%	1.7	28%	53%
	Pasture/Hay	309.9	4.9	3.2	35%	2.3	28%	53%
	Cultivated Crops	51.4	5.5	3.4	38%	2.5	28%	55%
	Woody Wetlands	134.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	188.4	<1	<1	0%	<1	0%	0%
	Transitional	18.5	<1	<1	0%	<1	0%	0%
	Other	575.5	8.7	8.7	0%	6.3	28%	28%
	Total	**19,747**	**296**	**291**	**2%**	**210**	**28%**	**29%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Therriault Creek	Developed, Open Space	61.7	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	105.3	<1	<1	0%	<1	0%	0%
	Evergreen Forest	11,316.7	84.2	84.2	0%	56.8	33%	33%
	Shrub/Scrub	687.0	5.2	5.2	0%	3.5	33%	33%
	Grasslands/Herbaceous	81.9	4.3	2.8	35%	1.9	33%	56%
	Pasture/Hay	70.8	<1	<1	0%	<1	0%	0%
	Cultivated Crops	116.3	3.2	2.0	38%	1.3	33%	58%
	Woody Wetlands	65.1	1.4	1.4	0%	1.0	33%	33%
	Emergent Herbaceous Wetlands	125.7	<1	<1	0%	<1	0%	0%
	Transitional	670.4	1.9	1.9	0%	1.3	33%	33%
	Other	14.7	<1	<1	0%	<1	0%	0%
	Total	**13,316**	**101**	**98**	**3%**	**67**	**33%**	**34%**
Sinclair Creek	Developed, Open Space	10.6	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	22.2	<1	<1	0%	<1	0%	0%
	Evergreen Forest	6,470.5	63.6	63.6	0%	41.1	35%	35%
	Shrub/Scrub	997.5	7.3	7.3	0%	4.7	35%	35%
	Grasslands/Herbaceous	75.8	2.4	1.5	35%	1.0	35%	58%
	Pasture/Hay	281.8	2.0	1.3	35%	0.8	35%	58%
	Cultivated Crops	15.2	<1	<1	0%	<1	0%	0%
	Woody Wetlands	21.5	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	10.6	<1	<1	0%	<1	0%	0%
	Transitional	36.4	<1	<1	0%	<1	0%	0%
	Other	29.2	<1	<1	0%	<1	0%	0%
	Total	**7,971**	**76**	**74**	**2%**	**48**	**35%**	**37%**

Table F3-1. Delivered Sediment Load by Land Cover Type

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2		Scenario 3		
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)	**Upland BMP Load Reduction**	Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)	**Riparian BMP Load Reduction**	**Overall Sediment Load Reduction**
Indian Creek	Developed, Open Space	73.9	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	38.7	<1	<1	0%	<1	0%	0%
	Evergreen Forest	6,606.4	89.0	89.0	0%	57.5	35%	35%
	Shrub/Scrub	2,815.6	20.7	20.7	0%	13.3	35%	35%
	Grasslands/Herbaceous	512.1	5.5	3.6	35%	2.3	35%	58%
	Pasture/Hay	657.8	6.4	4.2	35%	2.7	35%	58%
	Cultivated Crops	286.1	7.7	4.8	38%	3.1	35%	60%
	Woody Wetlands	26.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	12.7	<1	<1	0%	<1	0%	0%
	Transitional	100.5	2.4	2.4	0%	1.6	35%	35%
	Other	42.1	<1	<1	0%	<1	0%	0%
	Total	**11,172**	**132**	**125**	**5%**	**81**	**35%**	**39%**
Tobacco River	Developed, Open Space	308.3	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	556.0	<1	<1	0%	<1	0%	0%
	Evergreen Forest	23,647.6	112.4	112.4	0%	68.3	39%	39%
	Shrub/Scrub	9,155.9	47.7	47.7	0%	29.0	39%	39%
	Grasslands/Herbaceous	1,265.4	9.2	6.0	35%	3.6	39%	60%
	Pasture/Hay	1,222.7	10.7	7.0	35%	4.2	39%	60%
	Cultivated Crops	465.0	13.7	8.6	38%	5.2	39%	62%
	Woody Wetlands	247.4	2.3	2.3	0%	1.4	39%	39%
	Emergent Herbaceous Wetlands	277.4	<1	<1	0%	<1	0%	0%
	Transitional	1,138.5	4.9	4.9	0%	3.0	39%	39%
	Other	227.2	<1	<1	0%	<1	0%	0%
	Total	**38,511**	**202**	**190**	**6%**	**116**	**39%**	**43%**

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Upper Fortine Creek	Developed, Open Space	15.6	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	32.9	<1	<1	0%	<1	0%	0%
	Evergreen Forest	18,697.5	92.4	92.4	0%	68.2	26%	26%
	Shrub/Scrub	5,256.3	53.6	53.6	0%	39.5	26%	26%
	Grasslands/Herbaceous	33.9	<1	<1	0%	<1	0%	0%
	Pasture/Hay	13.6	<1	<1	0%	<1	0%	0%
	Cultivated Crops	2.0	<1	<1	0%	<1	0%	0%
	Woody Wetlands	89.4	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	72.9	<1	<1	0%	<1	0%	0%
	Transitional	602.5	1.6	1.6	0%	1.2	26%	26%
	Other	17.6	<1	<1	0%	<1	0%	0%
	Total	**24,834**	**150**	**150**	**0%**	**111**	**26%**	**26%**
Swamp Creek – Lake Creek	Developed, Open Space	2.9	<1	<1	0%	<1	0%	0%
	Evergreen Forest	17,900.7	131.4	131.4	0%	83.2	37%	37%
	Shrub/Scrub	7,456.5	102.8	102.8	0%	65.0	37%	37%
	Grasslands/Herbaceous	51.3	<1	<1	0%	<1	0%	0%
	Pasture/Hay	13.4	<1	<1	0%	<1	0%	0%
	Cultivated Crops	4.9	<1	<1	0%	<1	0%	0%
	Woody Wetlands	370.2	3.5	3.5	0%	2.2	37%	37%
	Emergent Herbaceous Wetlands	562.4	<1	<1	0%	<1	0%	0%
	Transitional	2,258.1	14.5	14.5	0%	9.1	37%	37%
	Total	**28,620**	**252**	**252**	**0%**	**160**	**37%**	**37%**

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Lime Creek	Developed, Open Space	4.7	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	25.5	<1	<1	0%	<1	0%	0%
	Evergreen Forest	4,986.9	28.4	28.4	0%	20.0	30%	30%
	Shrub/Scrub	515.5	2.1	2.1	0%	1.5	30%	30%
	Grasslands/Herbaceous	8.6	<1	<1	0%	<1	0%	0%
	Pasture/Hay	47.4	<1	<1	0%	<1	0%	0%
	Cultivated Crops	3.4	<1	<1	0%	<1	0%	0%
	Woody Wetlands	22.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	66.6	<1	<1	0%	<1	0%	0%
	Transitional	645.2	4.9	4.9	0%	3.4	30%	30%
	Other	3.8	<1	<1	0%	<1	0%	0%
	Total	**6,330**	**35**	**35**	**0%**	**25**	**29%**	**29%**
Edna Creek	Evergreen Forest	12,040.4	66.3	66.3	0%	43.7	34%	34%
	Shrub/Scrub	1,848.1	25.2	25.2	0%	16.6	34%	34%
	Grasslands/Herbaceous	31.4	1.1	0.7	35%	0.5	34%	57%
	Pasture/Hay	13.5	<1	<1	0%	<1	0%	0%
	Cultivated Crops	3.4	<1	<1	0%	<1	0%	0%
	Woody Wetlands	45.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	149.1	<1	<1	0%	<1	0%	0%
	Transitional	582.5	4.3	4.3	0%	2.8	34%	34%
	Total	**14,714**	**99**	**98**	**1%**	**64**	**34%**	**35%**

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Middle Fortine Creek*	Developed, Open Space	46.6	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	111.4	<1	<1	0%	<1	0%	0%
	Evergreen Forest	66,940.7	379.3	379.3	0%	254.4	33%	33%
	Shrub/Scrub	17,215.6	202.9	202.9	0%	135.1	33%	33%
	Grasslands/Herbaceous	165.4	3.3	2.2	35%	1.4	33%	57%
	Pasture/Hay	143.8	1.6	1.1	35%	0.7	34%	57%
	Cultivated Crops	17.7	<1	<1	0%	<1	0%	0%
	Woody Wetlands	693.4	5.6	5.6	0%	3.7	35%	35%
	Emergent Herbaceous Wetlands	1,012.3	1.6	1.6	0%	1.1	35%	35%
	Transitional	5,064.9	32.4	32.4	0%	21.4	34%	34%
	Other	25.3	<1	<1	0%	<1	0%	0%
	Total	**91,437**	**629**	**628**	**0%**	**417**	**34%**	**34%**
*Middle Fortine Creek results are a summation of the results of that sub-basin plus Edna Creek, Lime Creek, Upper Fortine Creek, and Swamp Creek/Lake Creek.								
Deep Creek	Developed, Open Space	54.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	48.3	<1	<1	0%	<1	0%	0%
	Evergreen Forest	10,814.6	133.3	133.3	0%	114.8	14%	14%
	Shrub/Scrub	463.1	22.5	22.5	0%	19.4	14%	14%
	Grasslands/Herbaceous	263.8	5.1	3.3	35%	2.9	14%	44%
	Pasture/Hay	261.4	2.3	1.5	35%	1.3	14%	44%
	Woody Wetlands	8.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	2.0	<1	<1	0%	<1	0%	0%
	Transitional	191.1	<1	<1	0%	<1	0%	0%
	Other	125.1	<1	<1	0%	<1	0%	0%
	Total	**12,232**	**168**	**163**	**3%**	**141**	**14%**	**16%**

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Meadow Creek	Developed, Open Space	2.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	3.8	<1	<1	0%	<1	0%	0%
	Evergreen Forest	14,542.4	79.3	79.3	0%	51.2	35%	35%
	Shrub/Scrub	1,393.6	18.6	18.6	0%	12.0	35%	35%
	Grasslands/Herbaceous	69.4	2.0	1.3	35%	0.8	35%	58%
	Pasture/Hay	79.2	1.5	1.0	35%	0.6	35%	58%
	Cultivated Crops	3.0	<1	<1	0%	<1	0%	0%
	Woody Wetlands	67.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	227.6	<1	<1	0%	<1	0%	0%
	Transitional	746.8	5.0	5.0	0%	3.3	35%	35%
	Other	3.8	<1	<1	0%	<1	0%	0%
	Total	**17,139**	**108**	**107**	**1%**	**69**	**35%**	**36%**
Lower Fortine Creek*	Developed, Open Space	836.3	2.7	2.7	0%	2.0	25%	25%
	Developed, Low Intensity	697.2	<1	<1	0%	<1	0%	0%
	Evergreen Forest	122,804.8	750.4	750.4	0%	540.2	28%	28%
	Shrub/Scrub	21,829.6	265.1	265.1	0%	182.5	31%	31%
	Grasslands/Herbaceous	895.6	17.4	11.3	35%	8.6	24%	51%
	Pasture/Hay	1,747.8	12.1	7.9	35%	5.9	25%	51%
	Cultivated Crops	103.1	3.3	2.0	38%	1.5	27%	54%
	Woody Wetlands	1,047.1	7.0	7.0	0%	4.6	33%	33%
	Emergent Herbaceous Wetlands	1,571.5	2.4	2.4	0%	1.6	33%	33%
	Transitional	6,466.3	43.0	43.0	0%	29.2	32%	32%
	Other	449.2	1.7	1.7	0%	1.3	22%	22%
	Total	**158,449**	**1,106**	**1,094**	**1%**	**778**	**30%**	**30%**

*Lower Fortine Creek results are a summation of the results of that sub-basin plus Middle Fortine Creek, Meadow Creek, and Deep Creek.

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Upper Grave Creek	Evergreen Forest	24,727.2	297.3	297.3	0%	224.8	24%	24%
	Shrub/Scrub	2,838.1	73.0	73.0	0%	55.2	24%	24%
	Grasslands/Herbaceous	58.0	11.7	7.6	35%	5.8	24%	51%
	Pasture/Hay	4.4	<1	<1	0%	<1	0%	0%
	Other	274.3	2.0	2.0	0%	1.5	24%	24%
	Total	**27,902**	**384**	**380**	**1%**	**287**	**24%**	**25%**
Lower Grave Creek*	Developed, Open Space	68.2	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	72.0	<1	<1	0%	<1	0%	0%
	Evergreen Forest	42,147.0	549.5	549.5	0%	406.6	26%	26%
	Shrub/Scrub	3,622.7	93.0	93.0	0%	69.6	25%	25%
	Grasslands/Herbaceous	182.3	15.3	10.0	35%	7.4	25%	51%
	Pasture/Hay	314.3	5.0	3.3	35%	2.4	28%	53%
	Cultivated Crops	51.4	5.5	3.4	38%	2.5	28%	55%
	Woody Wetlands	134.2	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	188.4	<1	<1	0%	<1	0%	0%
	Transitional	18.5	<1	<1	0%	<1	0%	0%
	Other	849.9	10.7	10.7	0%	7.8	27%	27%
	Total	**47,649**	**703**	**671**	**1%**	**497**	**26%**	**27%**

*Lower Grave Creek results are a summation of the results of that sub-basin plus Upper Grave Creek.

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Therriault Creek	Developed, Open Space	61.7	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	105.3	<1	<1	0%	<1	0%	0%
	Evergreen Forest	11,316.7	84.2	84.2	0%	56.8	33%	33%
	Shrub/Scrub	687.0	5.2	5.2	0%	3.5	33%	33%
	Grasslands/Herbaceous	81.9	4.3	2.8	35%	1.9	33%	56%
	Pasture/Hay	70.8	<1	<1	0%	<1	0%	0%
	Cultivated Crops	116.3	3.2	2.0	38%	1.3	33%	58%
	Woody Wetlands	65.1	1.4	1.4	0%	1.0	33%	33%
	Emergent Herbaceous Wetlands	125.7	<1	<1	0%	<1	0%	0%
	Transitional	670.4	1.9	1.9	0%	1.3	33%	33%
	Other	14.7	<1	<1	0%	<1	0%	0%
	Total	**13,316**	**101**	**98**	**3%**	**67**	**33%**	**34%**
Sinclair Creek	Developed, Open Space	10.6	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	22.2	<1	<1	0%	<1	0%	0%
	Evergreen Forest	6,470.5	63.6	63.6	0%	41.1	35%	35%
	Shrub/Scrub	997.5	7.3	7.3	0%	4.7	35%	35%
	Grasslands/Herbaceous	75.8	2.4	1.5	35%	1.0	35%	58%
	Pasture/Hay	281.8	2.0	1.3	35%	0.8	35%	58%
	Cultivated Crops	15.2	<1	<1	0%	<1	0%	0%
	Woody Wetlands	21.5	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	10.6	<1	<1	0%	<1	0%	0%
	Transitional	36.4	<1	<1	0%	<1	0%	0%
	Other	29.2	<1	<1	0%	<1	0%	0%
	Total	**7,971**	**76**	**74**	**2%**	**48**	**35%**	**37%**

Table F3-2. Delivered Sediment Load by Land Cover Type Cumulative through the Watershed

Sub-basin	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2	Upland BMP Load Reduction	Scenario 3	Riparian BMP Load Reduction	Overall Sediment Load Reduction
			Upland Erosion USLE **Existing** Load Corrected for **Existing** Riparian Health Condition (tons/year)	Upland Erosion USLE **BMP** Load Corrected for **Existing** Riparian Health Condition (tons/year)		Upland Erosion USLE **BMP** Load Corrected for **BMP** Riparian Health Condition (tons/year)		
Indian Creek	Developed, Open Space	73.9	<1	<1	0%	<1	0%	0%
	Developed, Low Intensity	38.7	<1	<1	0%	<1	0%	0%
	Evergreen Forest	6,606.4	89.0	89.0	0%	57.5	35%	35%
	Shrub/Scrub	2,815.6	20.7	20.7	0%	13.3	35%	35%
	Grasslands/Herbaceous	512.1	5.5	3.6	35%	2.3	35%	58%
	Pasture/Hay	657.8	6.4	4.2	35%	2.7	35%	58%
	Cultivated Crops	286.1	7.7	4.8	38%	3.1	35%	60%
	Woody Wetlands	26.3	<1	<1	0%	<1	0%	0%
	Emergent Herbaceous Wetlands	12.7	<1	<1	0%	<1	0%	0%
	Transitional	100.5	2.4	2.4	0%	1.6	35%	35%
	Other	42.1	<1	<1	0%	<1	0%	0%
	Total	**11,172**	**132**	**125**	**5%**	**81**	**35%**	**39%**
Tobacco River*	Developed, Open Space	1,358.9	3.3	3.3	0%	2.4	27%	27%
	Developed, Low Intensity	1,491.5	1.0	1.0	0%	0.7	29%	29%
	Evergreen Forest	212,992.9	1,649.2	1,649.2	0%	1,170.5	29%	29%
	Shrub/Scrub	39,108.3	439.0	439.0	0%	302.6	31%	31%
	Grasslands/Herbaceous	3,013.0	54.2	35.2	35%	24.9	29%	54%
	Pasture/Hay	4,295.1	36.5	23.7	35%	16.1	32%	56%
	Cultivated Crops	1,037.1	33.5	20.9	38%	13.7	35%	59%
	Woody Wetlands	1,541.7	11.8	11.8	0%	7.8	34%	34%
	Emergent Herbaceous Wetlands	2,186.3	3.1	3.1	0%	2.0	34%	34%
	Transitional	8,430.5	52.4	52.4	0%	35.1	33%	33%
	Other	1,612.3	12.7	12.7	0%	9.3	27%	27%
	Total	**277,068**	**2,297**	**2,252**	**2%**	**1,585**	**30%**	**31%**

*Tobacco River results are a summation of the results of that sub-basin plus Lower Fortine Creek, Lower Grave Creek, Indian Creek, Sinclair Creek, and Therriault Creek.

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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 Tobacco River 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 Tobacco River 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 Tobacco River watershed were determined for the existing conditions based on ground cover information from NRCS and USFS employees familiar with the Tobacco River watershed. (**Table A-1**)

Per the best professional judgment of Kenny Kindel with the Kootenai National Forest in Eureka, the existing percent ground cover for the evergreen forest land use was estimated to be 95-100 percent.

Per the best professional judgment of Kirk Sullivan with the NRCS in Eureka, the existing percent ground cover was estimated to be 80% for 'shrub/scrub', 60% for 'grassland/herbaceous', 60% for 'pasture/hay', 60% for 'woody wetlands', and 95-100% for 'emergent herbaceous wetlands'.

Per the best professional judgment of Walter Lujan with the NRCS in Missoula, the existing percent ground cover was estimated to be 90% for 'shrub/scrub', 90% for 'grassland/herbaceous', 90% for 'pasture/hay', 95-100% for 'woody wetlands', 95-100% for 'emergent herbaceous wetlands', and 90% for 'transitional'.

Where there were two estimates of the percent ground cover for the same land use, the average of the two estimates was used.

For the well managed scenario, the percent ground cover was increased by 10% over the existing percentage for the 'grassland/herbaceous' and 'pasture/hay' land uses, and by 20% for the 'cultivated crops' land use. For the 'transitional' land use, the well managed scenario assumed a return to a forest land use in logged areas but logging in currently forested areas, resulting in no change to the C factor. The C-factors for the other land use types were not changed. (**Table A-2**).

Table A-3 provides the C-factors for the remaining minor land use types that make up less than 1% of the watershed. The C-factors for these land uses are the same for both the existing and well managed scenarios. These are the same C-factors previously recommended by Richard Fasching, the NRCS Montana State Agronomist, for other hillslope USLE modeling efforts.

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-factor for principle land use types in the Tobacco River watershed for existing conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover[1]	Type	Percent Ground Cover[2]	C-factor	Percent of Watershed
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003	0.5
22	Developed, low intensity	-	-	-	-	0.001	0.5
42	Evergreen forest	trees	75	G	95-100	0.003	78
52	Shrub/scrub	appreciable brush	25	G	85	0.008	14.2
71	Grassland/herbaceous	no appreciable canopy	-	G	75	0.020	1.1
81	Pasture/hay	no appreciable canopy	-	G	75	0.020	1.6
82	Cultivated crops	no appreciable canopy	-	G	20	0.240	0.4
90	Woody wetlands	trees	25	G	80	0.013	0.6
95	Emergent herbaceous wetlands	tall grass	75	G	95-100	0.003	0.8
N/A	Transitional	no appreciable canopy	-	G	90	0.006	1.7

Notes:
1) Canopy cover percents were selected based on the land cover class definition.
2) Percent ground cover as per conversations with local NRCS and USFS employees.

Table A-2 C-factor for principle land use types in the Tobacco River watershed for well managed conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover[1]	Type	Percent Ground Cover[2]	C-factor	Percent of Watershed
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003	0.5
22	Developed, low intensity	-	-	-	-	0.001	0.5
42	Evergreen forest	trees	75	G	95-100	0.003	78.0
52	Shrub/scrub	appreciable brush	25	G	85	0.008	14.2
71	Grassland/herbaceous	no appreciable canopy	-	G	85	0.013	1.1
81	Pasture/hay	no appreciable canopy	-	G	85	0.013	1.6
82	Cultivated crops	no appreciable canopy	-	G	40	0.150	0.4
90	Woody wetlands	trees	25	G	80	0.013	0.6
95	Emergent herbaceous wetlands	tall grass	75	G	95-100	0.003	0.8
N/A	Transitional	no appreciable canopy	-	G	90	0.006	1.7

Notes:
1) Canopy cover percents were selected based on the land cover class definition.
2) Percent ground cover as per conversations with local NRCS and USFS employees.

Table A-3 C-factor for minor land use types in the Tobacco River watershed for all conditions.

NLCD #	Name	C-factor	Percent of Watershed
23	Developed, medium intensity	0.001	0.1
24	Developed, high intensity	0.001	0.01
31	Barren land	0.001	0.1
41	Deciduous forest	0.003	0.3
43	Mixed forest	0.003	0.1

Notes:
Medium and high intensity development land uses are assumed to be the same as barren land.
Deciduous and mixed forest land uses are assumed to be the same as evergreen forest.

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G1.0 INTRODUCTION

This appendix presents a sediment and culvert assessment of the road network within the Tobacco River TMDL Planning Area (TPA). The information is derived from a roads assessment report prepared by Water and Environmental Technologies for presentation to the Kootenai River Network and the Montana Department of Environmental Quality (DEQ) (Water and Environmental Technologies, PC, 2009). 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 road crossing and parallel road 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 and failure from runoff events.

G2.0 DATA COLLECTION

The Tobacco Road Sediment assessment consisted of three primary tasks:

1.) GIS Layer development and summary statistics,
2.) field assessment (2008) and subsequent sediment modeling, and
3.) sediment load calculations and assessment of existing and potential load reduction capability via application of best management practices.

Additional information on assessment techniques is available in prior reporting for this project: Road GIS Layers and Summary Statistics (Water & Environmental Technologies, PC., 2007a), and Sampling and Analysis Plan (Water & Environmental Technologies, PC., 2007b).

G2.1 SPATIAL ANALYSIS

Using road layers provided by the Kootenai National Forest (KNF), road crossings and parallel segments in the road network were identified and classified relative to 6th code subwatershed, land ownership, and landscape type (**Table G2-1 and Figures G1, G2 and G3**). These classifications facilitated a statistically representative sample of roads within the entire watershed, based on a number of road conditions (subwatershed, road design, soil type, maintenance level, etc). Summary statistics show that there are a total of 1345 road crossings in the Tobacco River TPA, with 1231 unpaved crossings and 105 paved crossings. There are 854 Mountain crossings (838 unpaved), 438 Foothill crossings (377 unpaved), and 44 Valley crossings (16 unpaved). There are 822 road crossings on federal lands (797 unpaved), 455 crossings on private lands (378 unpaved), and 59 crossings (56 unpaved) crossings on state lands. A random subset of unpaved crossing sites was generated for field assessment based on the proportion of total crossings within each landscape type, with approximately 4% of the total unpaved crossings assessed (50 sites). Parallel road segments were identified as areas where roads encroach upon the stream channel, and total road lengths within 50-foot buffer zones were generated. There is a total of 19.2 miles of unpaved parallel road segments within 50 feet of stream channels. Statistics generated using GIS were updated in the field, as described in **Section G2.4**.

Table G2-1. Road Summary by Landscape Type, Land Ownership, and Soil Erosion Hazard Classification

Landscape Type	**Area (Mi2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing / Mi2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)**
Foothill	121.15	242.47	377	3.11	61	438	533.66	4.41	86.9%	8.36	0.07
Mountain	216.27	455.91	838	3.87	16	854	712.86	3.30	98.1%	10.40	0.05
Valley	28.71	42.79	16	0.56	28	44	79.45	2.77	44.8%	0.43	0.02
Total	366.13	741.17	1231	3.36	105	1336	1325.97	3.62	90.4%	19.2	0.05
Land Ownership	**Area (Mi2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing / Mi2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)**
Federal Land	228.88	454.70	797	3.48	25	822	762.47	3.33	96.6%	11.75	0.05
Private	123.22	251.83	378	3.07	77	455	523.87	4.25	81.2%	6.64	0.05
State Land	11.49	26.47	56	4.87	3	59	38.77	3.38	91.7%	0.80	0.07
Water	2.54	17.31									
Total	366.13	741.17	1231	3.36	105	1336	1325.12	3.62	90.4%	19.2	0.05
Soil Erosion Hazard Classification	**Area (Mi2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing / Mi2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)**
Mod(60%), Slight(40%)	5.38	23.05	29	5.39	8	37	33.23	6.17	73.1%	0.28	0.05
Moderate	8.88	24.79	25	2.82	5	30	35.66	4.02	69.3%	0.24	0.03
Severe	328.37	594.56	1119	3.41	62	1181	1177.14	3.58	93.2%	17.54	0.05
Slight	19.42	81.46	57	2.94	30	87	79.46	4.09	65.3%	1.10	0.06
Water	3.57	17.31	1	0.28		1					
Total	365.62*	741.17	1231	3.37	105	1336	1325.49	3.62	90.4%	19.2	0.05

*The GIS boundary was slightly smaller for soil erosion hazard classification than for landscape type and land ownership models. Thus, total area is slightly less within the soil classification boundary.

G2.2 Field Data Collection

A total of 50 unpaved crossings and 10 parallel segments were evaluated in the field during 2008. Thirty-seven crossings were assessed on Federal lands, 12 crossings were assessed on Private lands, and one crossing was assessed on State lands. Twenty-nine crossings were assessed in the mountain landscape (25 Federal, 4 private); 17 crossings were assessed in the foothill landscape (12 Federal, 5 private); and 4 crossings (3 private; one State) were assessed in the valley landscape type. Forty-eight crossings were assessed on soil rated "severe" per the USDA-NRCS, Hazard of Erosion and Suitability for Roads on Forestland category (**Figure G4**). The remaining two crossings were LFTN-F-09 on "moderate" soil and INC-V-26 on "slight" soil. Crossing assessment sites were randomly selected with the goal of being representative of landscape type and ownership category.

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. Generally, the majority of parallel road segments are located in narrow stream valleys or canyons in foothill and mountain landscapes, where roads are constructed near streams. Three (3) parallel segments were assessed in the mountain landscape type and seven (7) segments were assessed in the foothill landscape type. No parallel segments were encountered or assessed in the valley landscape type due to the small overall area of the valley landscape, and the observation that the majority of valley roads were paved and/or did not parallel a stream channel. All ten of the parallel sites were located on federal lands and on soil rated "severe" per the USDA-NRCS, Hazard of Erosion and Suitability for Roads on Forestland category.

G2.3 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 and culvert failure.

Site-specific climate profiles were created using data from the Western Regional Climate Center (http://www.wrcc.dri.edu). Climate stations were selected from within the Tobacco TPA boundary that exhibited similar conditions for each specific landscape type. The Eureka Ranger station (242827: 2530 ft elevation, 14.34-inches annual precipitation), was selected for valley sites, the Fortine 1N station (243139: 3000-feet elevation, 16.79-inches annual precipitation) was selected to model the foothill sites, and the Olney station (246218: 3180-feet elevation, 22.06-inches annual precipitation) was used to model the mountain sites.

Generally, 30-year model simulations are adequate to obtain a reliable average erosion estimate. However, in drier climates (less than 500 mm/19.68 inches of precipitation), 50-year or longer

simulations are necessary to obtain average erosion estimates. For the Tobacco TPA, 30-year simulations were run for mountain sites, and fifty-year simulations were run for valley and foothill sites.

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 B** contains a description of model or site condition adjustments, as recommended by the model author or by professional judgment.

G2.4 FIELD ADJUSTMENTS

Field conditions required that a number of sites be moved to different locations due to lack of access (landowner permission or road condition), or inaccuracies in the road or stream GIS layers. It was noted during field activities that some roads were classified as unpaved on the GIS layer attributes, when in fact, they were found to be paved roads upon field inspection. Also, some road crossings or parallel segments were not present upon field inspection. GIS layers often contain additional crossings when road and stream layers parallel each other close together. Records were kept in the field and edits were made to the GIS layers. Revised unpaved road network statistics were generated, which resulted in unpaved road crossings decreasing from 1240 to 1231 crossings (**Table G2-2**).

The ability to generate completely accurate road and stream crossing layers is not feasible; however, this revised tally represents a more accurate representation of existing conditions.

Table G2-2. Total Number of Unpaved Crossings

Landscape Type	Unpaved Road Crossings using GIS Only	Revised Unpaved Crossings After Field and Map Adjustments
Mountain	839	838
Foothill	386	377
Valley	15	16
Total	1240	1231

Total unpaved road crossings and crossing densities were also classified by major land ownership within the TPA, with results shown in **Table G2-3**. **Table G2.3** also includes the sampling statistics by ownership.

Table G2-3. Unpaved Road Crossings Sorted by Major Land Ownership

Land Ownership / Management Unit	Number of Unpaved Crossings	Ownership Area (sq mi)	Ownership Area (%)	Crossing Density (crossings/sq mi)	Sites Sampled (& Percent of Total)
Federal	797	228.9	62.5%	3.48	37 (4.6%)
State of Montana	56	11.5	3.1%	4.87	1 (1.8%)
Private	378	123.2	33.7%	3.07	12 (3.2%)
Water	0	2.5	0.7%	0.0	NA
Total	1231	366.1	100%	3.37	50 (4.1%)

Federal land contains the most unpaved road crossings, and State lands have the highest density of road crossings when compared with ownership area.

G2.5 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

within each sediment-listed watershed was generated using the applicable dataset of field assessed crossing and parallel 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 landscape type that was the basis of the field assessment. Mean sediment loads from unpaved road crossings were modeled at 0.07 tons/year in mountain landscapes, 0.04 tons/year in the foothill landscapes, and 0.26 tons/year in the valley landscapes. A statistical summary of sediment loads for field assessed sites are included in **Table G2-4**. This information will be used for extrapolating total loads throughout the watershed (**Section G3**).

Table G2-4. Sediment Load Summary for Field Assessed Crossings by Landscape Type

Statistical Parameter	Mountain	Foothill	Valley	Total of Field Assessed Crossings
Number of Sites (n)	29	17	4	50
Mean Contributing Length (ft)	214	305	433	262
Mean Load (tons/year)	0.07	0.04	0.26	0.08
Median Load (tons/year)	0.01	0.01	0.06	0.01
Maximum Load (tons/year)	0.37	0.25	0.92	0.92
Minimum Load (tons/year)	0	0	0	0
25th Percentile (tons/year)	0.006	0.004	0.040	0.005
75th Percentile (tons/year)	0.09	0.07	0.28	0.08

The sediment load summary shows significant differences between minimum and maximum load values, as well as between mean and median values for valley landscape types. These data suggest that a small number of high sediment load crossing sites impact the average values.

When evaluated by ownership, the mean load for the 12 private crossings was 0.12 tons/year. The mean load for the 37 federal crossing plus the one state crossing was 0.06 tons/year, or about half of the mean load per private crossing. This information is useful to evaluate and track BMP implementation by major owner categories, but because ownership is typically not distributed equally among landscape types, it is not used as an extrapolation factor for estimating the total loads throughout the watershed.

G2.6 Sediment Loads from Field Assessed Sites – Unpaved Parallel Road Segments

Mean sediment loads were calculated for 10 assessed unpaved parallel road segments; 3 sites were within the mountain landscape type and 7 sites were within foothills landscape type. No valley parallel segments were assessed in the field due to the minimal presence of roads (within 50 feet) which paralleled streams in the valley landscape. The average load from the 7 parallel sites in the foothills landscape type was 0.03 tons/year, and the average load from the 3 parallel sites in the mountain landscape type was also 0.03 tons/year. The load per mile of contributing road length was also evaluated for the 10 sites with an average loading rate of about 0.47 tons/year/mile. A summary of modeling results from field assessed sites is located in **Attachment C**.

G2.7 Paved Roads

As shown by **Table G2.1** and **Figure G5**, many of the road crossings and parallel roads are paved. Traction sand is used in the winter on the paved roads and is divided between county and state responsibility. The Lincoln County Road Department, District 3 estimates an annual average application of 3,500 to 4,000 cubic yards of sand for a total of 180 miles (24 tons/mile). The Montana Department of

Transportation (MDT) estimates 1,500 cubic yards of sand each year for the past five years for 28 miles of road along the Tobacco River (67 tons/mile); however the state has discontinued the use of sand in 2008 in favor of using salt. Conversions were calculated with an assumed bulk density of 1.25 tons per cubic yard. Over 208 miles of road, the normalized annual application rate (prior to 2008) for paved roads would equate to about 30 tons/mile.

Below is a summary of traction sand application reported from other TMDL project areas. Note that application rates can vary considerably. The application rate in the Tobacco is closest to the amount of traction sand in the Prospect Creek TPA and the Blackfoot Headwaters TPA:

- Bitterroot Headwaters TPA: MDT estimated an application rate of 1 ton/mile/year on Highway 93
- Prospect Creek TPA: MDT: 1587.3 tons / 22 miles / year = 72 tons/mile/year
- Blackfoot Headwaters TPA: The amount of traction sand applied to the highways was provided by MDT personnel and was 73 tons/mile/year (Highway 200 from the junction of Highway 279 to Rogers Pass and Highway 279 from the junction with Highway 200 to Flesher Pass) and 36 tons/mile/year (Highway 200 from the junction of Highway 279 to all points west).
- Upper Lolo Creek TPA: Approximately 3,300 tons/ 6.4 miles on the West Fork of Upper Lolo Creek equates to 516 tons/mile/year.

No field assessments were completed for paved road crossings or paved parallel segments. Dave Rauser has been with MDT for 21 years and stated that many of the silt fences near the Tobacco River show minimal accumulation of traction sand, suggesting an overall low delivery rate for road sand.

The above information along with assessment approaches from other TMDL documents is used to estimate a road sand load in **Section G3** of this appendix.

G2.8 Road Statistics by Subwatershed

Total road crossings and parallel road distances were further defined by land ownership and subwatershed. USGS 6th code subwatersheds were used as a basis for road sediment categorization in order to provide means for identifying the most impacted areas, and opportunities for potential restoration planning. A summary of road conditions by 6th code/303(d) subwatershed is included as **Table G2-5**; road crossing and parallel road distance sorted by ownership and landscape type is included in **Table G2-6** and **Table G2-7**.

Table G2-5. Tobacco River TPA Road Summary by 6th Code HUC/303(d) Watershed

6th Code Subwatershed (USGS HUC 12)	Area (Mi2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi & % of total)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)
Deep Creek	19.39	45.63	45	2.32	3	54	59.15	3.05	96.7%	0.71 (3.7)	0.04
Edna Creek	23.28	54.50	120	5.15	3	123	105.10	4.52	97.5%	1.97 (10.3)	0.08
Indian Creek	17.72	37.35	8	0.45	4	12	20.13	1.14	64.5%	0.26 (1.4)	0.01
Lower Fortine Creek	60.79	137.52	231	3.80	19	255	242.33	3.99	90.2%	4.85 (25.3)	0.08
Meadow Creek	27.32	62.74	171	6.26	7	179	133.07	4.87	95.8%	3.41 (17.8)	0.12
Middle Fortine Creek	36.86	87.03	202	5.48	8	206	171.15	4.64	95.3%	2.56 (13.3)	0.07
Sinclair Creek	12.63	23.55	9	0.71	7	16	11.74	0.93	47.3%	0.04 (0.2)	0.00
Swamp Creek-Lake Creek	45.25	75.04	127	2.81	0	128	152.73	3.38	99.8%	0.54 (2.8)	0.01
Therriault Creek	21.13	39.87	50	2.37	13	65	59.02	2.79	84.1%	0.82 (4.3)	0.04
Tobacco River	62.53	88.94	104	1.66	30	131	233.75	3.74	76.7%	2.91(15.2)	0.05
Upper Fortine Creek	39.24	88.99	164	4.18	11	176	137.79	3.51	94.2%	1.12 (5.8)	0.03
Total	366.13	741.17	1231	3.36	105	1345	1325.97	3.62	90.4%	19.19 (100)	0.05

Table G2-6. Unpaved Road Crossings by Ownership and Landscape Type

Ownership	2010	Federal			Private			State			
Watershed	303(d)	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Total
Deep Creek	Yes	0	25	9	0	11	0	0	0	0	59
Edna Creek	Yes	0	0	68	0	1	51	0	0	0	12
Indian Creek	No	0	0	0	4	0	0	3	0	1	10
Lower Fortine Creek	Yes	0	96	39	0	87	9	0	0	0	1
Meadow Creek	No	0	4	75	0	39	42	0	0	11	91
Middle Fortine Creek	Yes	0	1	117	0	7	39	0	0	38	21
Sinclair Creek	No	0	0	5	1	3	0	0	0	0	46
Swamp Creek-Lake Creek	Yes	0	0	118	0	0	9	0	0	0	120
Therriault Creek	Yes	0	7	14	0	26	3	0	0	0	147
Tobacco River	Yes	0	39	25	8	29	1	0	2	0	121
Upper Fortine Creek	Yes	0	0	155	0	0	8	0	0	1	73
Total		0	172	625	13	203	162	3	2	51	1231

Table G2-7. Detailed Length (miles) of Parallel Road Segments Within 50-Feet of Streams

Ownership	**2010**	**Federal**			**Private**			**State**			
SubWatershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Total**
Deep Creek	Yes	0.0	0.5	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.7
Edna Creek	Yes	0.0	0.0	1.2	0.0	0.0	0.8	0.0	0.0	0.0	2.0
Indian Creek	No	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.3
Lower Fortine Creek	Yes	0.0	2.2	0.6	0.0	1.8	0.2	0.0	0.1	0.0	4.9
Meadow Creek	No	0.0	0.1	1.6	0.0	0.6	0.9	0.0	0.0	0.2	3.4
Middle Fortine Creek	Yes	0.0	0.0	1.7	0.0	0.0	0.4	0.0	0.0	0.4	2.6
Sinclair Creek	No	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp Creek-Lake Creek	Yes	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.5
Therriault Creek	Yes	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.8
Tobacco River	Yes	0.1	1.4	0.6	0.1	0.7	0.0	0.0	0.0	0.0	2.9
Upper Fortine Creek	Yes	0.0	0.0	1.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1
Total		0.1	4.4	7.3	0.3	3.8	2.5	0.1	0.1	0.6	19.2

G3.0 ROAD NETWORK LOAD ANALYSIS

This section uses the **Section G2.0** information to extrapolate road loads at a watershed scale.

G3.1 SEDIMENT LOAD FROM ROAD CROSSINGS

Mean unpaved road crossing sediment loads from field assessed sites were used to extrapolate existing loads throughout the entire watershed. Mean loads for unpaved crossings within mountain (0.07 tons/year), foothill (0.04 tons/year), and valley (0.26 tons/year) landscape types were applied to the total number of crossings within the TPA, and further classified by 6th code HUC and land ownership. The existing total Tobacco River watershed sediment load from unpaved road crossings was estimated at 77.9 tons/year (**Table G3-1**). Detailed sediment loads for road crossings classified by ownership and landscape type within each 6th code/303(d) subwatershed are included in **Table G3-2**.

Table G3-1. Sediment Load Summary from Unpaved Road Crossings – Existing Conditions

Road Feature	Landscape Type	Total Number of Crossings	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)
Crossing	Mountain	838	0.07	58.7
Crossing	Foothill	377	0.04	15.1
Crossing	Valley	16	0.26	4.2
Total:		1231		77.9

Using the above described landscape extrapolation approach, the total sediment load from unpaved crossings was 77.9 tons/year from a total of 1231 crossings, or an average of 0.075 tons/year/crossing across all land units. Per **Table G2-6** the majority of sediment load is generated from crossings on Federal land (50.63 tons/year), followed by private land (22.84 tons/year), and State land (4.43 tons/year). This equates to approximately 0.06 tons/year per crossing on federal land and also to approximately 0.06 tons/year per crossing on private lands. The value for state land is higher at 0.08 tons/year per crossing, but this value is based on only one sampled location.

Road crossing results showed that the Middle Fortine Creek (13.90 tons/year), Upper Fortine Creek (11.48 tons/year), and the Upper Fortine Creek / Meadow Creek (both segments 10.68 tons/year) contained the three highest sediment loads from unpaved road crossings (**Table G3-2**). Lime Creek, also a 303(d) impaired water, is located within the Middle Fortine Creek subwatershed. Lime Creek includes 50 unpaved road crossings, 49 of which are within the Mountain landscape and 1 which is in the Foothill landscape. This results in an extrapolated sediment load of 3.5 tons/year for Lime Creek. In other words, of the 13.9 tons/year extrapolated load for the Middle Fortine Creek subwatershed, 3.5 tons is from the Lime Creek portion of this subwatershed.

Note that the **Table G3-2** results are summarized by HUC and impaired subwatersheds. To obtain the load for the complete Fortine Creek and Tobacco River watersheds, some subwatershed areas must be summed. The annual summed sediment loads by impaired waters are:

- Deep Creek: 2.1 tons/year
- Edna Creek: 8.4 tons/year
- Sinclair Creek: 0.7 tons/year
- Swamp Creek: 8.9 tons/year
- Therriault Creek: 2.5 tons/year

- Fortine Creek: 65.5 tons (includes everything except Tobacco River, Therriault Creek Sinclair Creek, and Indian Creek).
- Tobacco River: 77.9 tons (includes all loads)

Table G3-2. Detailed Sediment Load From Unpaved Road Crossings by HUC /303(d) Subwatershed – Existing Conditions

Ownership	**2010**	**Federal Land**			**Private**			**State**			**Total**
SubWatershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Load (t/y)**
Deep Creek	Yes	0	1	0.63	0	0.44	0	0	0	0	2.07
Edna Creek	Yes	0	0	4.76	0	0.04	3.57	0	0	0	8.37
Indian Creek	No	0	0	0	1.04	0	0	0.78	0	0.07	1.89
Lower Fortine Creek	Yes	0	3.84	2.73	0	3.48	0.63	0	0	0	10.68
Meadow Creek	No	0	0.16	5.25	0	1.56	2.94	0	0	0.77	10.68
Middle Fortine Creek	Yes	0	0.04	8.19	0	0.28	2.73	0	0	2.66	13.90
Sinclair Creek	No	0	0	0.35	0.26	0.12	0	0	0	0	0.73
Swamp Creek-Lake Creek	Yes	0	0	8.26	0	0	0.63	0	0	0	8.89
Therriault Creek	Yes	0	0.28	0.98	0	1.04	0.21	0	0	0	2.51
Tobacco River	Yes	0	1.56	1.75	2.08	1.16	0.07	0	0.08	0	6.70
Upper Fortine Creek	Yes	0	0	10.85	0	0	0.56	0	0	0.07	11.48
Total		0	6.88	43.75	3.38	8.12	11.34	0.78	0.08	3.57	77.9

G3.2 SEDIMENT LOAD FROM PARALLEL ROADS

As identified in **Table G2.1**, there are approximately 19.2 miles of parallel road segment within 50 feet of a stream in the watershed. A load is determined using the same extrapolation value for all landscape types because of the relatively small sample size, the similar loading results for the mountain and foothill landscape types where the majority of parallel sites are located, and the relatively low sediment contribution in comparison to the unpaved road crossings. The contributing length of the assessed parallel segments equates to approximately 0.6 mile, and the contributing load from these assessed segments equals 0.28 tons. If it assumed that the 0.6 miles assessed is a fractional representation of the total 19.2 miles of parallel road segments within 50 feet, then the total modeled load from parallel segments would equal 9.0 tons per year. Each watershed's existing unpaved parallel road load can be determined using the percentage of parallel road segment within each watershed (**Table G2.7**). Note that the **Table G2.8** results are summarized by subwatersheds. To obtain the load for the complete Fortine Creek watershed, some subwatershed areas must be summed. This results in the following contributions:

- Deep Creek: 0.33 tons/year
- Edna Creek: 0.93 tons/year
- Sinclair Creek: 0.02 tons/year
- Swamp Creek: 0.2 tons/year
- Therriault Creek: 0.4 tons/year
- Fortine Creek: 8.56 tons
- Tobacco River: 9.0 tons

Not included in **Table G2.7** is a parallel road length value for Lime Creek, where there are 50 unpaved road crossings. A contribution from Lime Creek can be calculated using the percentage of these crossings to all crossings (50/1231 or 4%), multiplied by the total 9.0 ton load to provide an estimate of parallel road segment sediment contribution. This results in an estimated load of 0.4 tons/year for Lime Creek parallel road segments, which would be a subset of the total Fortine Creek load.

G3.3 GRAVE CREEK ROAD SEDIMENT LOAD

The total Tobacco River TPA load of 77.9 tons/year does not include Grave Creek loading. The road load from Grave Creek should be added to this value to accurately account for all road sediment loading to the Tobacco River since Grave Creek is a major tributary to the Tobacco River.

Roads sediment loading for the Grave Creek TMDL (Montana Department of Environmental Quality, et al., 2005) source assessment was modeled using a different type of WEPP: Road application that resulted in 203 tons/year contribution from road crossings and parallel segments. This is from the Grave Creek watershed where there was a road density of about 2 to 2.5 miles per square mile and a total road length of about 170 miles. This is significantly lower road density and total road length than the remainder of the Tobacco watershed (i.e., the Tobacco TPA) where there is a road density of about 3.6 miles per square mile and a total road length of about 1,326 miles. The significantly higher modeled load in the Grave Creek watershed provides an example of how differing TMDL assessment approaches can result in very different total load values. Since no calibration has been performed for either assessment approach, the sediment loads within each evaluation can be considered as relative loads among the various roads within the specific modeled project area, but should not be considered actual load values.

In order to provide a Grave Creek road load to the Tobacco River that is consistent with the method described in this appendix, total road length is used as an indicator for sediment loading in both watersheds. The ratio of Grave Creek total road length to the Tobacco TPA road length is therefore used to extrapolate an equivalent Grave Creek road load for Tobacco TPA comparison purposes. The resulting road length ratio of 0.13 (170/1326) is multiplied by the total Tobacco road sediment load for road crossings, resulting in a total estimated Grave Creek road load of 10 tons per year ((0.13)(78)). This same approach for parallel segments results in a load estimate of about 1 ton per year.

G3.4 Sediment Load from Road Sand

An estimate of road sand loading from paved roads can be made for the 105 paved road crossings by using the unpaved road results summarized in this appendix along with road sand loading estimates from previous TMDL projects. The average contributing length of all unpaved crossings is 228 feet (**Attachment C**). If this value is assumed similar for the 105 paved crossings, then there would be a total of 4.5 miles of paved road length with about 136 tons of road sand applied within the contributing length of paved road crossings.

For the Blackfoot Headwaters TPA DEQ assumed a delivery rate of 5% for roads within 100 to 200 feet and 10% for roads within 100 feet of surfacewater. DEQ assumed similar delivery rates for contributing paved road lengths along the Swan TPA, with a 5% delivery for low potential sites and a 10% delivery rate for high potential sites. Using an average delivery rate value of 7.5% for all paved Tobacco road crossings would result in a total yearly road sand load of about 10 tons prior to 2008.

Per Table 2.6, about 10% of the parallel segments within 50 feet of a stream are paved; resulting in about 2 miles of paved roads within 50 feet of a stream. If a 10% delivery is assumed for these segments consistent with approaches used in the Blackfoot Headwaters and Swan TMDL documents, then the additional road sand load from parallel paved segments would equate to 6 tons per year (2 miles x 30 tons sand applied per mile x 10%).

Of the above computed total road sand load of 16 tons, 30% is linked to State road maintenance and would represent loading prior to 2008 only, reducing the existing (post 2008) load to about 11 tons/year from road sanding throughout the Tobacco TPA.

G4.0 Culvert Assessment

Culverts were analyzed for their ability to allow for fish passage, and for their ability to pass adequate flood flows. Of the 50 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, eight (8) culverts were determined to be suitable for fish passage assessment and forty-seven (47) were suitable for culvert failure potential (**Figure G6**).

G4.1 Fish Passage

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 (U.S. Forest

Service Alaska Region, 2002). The analysis uses site-specific information to classify culverts as green (passing all lifestages 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, 4 of 8 culverts (50%) were classified as partial or total fish barriers, and 4 of 8 (50%) 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 G4-1** and **Table G4-2**).

Table G4-1. Fish Passage Analysis for Selected Culverts

Culvert Classification or Indicator	Definition of Indicator	Number of Culverts	Percentage of Total Culverts Assessed (n = 8)
Green(1)	High certainty of meeting juvenile fish passage at all flows	0	0%
Grey(2)	Additional and more detailed analysis is required to determine juvenile fish passage ability	4	50%
Red(3)	High certainty of not providing juvenile fish passage at all desired streamflows	4	50%

Table G4-2. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria

Location ID	Structure Type	Structure Diameter or Dimensions	Culvert width (ft)	Structure Gradient (%)	Culvert slope	Bankfill (BF) in Riffle Above Culvert (ft)	Culvert /BF ratio	Fill Height (ft)	Fill Width (ft)	Fill Length (ft)	Fill Volume (Fill Height x width x Bf)	Outlet Invert (inches)	Final Classification
MFTN-M-5A	Wood Culvert	24"	2	1.0%	1(2)	2.5	0.80(1)	2.5	18	15	4.17	0(1)	GREY(2)
TOB-F-23	CMP	2'	2	4.0%	4(3)	3	0.67(2)	1	16	120	1.78	2(2)	RED(3)
MFTN-M-7A	CMP	24"	2	1.5%	1.5(3)	4	0.50(2)	5	22	15	16.30	1(2)	RED(3)
UFTN-M-32	CMP	2'	2	6.0%	6(3)	6	0.33(3)	6.5	30	27	43.33	7(3)	RED(3)
UFTN-M-30	CMP	3.5'	3.5	3.0%	3(3)	12	0.29(3)	3	37	22	49.33	0.5(2)	RED(3)
MC-F-35	CMP	5'	5	2.0%	2(2)	4	1.3(1)	0.5	28	25		0(1)	GREY(2)
UFTN-M-3A	Squash CMP	36"H x 54"W	4.5	1.0%	1(2)	4	1.1(1)	2	20	12	0.00	0(1)	GREY(2)
LFTN-F-10A	CMP (square)	72"H x 84"W	7	1.5%	1.5(2)	10	0.7(2)	1.5	18	12	10.00	0(1)	GREY(2)

Constriction ratios less than 1.0 not only indicate a potential fish passage problem, but also an increased potential for culvert failure. Five of the eight culverts assessed (63%) have a constriction ratio less than 1.0.

Many of the assessed culverts could not be assessed for fish passage because the bankfull width was not available (23 culverts) or the bankfull width was zero due to the lack of a defined stream channel as shown in **Photograph G1**. These culverts would not be viable for a year-round fish population. An example of a culvert assessed for fish passage is shown in **Photograph G2**; UFTN-M-3A was classified as Grey in the fish passage analysis.

Photograph G1. THR-F-19A

Photograph G2. UFTN-M-3A

G4.2 Culvert Failure Potential

Each culvert with available data was evaluated to determine peak flow using USGS regression equations developed by Omang (1992) for un-gaged sites, and flow estimates using Manning's equation. Using the regression equations, peak discharge flows were developed for the 2-, 5-, 10-, 25-, 50-, and 100-

recurring intervals for each selected culvert. Montana is divided into eight hydrologic regions, with a unique set of equations developed for each region. The Tobacco River TPA is located in the West Region for Omang equations; independent variables within these equations are drainage area (square miles) and precipitation (inches). Drainage area above each culvert was calculated using a digital elevation model (DEM) and the ArcSwat extension in GIS. The average mean annual precipitation was calculated within each drainage area from a mean precipitation layer available on NRIS (Prism Group, 2004).

Using site-specific culvert information collected in the field (including material, shape, dimensions, and slope) a peak flow was also calculated using Manning's equation. Variables in Manning's equation are culvert area, hydraulic radius, slope, and roughness coefficient (based on culvert material). The peak flow calculated using Manning's equation was compared with Omang values to estimate the maximum storm event that each culvert could convey without water backup. The number of culverts passing each specific storm event is shown in **Table G4-3**. Data for each culvert is shown in **Table G4-4**.

Table G4-3. Percent of Culverts Passing Design Storm Events

Design Storm Event	Number of Culverts Passing	Number of Culverts Failing Design Flow	Cumulative Percent Passing (All)	Cumulative Percent Passing (Federal)	Cumulative Percent Passing (Private)
Total Culverts	47		100%	100%	100%
Q2	42	5	89%	94%	73%
Q5	38	9	81%	89%	55%
Q10	36	11	77%	86%	46%
Q25	29	18	62%	69%	36%
Q50	29	18	62%	69%	36%
Q100	27	20	57%	66%	27%

Table G4-4. Culvert Failure Analysis

Site ID	Ownership	Peak Discharge Results Using Omang Equations Formula Variables											Peak Discharge Results Using Manning's Equation, pipes flowing full Formula Variables					
		Area - A (sqmi)	Avg Precip - p (in)	Structure	Volume of fill at risk (tons)	CMP Diameter or Height (ft)	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)	Streambed Materials in Culvert	Roughness Coefficient[1]	Slope %	Velocity (ft/sec)	Peak Flow (cfs)	Max. Conveyance Manning's > Omang
DEP-F-11A	Private	0.17	20.8	CMP	0	1.5	0.7	1.5	2.1	3.0	3.7	4.4	N/A	0.035	1.0	2.21	3.90	Passes All
DEP-F-12A	Federal	0.55	25.5	CMP	0	1.5	3.0	5.7	7.9	10.6	13.1	15.3	N/A	0.035	5.0	4.94	8.72	<Q25
DEP-F-15A	Federal	0.24	33.9	CMP	1.8	2.5	2.1	3.9	5.3	7.2	8.9	10.4	N/A	0.035	1.5	3.80	18.66	Passes All
EN-M-03	Federal	0.07	30.4	CMP	9.4	1.5	0.5	1.1	1.5	2.1	2.7	3.2	No	0.035	6.0	5.41	9.56	Passes All
EN-M-04	Federal	0.22	26.4	CMP	9.0	1.5	1.3	2.6	3.7	5.0	6.2	7.4	Yes	0.035	4.0	4.42	7.80	Passes All
EN-M-06	Federal	0.64	25.1	CMP	16.4	2	3.3	6.3	8.8	11.8	14.6	17.0	No	0.035	8.0	7.57	23.77	Passes All
EN-M-07	Federal	10.91	29.6	CMP	66	10	61.9	101.9	136.3	171.0	204.2	231.0	Yes	0.035	2.0	11.06	868.66	Passes All
INC-V-26	Private	0.06	14.6	CMP	5.9	1.5	0.2	0.4	0.6	0.8	1.0	1.2	No	0.035	4.0	4.42	7.80	Passes All
INC-V-27	Private	4.26	37.0	CMP	172.3	2	35.6	58.4	77.9	98.2	117.9	134.0	No	0.035	4.0	5.35	16.81	<Q2
INC-V-28	State	0.02	20.0	CMP	N/A	1.5	0.1	0.2	0.3	0.4	0.5	0.6	No	0.035	2.0	3.12	5.52	Passes All
LFTN-F-10A	Federal	2.94	34.0	CMP (square)	6.5	7	22.1	37.5	50.4	64.3	77.6	88.7	No	0.035	1.5	7.55	317.15	Passes All
LFTN-M-08	Federal	0.04	19.5	CMP	1.0	1.5	0.2	0.4	0.6	0.8	1.0	1.3	No	0.035	2.0	3.12	5.52	Passes All
LFTN-F-09	Private	0.08	16.4	CMP	11.0	1.5	0.3	0.6	0.8	1.2	1.5	1.8	No	0.035	3.0	3.82	6.76	Passes All
LFTN-F-09A	Federal	0.46	17.7	CMP	5.4	2.5	1.5	3.0	4.2	5.9	7.3	8.6	N/A	0.035	1.5	3.80	18.66	Passes All
MC-F-19	Private	6.97	27.5	CMP	23.7	4	36.4	61.8	83.4	106.1	127.4	145.0	Yes	0.035	1.0	4.25	53.35	<Q5
MC-F-35	Private	19.54	24.5	CMP	1.8	5	80.6	134.1	180.3	226.2	269.6	304.4	No	0.035	2.0	6.97	136.81	<Q10
MC-M-16	Federal	0.08	28.3	CMP	13.8	2	0.6	1.2	1.6	2.3	2.9	3.4	No	0.035	3.0	4.63	14.55	Passes All
MC-M-17	Federal	0.88	26.0	CMP	91.5	1.5	4.8	8.9	12.3	16.3	20.1	23.3	No	0.035	5.0	4.94	8.72	<Q5
MC-M-18	Private	1.68	25.1	CMP	6.5	3	8.3	15.2	21.0	27.6	33.7	38.9	No	0.035	1.0	3.50	24.77	<Q25
MFTN-M-33	Federal	0.74	32.0	CMP	15.6	2	5.5	10.0	13.7	18.1	22.1	25.7	No	0.035	4.0	5.35	16.81	<Q25
MFTN-M-5A	Federal	1.49	27.0	Wood Culvert	3.4	2	8.3	15.0	20.6	27.1	33.0	38.2	Yes	0.035	1.0	2.67	8.40	<Q5
MFTN-M-6A	Federal	0.42	30.7	CMP	6.5	1.5	3.1	5.8	7.9	10.6	13.1	15.3	N/A	0.035	5.0	4.94	8.72	<Q25
MFTN-M-7A	Private	1.48	31.0	CMP	10.8	2	10.1	17.9	24.4	31.8	38.7	44.6	No	0.035	1.5	3.28	10.29	<Q5
MFTN-M-8A	Federal	0.11	34.6	CMP	1.6	1.5	1.0	2.0	2.8	3.8	4.7	5.6	N/A	0.035	1.5	2.70	4.78	<Q100
SWP-M-01	Federal	0.93	24.7	CMP	15.8	3	4.6	8.7	12.1	16.1	19.7	23.0	No	0.035	1.0	3.50	24.77	Passes All
SWP-M-10	Federal	0.52	30.7	CMP	4.2	2	3.7	6.8	9.4	12.5	15.4	18.0	No	0.035	9.0	8.02	25.21	Passes All
SWP-M-11	Federal	0.53	28.4	CMP	21.1	3	3.4	6.3	8.8	11.7	14.4	16.8	No	0.035	5.0	7.84	55.40	Passes All
SWP-M-12	Federal	0.39	24.9	CMP	11.8	3	2.1	4.0	5.6	7.6	9.4	11.0	No	0.035	12.0	12.14	85.82	Passes All
SWP-M-13	Federal	1.38	26.7	(2) CMP	31.8	3	7.6	13.8	19.0	25.0	30.5	35.3	No	0.035	2.0	4.96	70.07	Passes All
SWP-M-02	Federal	0.63	30.0	CMP	120.6	3	4.3	8.0	10.9	14.5	17.8	20.8	No	0.035	10.0	11.08	78.34	Passes All
THR-F-18A	Federal	1.51	16.3	CMP	2.2	1.5	4.0	7.8	11.1	15.0	18.5	21.6	N/A	0.035	1.0	2.21	3.90	<Q2
THR-F-19A	Federal	0.56	22.4	CMP	2.2	2	2.5	4.8	6.8	9.2	11.4	13.3	N/A	0.035	1.0	2.67	8.40	<Q25
THR-M-20A	Private	1.88	44.2	CMP	2.7	1.5	21.5	35.4	47.1	59.7	72.0	82.2	N/A	0.035	1.0	2.21	3.90	<Q2
TOB-F-20	Federal	0.20	20.4	CMP	6.5	1.5	0.8	1.7	2.4	3.4	4.3	5.0	No	0.035	10.0	6.98	12.34	Passes All
TOB-F-22	Federal	6.69	20.2	CMP	1.4	1.5	22.1	39.7	54.6	70.8	85.6	98.1	No	0.035	2.0	3.12	5.52	<Q2
TOB-F-23	Federal	0.08	19.2	CMP	12.9	2	0.3	0.7	1.0	1.4	1.8	2.2	No	0.035	4.0	5.35	16.81	Passes All
TOB-F-24	Federal	0.04	18.0	CMP	13.1	2	0.1	0.3	0.5	0.7	0.9	1.0	No	0.035	3.0	4.63	14.55	Passes All
TOB-F-25	Private	3.23	22.9	CMP	8.1	1.5	13.4	24.3	33.5	43.7	53.1	61.1	No	0.035	2.0	3.12	5.52	<Q2
TOB-F-36	Federal	0.61	22.9	CMP	12.1	1.5	2.8	5.4	7.6	10.2	12.6	14.8	Yes	0.035	3.0	3.82	6.76	<Q10
UFTN-M-14a	Private	0.12	24.9	CMP	1.1	1.5	0.7	1.4	2.0	2.8	3.6	4.2	No	0.035	1.0	2.21	3.90	<Q100
UFTN-M-15	Federal	1.71	26.1	Squash CMP	10.0	4	9.0	16.3	22.3	29.3	35.7	41.3	No	0.035	2.0	6.00	75.45	Passes All
UFTN-M-02A	Federal	0.20	25.0	CMP	4.3	1.5	1.1	2.2	3.1	4.2	5.3	6.3	No	0.035	5.0	4.94	8.72	Passes All
UFTN-M-30	Federal	2.03	31.8	CMP	28.4	3.5	14.2	24.6	33.4	43.1	52.3	60.1	No	0.035	3.0	6.73	64.73	Passes All
UFTN-M-31	Federal	0.08	29.0	CMP	9.7	1.5	0.6	1.2	1.7	2.4	3.0	3.6	No	0.035	7.0	5.84	10.32	Passes All

Table G4-4. Culvert Failure Analysis

Site ID	Ownership	Peak Discharge Results Using Omang Equations Formula Variables											Peak Discharge Results Using Manning's Equation, pipes flowing full Formula Variables					
		Area - A (sqmi)	Avg Precip - p (in)	Structure	Volume of fill at risk (tons)	CMP Diameter or Height (ft)	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)	Streambed Materials in Culvert	Roughness Coefficient[1]	Slope %	Velocity (ft/sec)	Peak Flow (cfs)	Max. Conveyance Manning's > Omang
UFTN-M-32	Federal	1.04	28.1	CMP	37.8	2	6.3	11.5	15.8	20.8	25.4	29.5	No	0.035	6.0	6.55	20.58	<Q25
UFTN-M-03A	Federal	1.46	28.9	Squash CMP	3.4	3	9.0	16.1	22.1	28.8	35.2	40.6	Yes	0.035	1.0	3.50	24.77	<Q25
UFTN-M-04A	Federal	0.07	27.4	CMP	1.6	1.5	0.5	0.9	1.3	1.9	2.3	2.8	N/A	0.035	1.0	2.21	3.90	Passes All

[1] Derived from: Manning's Equation Roughness Coefficient References: Wanielista, M., Kersten, R., & Eaglin, R. (1997). Hydrology, Water Quantity and Control, 2nd Ed., New York: John Wiley & Sons, Inc.
Corrugated metal pipe, maximum roughness for 6 by 2 in. corrugations

As peak discharge increases, so does the percentage of culverts incapable of passing the greater flows. Based on the peak flow analysis, it appears that most culverts were designed to pass the Q100 flow, as the majority of culverts (57%) passed the Q100 (**Table G4-3**). However, there were 18 culverts (38%) that failed to pass the Q25 design flow. Note that the culvert flow capabilities for the federal crossings are significantly greater than for private crossings (**Table G4-3**). For example, 69% of the federal crossings passed the Q25, whereas only 36% of the private crossings passed this flow event. Many of the private crossings did not pass the 2, 5 or 10 year flow events, indicating a significant culvert failure risk for this category of culverts.

It is difficult to develop a specific road crossing load estimate for sediment delivered in the event of a culvert failure, as there are several factors that may impact the accuracy of the data. First, peak flows generated using the USGS regression equations are subject to large standard errors that may substantially over or underestimate peak discharge. In addition, peak flows generated using Manning's equation rely heavily on culvert slope. Slope values measured during field activities were estimated using a handheld inclinometer where accessible and visual estimates were recorded where access or use of an inclinometer was not possible. Different slope estimates may lead to variations in peak flow calculations. Second, the culvert assessment was conducted on a small subset of culverts, which may or may not be representative of the entire Tobacco TPA. Third, it is difficult if not impossible to estimate which culverts will fail in any given year, and what percentage of at-risk fill material will be delivered to the stream. Some culvert failure might be mitigated by the ability to store excess runoff at the road crossing where there is significant freeboard between the top of the culvert and the road crossing location where runoff would overtop the road. Due to these difficulties in sediment delivery estimation, specific sediment loads were not developed for each crossing.

G5.0 Application of Best Management Practices

Sediment impacts are widespread throughout the Tobacco 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.

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. 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. This 200-foot BMP scenario is a general approximation of achievable modeled load reductions to help develop road crossing sediment load allocations. Field surveillance of existing road BMPs in portions of the Tobacco watershed reveals that the application of BMPs has reduced or has the ability to reduce the contributing length to less 100 feet for many or most road crossings. Ultimately, restoration efforts would need to consider site-specific BMPs that, on average, would likely be represented by the modeling assumptions. Load reductions from potential culvert failures could be addressed on a case-by-case basis depending on a number of evaluation factors such as design flow conveyance, constriction ratio, or fill at risk of being delivered.

G5.1 Contributing Road Length Reduction Scenario

A contributing road length reduction scenario for unpaved road crossings was selected assuming a length reduction to 200 feet (100-feet on each side of a crossing or 200-feet on one side). 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. Reduced mean sediment loads were then extrapolated to the entire watershed in the same manner in which the existing sediment loads were calculated. For the 200-foot BMP scenario, mean sediment loads would be reduced from 0.07 tons/year to 0.03 tons/year for mountain crossings, from 0.04 tons/year to 0.02 tons/year for foothill crossings, and from 0.26 tons/year to 0.05 tons/year for valley crossings. Estimated summary load reductions by landscape type are show in **Table G5-1**.

Table G5-1. Estimated Sediment Load Summary – Reduce Crossing Length to 200-feet

Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)	Load Reduction %
Mountain	838	0.03	25.14	57.0%
Foothill	377	0.02	7.54	50.0%
Valley	16	0.05	0.80	80.6%
Total:	1231		33.48	57.0%

Total sediment load from road crossings would be reduced from 77.9 tons/year to 33.5 tons/year (57.0% reduction), assuming all sites had a minimum 200-foot contributing length BMP applied.

The most significant reduction in total sediment load occurs in the mountain landscape type due to the overall percentage of mountain landscape (59.1%) and crossing density (3.88 crossing/sq.mile). Estimated total sediment load reductions for crossings with 200-foot contributing length BMP applications were also classified by 6th code HUC/303(d) watershed (**Table G5-2A and G5-2B**). When evaluated by ownership, the federal road crossing percent reduction calculates to a 56% reduction from 50.6 tons/year to 22.2 tons/year. The private road crossing percent reduction calculates to a 58% reduction from 22.8 to 9.6 tons/year.

Lime Creek is a sub-watershed of Middle Fortine Creek and therefore not included in the below table. Lime Creek has 50 unpaved road crossings, 49 of which are in the Mountain landscape type and 1 which is in the Foothills landscape type. This results in a total sediment load of 3.5 tons/year from unpaved road crossings. Application of the **Table G5-1** reductions to the Lime Creek watershed results in a sediment load of 1.5 tons/year.

Table G5-2A. Estimated Sediment Load from Unpaved Road Crossings – Reduce Length to 200-feet

Ownership	2010	Federal Land			Private			State			Total
Watershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Load (t/y)**
Deep Creek	Yes	0.00	0.50	0.27	0.00	0.22	0.00	0.00	0.00	0.00	0.99
Edna Creek	Yes	0.00	0.00	2.04	0.00	0.02	1.53	0.00	0.00	0.00	3.59
Indian Creek	No	0.00	0.00	0.00	0.20	0.00	0.00	0.15	0.00	0.03	0.38
Lower Fortine Creek	Yes	0.00	1.92	1.17	0.00	1.74	0.27	0.00	0.00	0.00	5.10
Meadow Creek	No	0.00	0.08	2.25	0.00	0.78	1.26	0.00	0.00	0.33	4.70
Middle Fortine Creek	Yes	0.00	0.02	3.51	0.00	0.14	1.17	0.00	0.00	1.14	5.98
Sinclair Creek	No	0.00	0.00	0.15	0.05	0.06	0.00	0.00	0.00	0.00	0.26
Swamp Creek-Lake Creek	Yes	0.00	0.00	3.54	0.00	0.00	0.27	0.00	0.00	0.00	3.81
Therriault Creek	Yes	0.00	0.14	0.42	0.00	0.52	0.09	0.00	0.00	0.00	1.17
Tobacco River	Yes	0.00	0.78	0.75	0.40	0.58	0.03	0.00	0.04	0.00	2.58
Upper Fortine Creek	Yes	0.00	0.00	4.65	0.00	0.00	0.24	0.00	0.00	0.03	4.92
Total		0.00	3.44	18.75	0.65	4.06	4.86	0.15	0.04	1.53	33.48

Table G5-2B. Total Sediment Load Reductions from Unpaved Road Network: 200-feet Crossing BMP

Watershed	2010 303(d)	Total Sediment Load From Unpaved Roads Existing Conditions (tons/year)	Total Sediment Load After 200-ft Crossing Road Length BMPs (tons/year)	Percent Reduction in Load After 200-ft Crossing Road Length BMPs (tons/year)
Deep Creek	Yes	2.07	0.99	52.2%
Edna Creek	Yes	8.37	3.59	57.1%
Indian Creek	No	1.89	0.38	79.9%
Lower Fortine Creek	Yes	10.68	5.10	52.2%
Meadow Creek	No	10.68	4.70	56.0%
Middle Fortine Creek	Yes	13.90	5.98	57.0%
Sinclair Creek	No	0.73	0.26	64.4%
Swamp Creek-Lake Creek	Yes	8.89	3.81	57.1%
Therriault Creek	Yes	2.51	1.17	53.4%
Tobacco River	Yes	6.70	2.58	61.5%
Upper Fortine Creek	Yes	11.48	4.92	57.1%
Total		77.9	33.48	57.0%

G5.2 Assessment of Existing BMPs

The presence of BMPs was noted for each of the field-assessed stream crossing sites. Of the 50 sites, 35 had at least one of the following: graveled surface, water bar, culvert drain, drive through dip, or a road swale. Results are shown in **Figure G7**. Sample sizes for each category are included in the legend on the graph. Almost all noted BMPs were applied at the federal road crossing locations. Of the 37 federal crossings, 27 (73%) had at least one type of BMP, whereas only 2 of the 12 private crossings (17%) had at least one type of BMP. The lone state crossing evaluated had no apparent BMPs in place.

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 G7** are preliminary due to the small sample sizes; however it appears that the absence of traffic eliminates sediment yield regardless of the presence of BMPs. The presence of gravel minimally improves sediment yield as noted in the comparison of the following categories: 0&1, 2&4, 3&5. The water bar or equivalent BMP to reduce road contributing length appeared to be the most effective BMP whether alone or in combination with other BMPs (categories 2, 4, and 6 through 12) for the Tobacco River assessed crossings. WEPP software does not allow for specific modeling of BMPs and the results may not completely indicate effectiveness.

G5.3 Culvert Replacement Recommendations

USFS documentation (U.S. Department of Agriculture, Forest Service, 1995) recommends that as old culverts are replaced, new culverts should be designed to pass the 100-year flow event. It is recommended that all culvert crossings in the Tobacco TPA be upgraded to pass the Q100 flood event. It is also recommended that culvert replacements be completed in a manner that allows for full fish and Aquatic Organism Passage (AOP) on fish-bearing streams. Specifically, culverts would be sized with constriction ratios at 1.0 or greater, and with a goal of re-creating the stream channel through the crossing to match those channel conditions outside of the crossing influence.

The identification of priority culverts for replacement should be on the following factors:
1.) Inability to pass the Q25 design flow;
2.) Constriction ratio <0.75;
3.) Location on a perennial fish bearing stream; and
4.) Fill at risk of being delivered to stream exceeds the median value of 8.6 tons/crossing.

Achieving full culvert replacement could take many years to complete if only addressed during major road upgrades or after some form of failure. This would result in continued potentially significant loads from culvert failures in the foreseeable future. Nevertheless, even if done over time, the replacement of culverts failing the above criteria will significantly reduce sediment loading potential. Because this culvert assessment work was intended as a coarse screening tool, additional evaluation should be conducted to prioritize culvert replacement work and verify conditions for each potentially undersized culvert in the watershed.

G5.4 Additional BMPs

As an alternative to or in combination with reductions in contributing road length or crossing density, 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.

G6.0 REFERENCES

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FIGURES

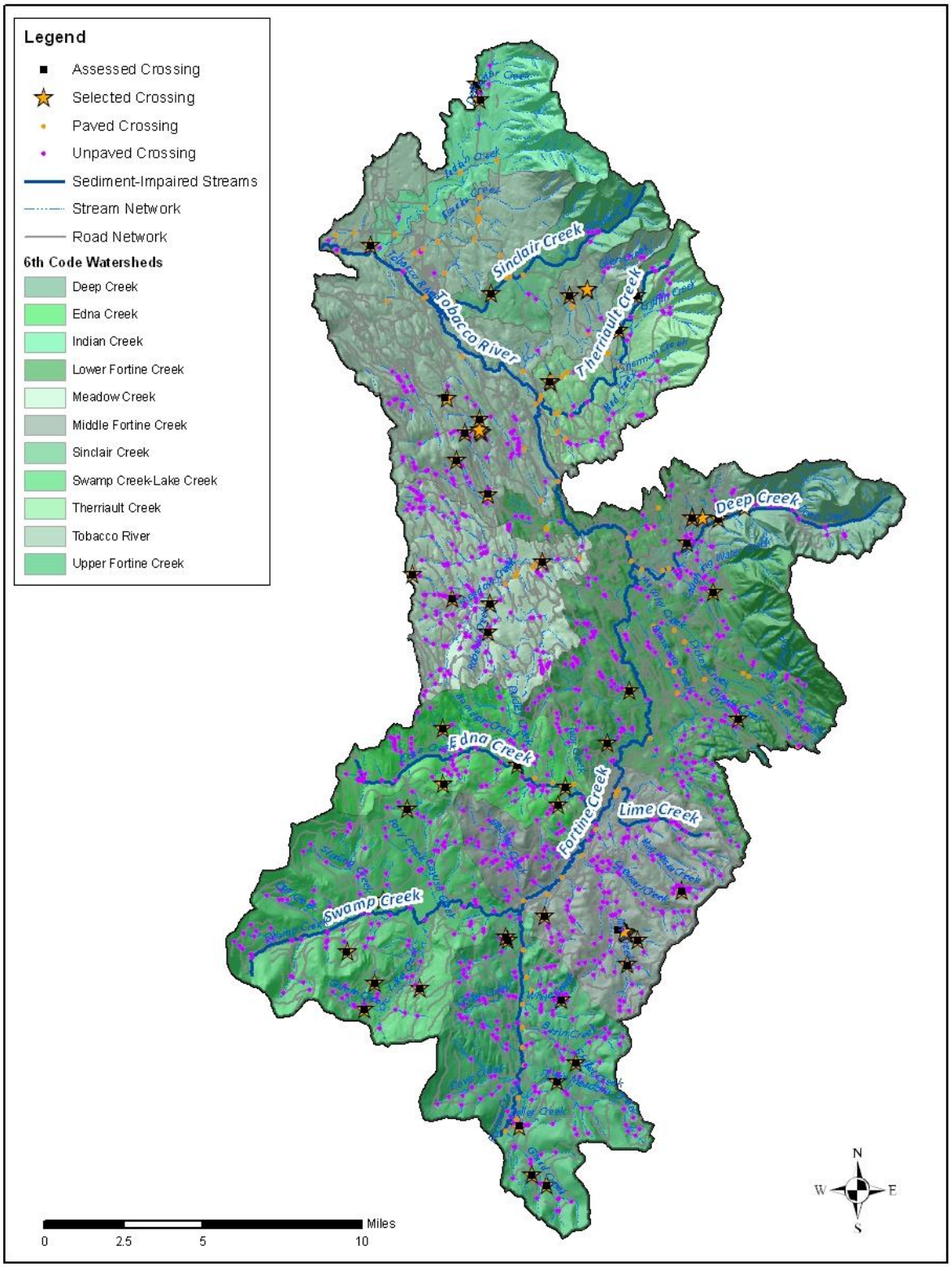

Figure G1. Road Crossings by 6th Code Subwatershed

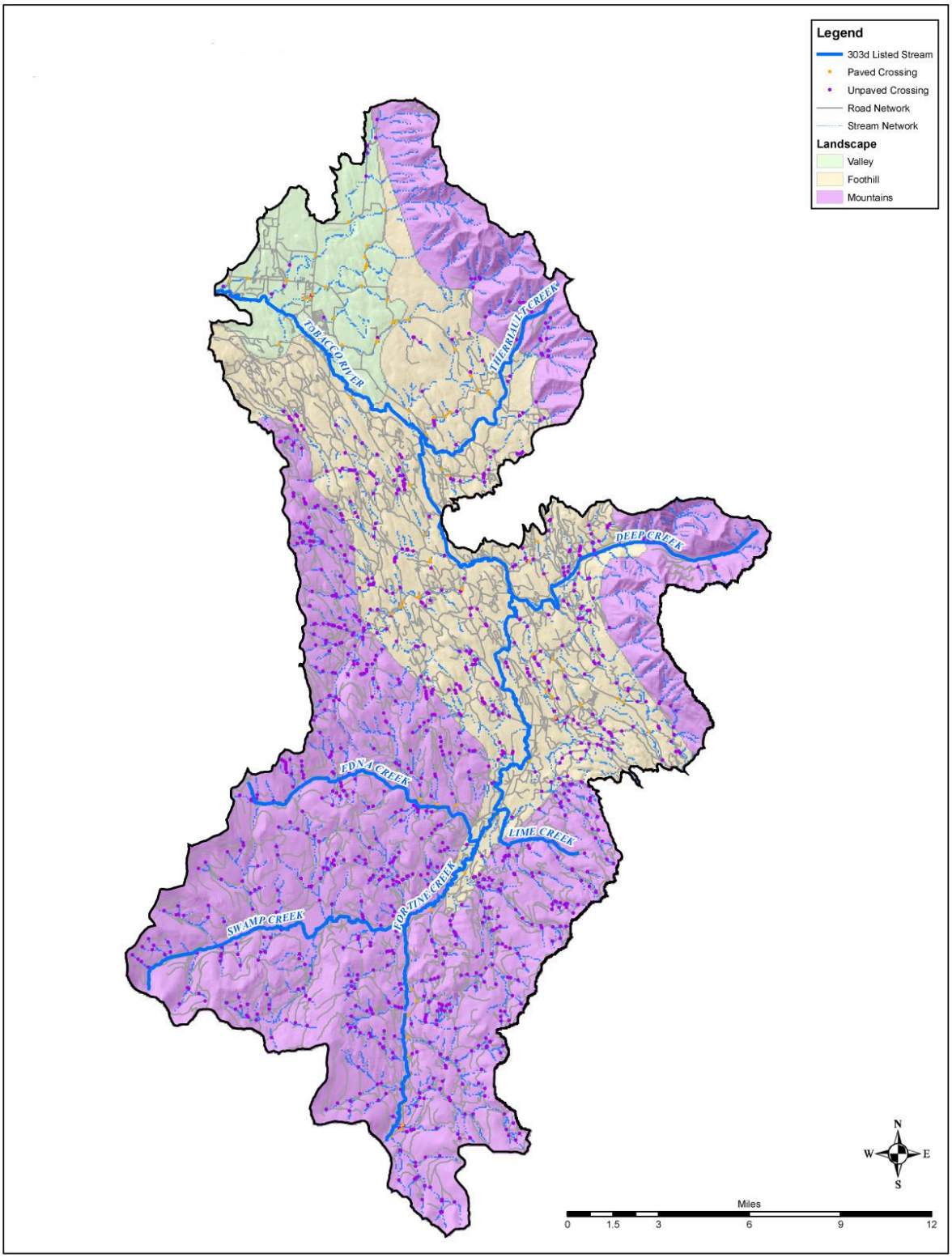

Figure G2. Road Crossings by Landscape Type

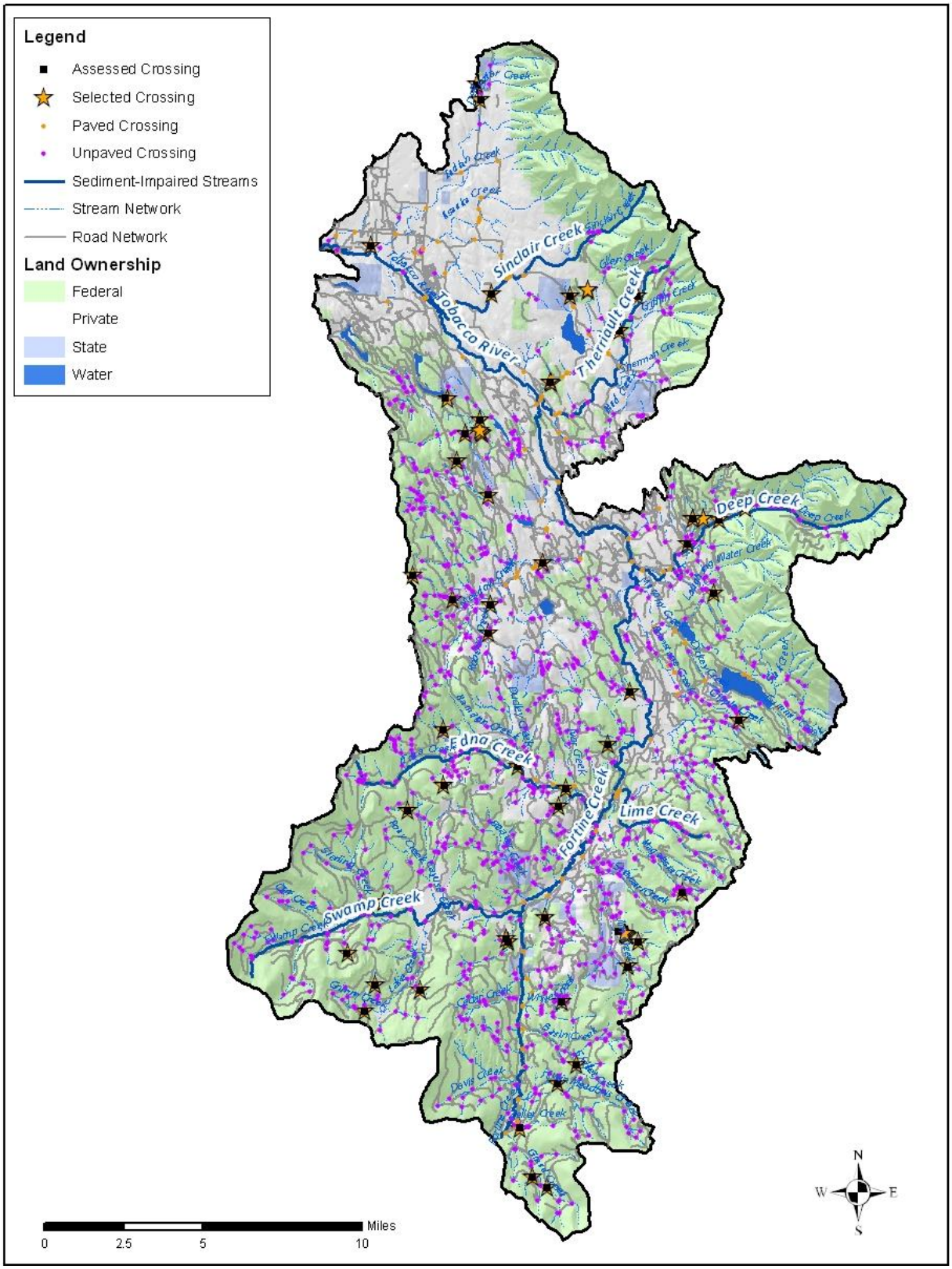

Figure G3. Road Crossings by Land Ownership

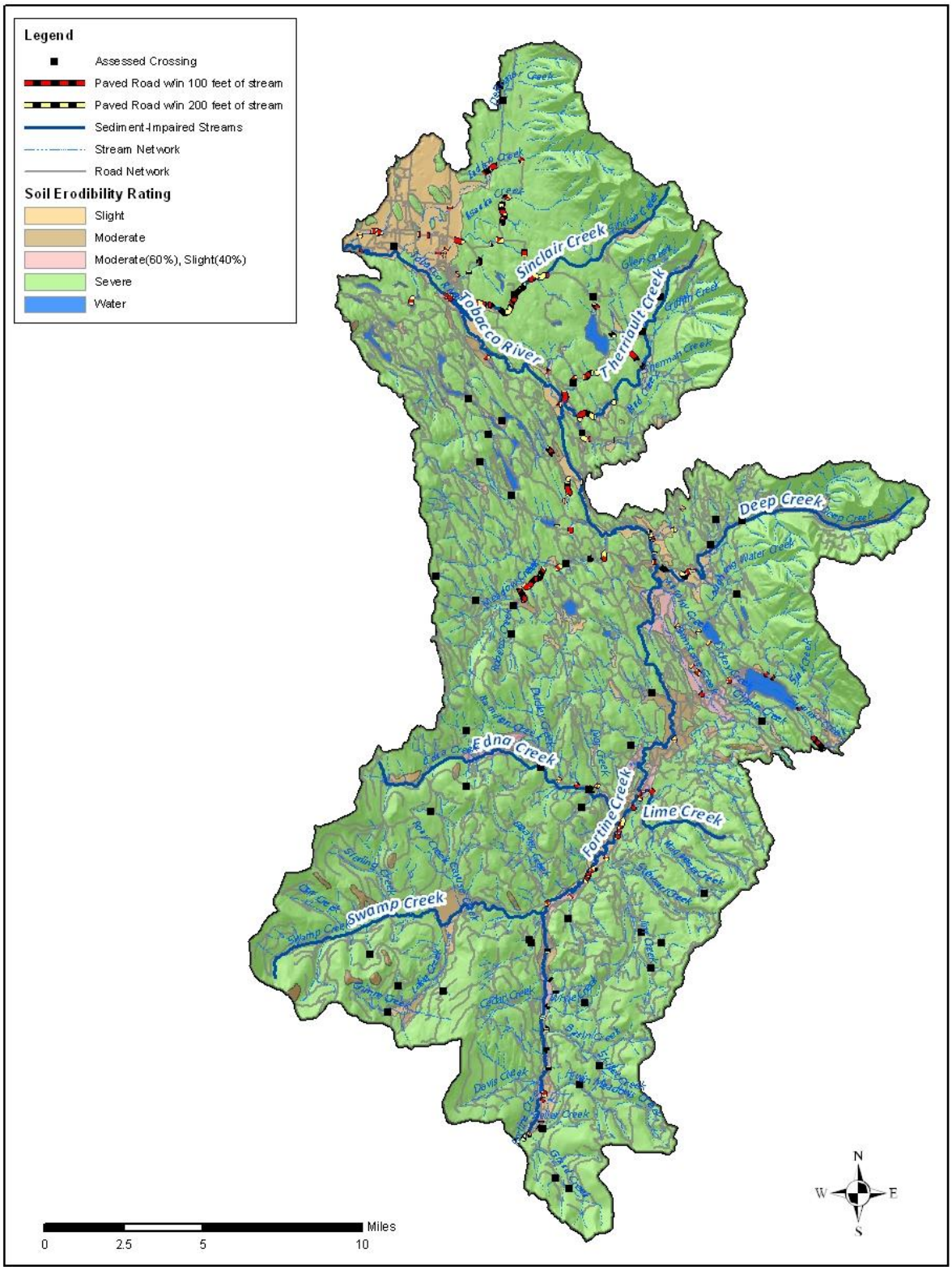

Figure G4. Road Crossings by Soil Erosion Hazard Classification

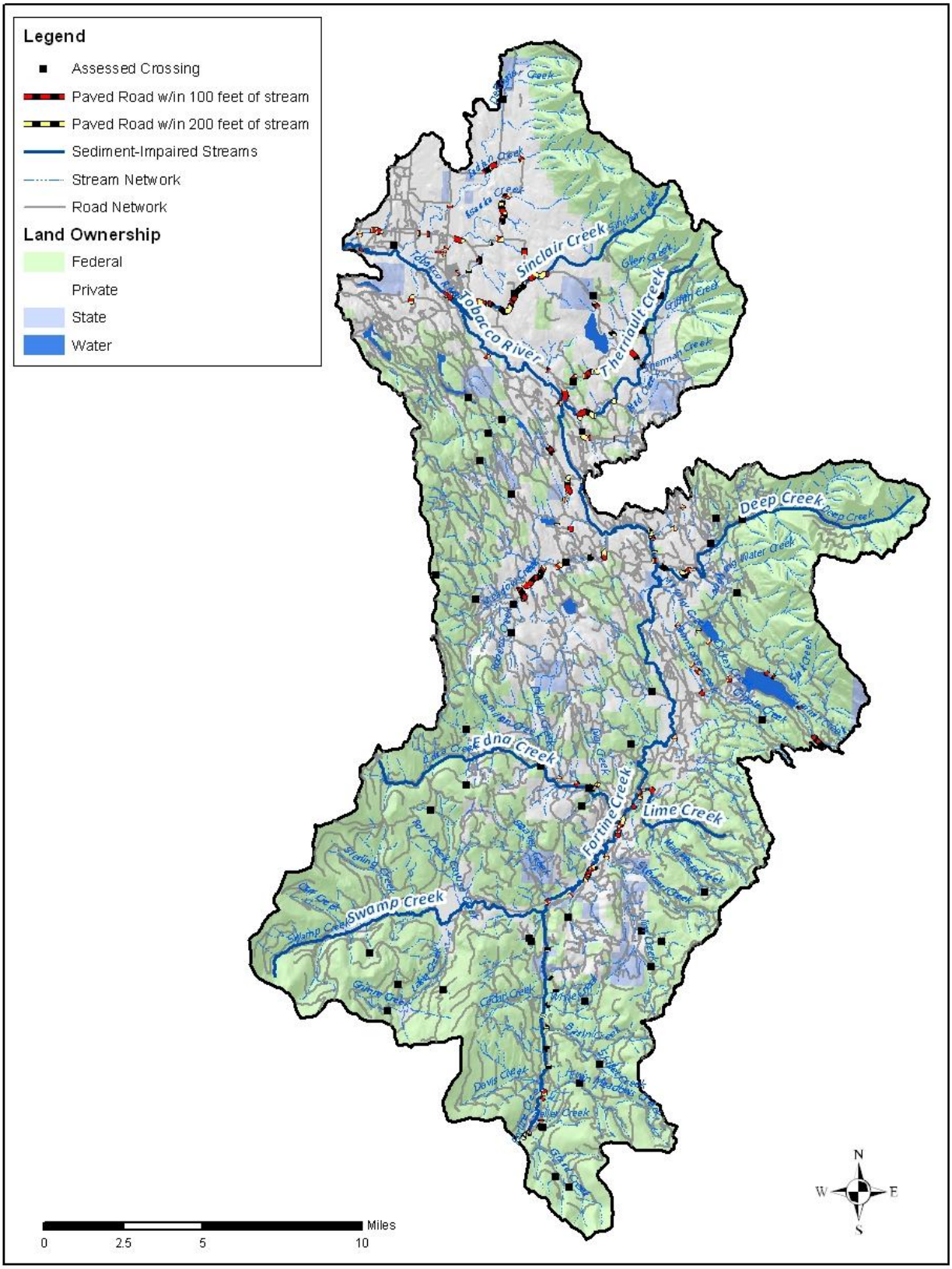

Figure G5. Paved Roads within 100 feet and within 200-Feet of Surface Water

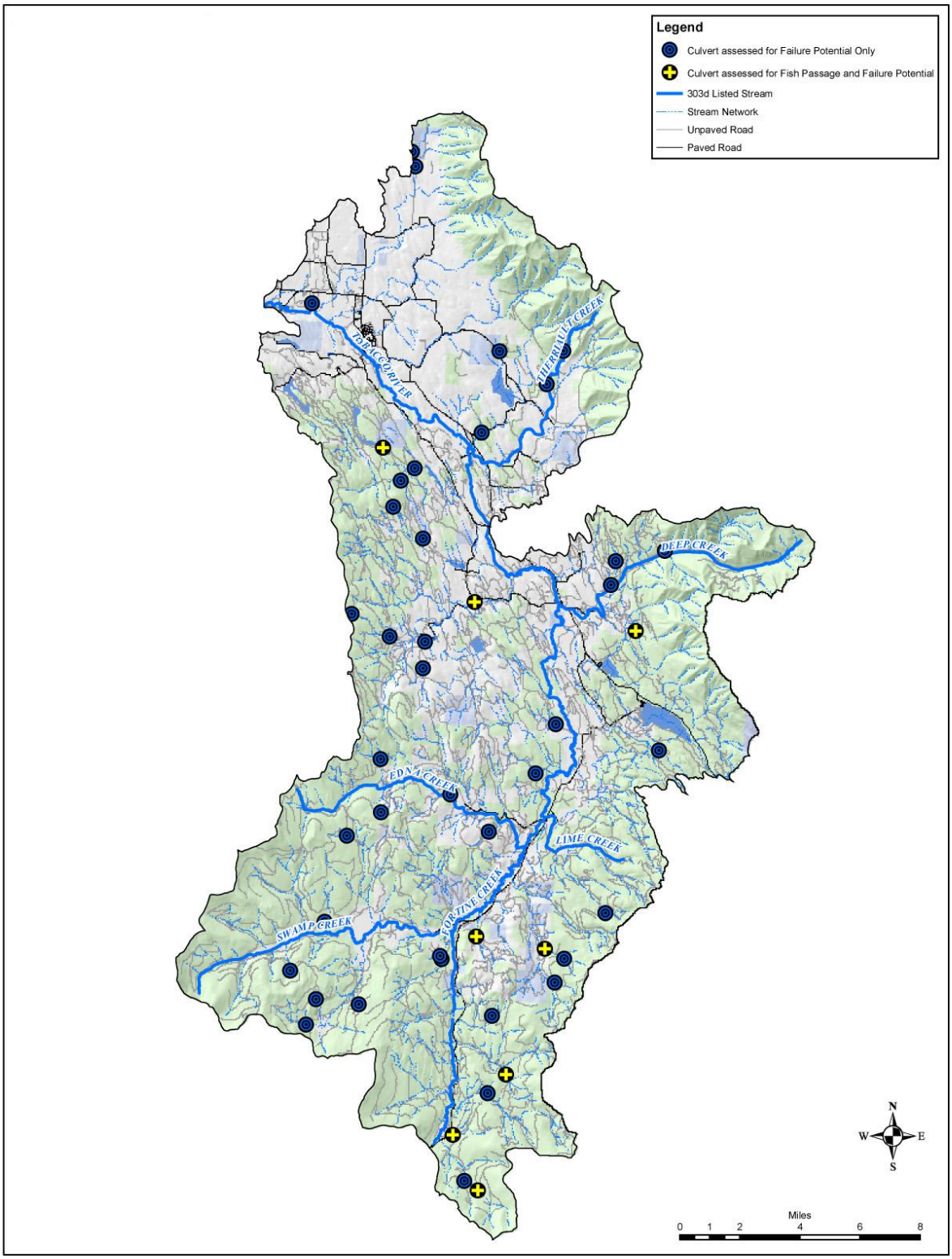

Figure G6. Culverts Assessed for Fish Passage and Failure Potential

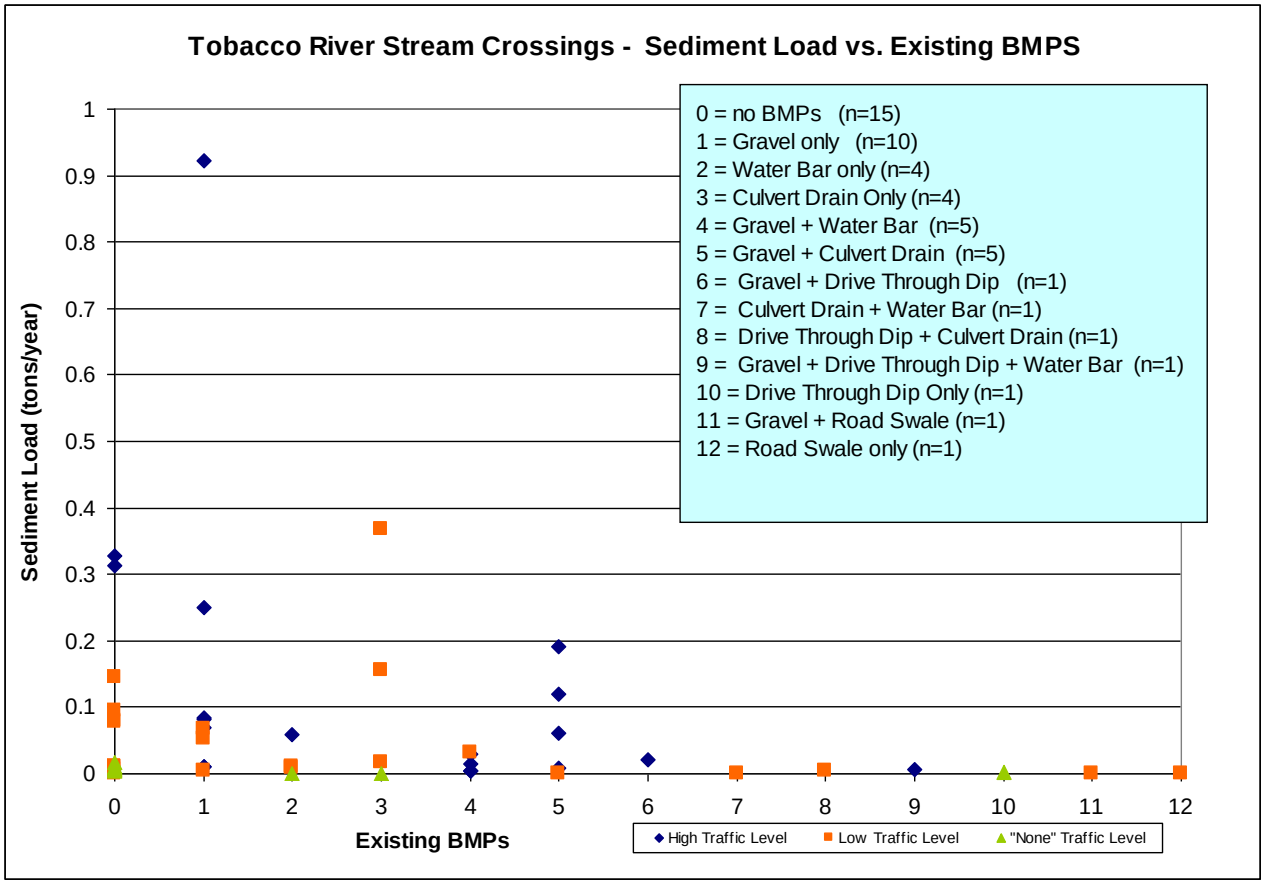

Figure G7. WEPP sediment results for each BMP category

ATTACHMENT A - FIELD ASSESSMENT SITE LOCATION DATA

Table A5. Field Assessment Site Location Information

SITE ID	X	Y	SITEID	X	Y
DEP-F-11A	-114.8617	48.7743	MFTN-M-8A	-114.8494	48.6165
DEP-F-12A	-114.8593	48.7859	SNC-V-29	-115.0084	48.8812
DEP-F-15A	-114.8241	48.7924	SWP-M-01	-115.0523	48.6029
DEP-F-16A	-114.8414	48.7864	SWP-M-02	-115.0405	48.6451
ENA-M-01A	-114.9336	48.6602	SWP-M-10	-115.0233	48.5644
ENA-M-03	-115.0171	48.6574	SWP-M-11	-115.0749	48.5784
ENA-M-04	-115.0201	48.6829	SWP-M-12	-115.0545	48.5654
ENA-M-06	-114.9378	48.6518	SWP-M-13	-115.0605	48.5529
ENA-M-07	-114.9676	48.6684	THR-F-18A	-114.9633	48.8431
INC-V-26	-115.0934	48.8994	THR-F-19A	-114.9184	48.8686
INC-V-27	-115.0251	48.9686	THR-M-20A	-114.9080	48.8850
INC-V-28	-115.0283	48.9755	TOB-F-20	-115.0196	48.8173
LFTN-F-09	-114.8946	48.7055	TOB-F-22	-115.0103	48.8238
LFTN-F-09A	-114.8184	48.6965	TOB-F-23	-115.0344	48.8326
LFTN-F-10A	-114.8413	48.7529	TOB-F-24	-115.0237	48.8046
LFTN-M-08	-114.9068	48.6812	TOB-F-25	-115.0006	48.7903
MC-F-19	-114.9938	48.7408	TOB-F-36	-114.9543	48.8828
MC-F-35	-114.9598	48.7615	UFTN-M-02A	-114.9256	48.5262
MC-M-16	-115.0485	48.7516	UFTN-M-03A	-114.9133	48.5357
MC-M-17	-115.0198	48.7421	UFTN-M-04A	-114.9262	48.5635
MC-M-18	-114.9938	48.7280	UFTN-M-14	-114.9669	48.5905
MFTN-M-33	-114.8769	48.5932	UFTN-M-15	-114.9657	48.5890
MFTN-M-5A	-114.9417	48.6011	UFTN-M-30	-114.9278	48.4791
MFTN-M-6A	-114.8827	48.5815	UFTN-M-31	-114.9380	48.4832
MFTN-M-7A	-114.8910	48.5973	UFTN-M-32	-114.9488	48.5050

ATTACHMENT B - WEPP: ROAD MODEL ADJUSTMENTS

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.

ATTACHMENT C - WEPP: ROAD MODELING RESULTS FOR FIELD ASSESSED SITES

Table C-1. WEPP: Road Modeling Results for Field Assessed Crossings

Comment	Climate	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)
Valley Crossings																	
INC-V-26	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	5	230	22	25	9	0.3	1	80	0.2	0	153	138
UNKN-V-27a	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	10	594	26	102	24	0.3	1	90	0.4	0	1953	1844
UNKN-V-27b	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	9	275	31	102	24	0.3	1	90				
UNKN-V-28	Eureka	Silty Loam	50	Outsloped, rutted	graveled low	6	530	14	87	9	0.3	1	75	0.2	0	111	105
SNC-V-29	Eureka	Silty Loam	50	Outsloped, rutted	graveled low	4	101	10	48	12	0.3	1	70	0.2	0	9	8
Valley Results							433									Mean (t/yr)	0.26
														25th	0.040	Median	0.06
														75th	0.28	Maximum	0.92
																Minimum	0.00
Mountain Crossings																	
UFTN-M-2A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	5	262	14	70	16	0.3	1	0	0.1	0	135	29
UFTN-M-3A	Olney	Silty Loam	30	Outsloped, rutted	native high	4	453	10	84	7	0.3	1	10	0.9	1.1	785	656
UFTN-M-4A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	1	100	14	70	9	0.3	1	0	0	0	42	7
MFTN-M-5A	Olney	Silty Loam	30	Insloped, bare ditch	native high	5	309	14	84	6	0.3	1	5	0.8	1	865	625
MFTN-M-6A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	6	250	15	70	10	0.3	1	0	0.1	0	154	42
MFTN-M-7A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	1	137	15	78	8	0.3	1	0	0.1	0	62	11
MFTN-M-8A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	5	388	16	70	8	0.3	1	0	0.1	0	232	60
THR-M-20A	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	9	361	14	32	8	0.3	1	0	0.5	0.1	439	381
SWP-M-01	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	3	49	14	82	12	0.3	1	30	0.2	0.1	18	8
SWP-M-02	Olney	Silty Loam	30	Outsloped, unrutted	native low	3	67	12	98	25	0.3	1	10	0	0	8	1
ENA-M-03	Olney	Silty Loam	30	Outsloped, unrutted	native low	9	168	15	85	9	0.3	1	4	0.2	0.1	50	16
ENA-M-04	Olney	Silty Loam	30	Outsloped, rutted	native none	4	78	14	83	15	0.3	1	10	0.2	0.2	15	5
ENA-M-06	Olney	Silty Loam	30	Outsloped, rutted	native high	5	95	20	102	13	0.3	1	40	0.6	0.4	164	117
ENA-M-07	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	8	40	26	110	14	0.3	1	60	0.1	0	25	15
LFTN-M-08	Olney	Silty Loam	30	Outsloped, rutted	graveled high	5	406	15.5	80	3	0.3	1	70	0.2	0	182	167
SWP-M-10	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native none	2	16	22	35	9	0.3	1	0	0.1	0	4	0
SWP-M-11 (extra)	Olney	Silty Loam	30	Outsloped, rutted	native low	3	90	22	81	18	0.3	1	25	0.3	0.2	46	33
SWP-M-12	Olney	Silty Loam	30	Outsloped, rutted	native low	9	132	21.5	94	33	0.3	1	65	0.8	0.4	428	313
SWP-M-13a	Olney	Silty Loam	30	Outsloped, rutted	native low	2	54	12	100	9	0.3	1	15	1	1.3	365	292
SWP-M-13b	Olney	Silty Loam	30	Outsloped, rutted	native low	5	395	12	100	9	0.3	1	15				
UFTN-M-14a	Olney	Silty Loam	30	Outsloped, rutted	native low	2	13	12	50	4	0.3	1	25	0.8	0.9	24	13
UFTN-M-14b	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	2	164	18	5	4	0.3	1	25				
UFTN-M-15	Olney	Silty Loam	30	Outsloped, rutted	native low	6	512	15	62	19	0.3	1	20	0.8	0.9	893	735
MC-M-16	Olney	Silty Loam	30	Outsloped, rutted	graveled high	5	103	13	35	13	0.3	1	60	0.1	0	27	19
MC-M-17	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	7	380	18	50	41	0.3	1	45	0.2	0	235	239
MC-M-18a	Olney	Silty Loam	30	Outsloped, rutted	native low	5	205	16	10	4	0.3	1	0	1.5	1.7	247	188
MC-M-18b	Olney	Silty Loam	30	Outsloped, rutted	native low	6	246	16	10	4	0.3	1	0				

Table C-1. WEPP: Road Modeling Results for Field Assessed Crossings

Comment	Climate	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)
FTN-M-30	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled low	5	413	8	90	17	0.3	1	80	0.4	0	70	63
FTN-M-30	Olney	Silty Loam	30	Outsloped, rutted	graveled low	5	413	8	90	17	0.3	1	80				
FTN-M-31	Olney	Silty Loam	30	Outsloped, unrutted	native none	10	50	11	111	14	0.3	1	5	0.1	0	10	1
FTN-M-32	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	8	53	9	133	15	0.3	1	45	0.5	0.2	46	22
MFTN-M-33	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native none	4	161	22	70	16	0.3	1	15	0.4	0.5	41	19
ENA-M-1A	Olney	Sandy Loam	30	Outsloped, unrutted	graveled high	5	53	19	55	13	0.3	1	0	0.1	0	25	9
Mountain Results							214									Mean (t/yr)	0.07
														25th	0.006	Median	0.01
														75th	0.09	Maximum	0.37
																Minimum	0.00
Foothill Crossings																	
DEP-F-11A	Fortine	Loam	50	Outsloped, rutted	native none	3	178	9	18	1	0.3	1	0	1.4	0.8	21	13
LFTN-F-10A	Fortine	Sandy Loam	50	Outsloped, unrutted	native low	1	10	14	47	8	0.3	1	10	0	0	0	0
LFTN-F-9A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled low	2	250	11	58	9	0.3	1	0	0	0	20	2
DEP-F-12A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled low	2	478	11	0.3	10	0.3	1	0	0	0	38	0
DEP-F-15A	Fortine	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled high	5	810	18	120	1	0.3	1	0	0.4	0	545	501
DEP-F-16A	Fortine	Silty Loam	50	Outsloped, rutted	native none	3	250	8	0.3	1	0.3	1	10	0.9	0.5	27	15
THR-F-18A	Fortine	Silty Loam	50	Outsloped, rutted	native none	6	165	14	63	10	0.3	1	15	0.5	0.2	58	32
THR-F-19A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled high	3	126	20	100	5	0.3	1	0	0.1	0	73	20
LFTN-F-09	Fortine	Silty Loam	50	Outsloped, rutted	graveled high	8	218	13.5	62	8	0.3	1	80	0.2	0	190	163
LFTN-F-09	Fortine	Silty Loam	50	Insloped, bare ditch	graveled high	8	218	13.5	62	8	0.3	1	80				
MC-F-19	Fortine	Silty Loam	50	Outsloped, rutted	native low	4	29	13	40	5	0.3	1	45	0.4	0.1	4	1
TOB-F-20	Fortine	Silty Loam	50	Outsloped, rutted	native none	8	90	10	8	12	0.3	1	10	0.2	0.1	22	7
TOB-F-22	Fortine	Silty Loam	50	Outsloped, rutted	native low	8	102	9	150	3	0.3	1	10	0.6	0.2	32	20
TOB-F-23	Fortine	Silty Loam	50	Outsloped, rutted	native low	5	410	9	60	9	0.3	1	20	0.9	0.4	187	161
TOB-F-24a	Fortine	Silty Loam	50	Outsloped, rutted	native low	5	242	11	46	1	0.3	1	10	1.5	0.7	189	156
TOB-F-24b	Fortine	Silty Loam	50	Outsloped, rutted	native low	4	307	12	48	15	0.3	1	10				
TOB-F-25	Fortine	Silty Loam	50	Outsloped, rutted	native low	7	116	9.5	50	7	0.3	1	5	0.5	0.1	28	19
MC-F-35a	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	9	810	8	90	9	0.3	1	75	0.2	0	146	136
MC-F-35b	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	8	320	8	90	9	0.3	1	75				
TOB-F-36	Fortine	Silty Loam	50	Outsloped, rutted	graveled high	5	270	24	100	9	0.3	1	60	0.1	0	138	122
Foothill Results							305									Mean (t/yr)	0.04
														25th	0.004	Median	0.01
														75th	0.07	Maximum	0.25
																Minimum	0.00
Total Crossing Data							262									Mean (t/yr)	0.08
														25th	0.005	Median	0.01
														75th	0.080	Maximum	0.92
																Minimum	0.00

Table C-2. WEPP: Road Modeling Results for Field Assessed Parallel Segments

Comment	Climate	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)
Foothill Parallel																	
DEP-F-13A-P	Fortine	Loam	50	Outsloped, unrutted	native none	1	200	6	0.3	1	1	20	57	0	0	9	0
DEP-F-14A-P	Fortine	Loam	50	Outsloped, rutted	native none	5	1000	6	0.3	1	1	30	5	0.3	0.2	639	78
THR-F-17A-P	Fortine	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled none	3	214	12	0.3	5	0.3	3	0	0.1	0	17	4
TOB-F3-21-Pa	Fortine	Silty Loam	50	Outsloped, rutted	native low	9	528	9	90	16	1	9	20	0.5	0.2	716	254
TOB-FP-21b	Fortine	Silty Loam	50	Outsloped, rutted	native low	6	264	9	40	12	1	11	15	0.2	0.1	113	27
TOB-FP-21b add	Fortine	Silty Loam	50	Outsloped, rutted	native low	8	36	9	0.3	1	0.3	1	15	0.3	0.1	5	1
TOB-F-37b-P	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	5	150	21	74	9	1	97	30	0	0	46	0
Foothill Results																Mean (t/yr)	0.026
																Median	0.002
																Maximum	0.127
																Minimum	0
Mountain Parallel																	
MFTN-M-34a-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	200	9	45	70	0.3	1	20	0.2	0.1	117	78
MFTN-M-34b-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	300	11	35	110	2	8	20	0.1	0.1	348	96
MFTN-M-34c-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	250	11	35	130	2	20	20	0.1	0	247	28
Mountain Results																Mean (t/yr)	0.034
																Median	0.039
																Maximum	0.048
																Minimum	0.014

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 an ecoregion.
Shaded cells in the last four columns were summed either because the road was crowned and was modeled as two widths (inslope and outslope portion) or because of the multiple upstream road sections

APPENDIX H - TOTAL MAXIMUM DAILY LOADS

H.1 SEDIMENT

H.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.

H.1.2 APPROACH

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. Although there is one streamflow gage on the Tobacco River (#12301300) that has been in operation since 1958, it does not have a long-term record for suspended sediment. The closest gage to the Tobacco River TPA with a long-term record of flow and suspended sediment is the USGS station on the Fisher River near Libby (#12302055). Because the Fisher watershed has a similar climate and hydrologic pattern as the Tobacco River watershed, with spring runoff occurring within a similar timeframe and most sediment loading occurring during periods of runoff and high flow, using data from the Fisher River gage is assumed to be a reasonable approach for calculating daily sediment loads in the Tobacco River TPA.

A sediment rating curve was developed using daily flow and suspended solids load data collected from 1967 through 1976, which is the only period of record with available daily suspended sediment data (**Figure H-1**). Sediment load records during January of 1974 were removed from the rating curve because these values corresponded to an extreme flood event that was not deemed representative of typical conditions in the Tobacco River watershed. The daily mean discharge based on 42 years of record (1968-2010) at the USGS gage was then plugged into the equation for the sediment rating curve to get a daily suspended sediment load. Although the suspended sediment load is only a portion of the total load from the source assessment, it provides an approximation of the relationship between sediment and flow in the Tobacco River TPA. Based on the sum of the calculated daily sediment loads, a daily percentage relative to the annual suspended sediment load was calculated for each day. The daily percentages were then applied to the total average annual loads associated with the TMDL percent reductions from **Section 5.0** to determine the average daily load.

To conserve resources, this appendix contains daily loads for the Tobacco River as an example. As discussed in **Section 5.7.3.8**, the TMDL for the Tobacco River is a 11% reduction in the total average annual sediment load, which is roughly equivalent to 20,600 tons/year. The daily percentages discussed above were then multiplied by the annual load of 20,600 tons to get a daily expression of the Tobacco

River TMDL (**Figure H-2, Table H-1**). For all other **waterbodies**, daily TMDLs may be derived by using the daily percentages in **Table H-2** and the TMDLs expressed as an average annual load, which are discussed in **Section 5.7** and presented in **Table H-2**. The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.7** to the daily load.

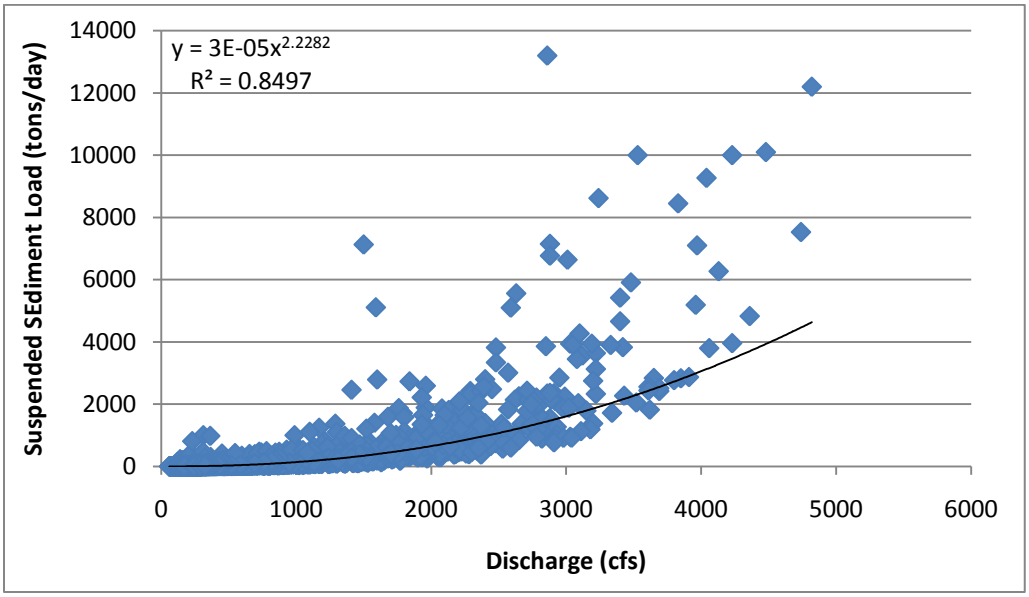

Figure H-1. Sediment Rating Curve for Fisher River based on USGS gage 12302055

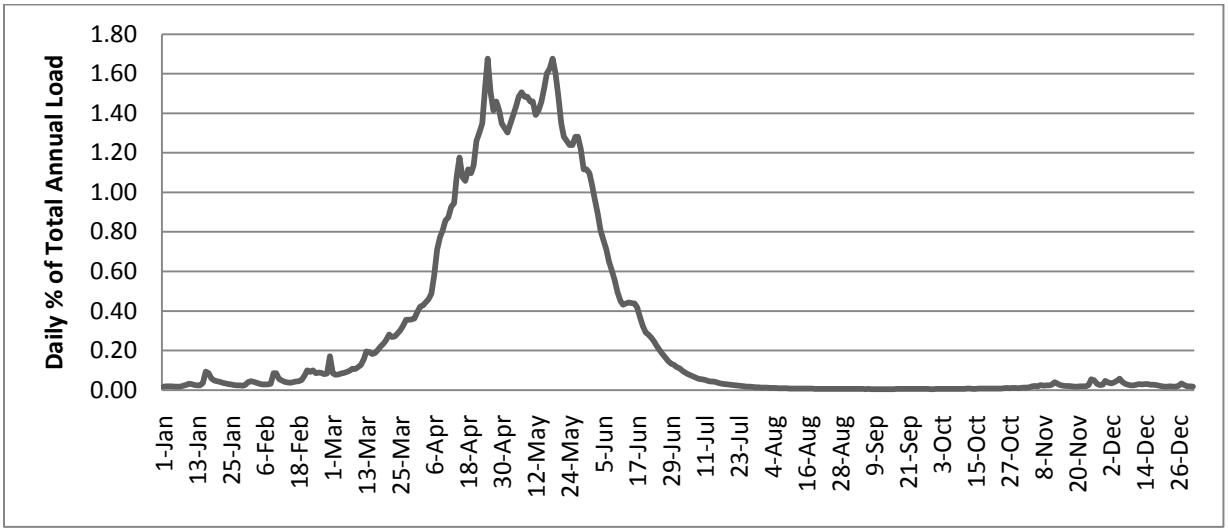

Figure H-2. TMDL for the Tobacco River

Table H-1. Daily Sediment TMDL for the Tobacco River

Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)	Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)
Jan	1	0.02	3.5	Feb	17	0.04	9.2
Jan	2	0.02	3.8	Feb	18	0.05	9.4
Jan	3	0.02	3.8	Feb	19	0.05	10.8

Table H-1. Daily Sediment TMDL for the Tobacco River

Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)	Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)
Jan	4	0.02	4.0	Feb	20	0.07	15.5
Jan	5	0.02	3.7	Feb	21	0.10	20.9
Jan	6	0.02	3.6	Feb	22	0.09	19.2
Jan	7	0.02	3.7	Feb	23	0.10	20.8
Jan	8	0.02	4.6	Feb	24	0.09	17.9
Jan	9	0.03	5.2	Feb	25	0.09	18.4
Jan	10	0.03	6.8	Feb	26	0.09	18.3
Jan	11	0.03	6.4	Feb	27	0.08	16.9
Jan	12	0.03	5.2	Feb	28	0.08	17.5
Jan	13	0.02	4.9	Feb	29	0.17	35.6
Jan	14	0.02	5.0	Mar	1	0.09	17.9
Jan	15	0.04	7.3	Mar	2	0.08	16.2
Jan	16	0.09	19.5	Mar	3	0.08	16.3
Jan	17	0.09	17.8	Mar	4	0.08	17.6
Jan	18	0.06	12.0	Mar	5	0.09	18.1
Jan	19	0.05	10.0	Mar	6	0.09	19.1
Jan	20	0.04	9.3	Mar	7	0.10	20.5
Jan	21	0.04	8.7	Mar	8	0.11	22.4
Jan	22	0.04	7.7	Mar	9	0.11	22.1
Jan	23	0.03	7.0	Mar	10	0.12	24.1
Jan	24	0.03	6.3	Mar	11	0.13	26.4
Jan	25	0.03	6.1	Mar	12	0.16	32.5
Jan	26	0.03	5.4	Mar	13	0.19	40.6
Jan	27	0.02	5.1	Mar	14	0.19	40.1
Jan	28	0.02	4.8	Mar	15	0.18	38.1
Jan	29	0.02	4.7	Mar	16	0.19	39.2
Jan	30	0.02	5.2	Mar	17	0.20	42.5
Jan	31	0.04	8.3	Mar	18	0.22	45.8
Feb	1	0.05	9.5	Mar	19	0.23	48.8
Feb	2	0.04	8.8	Mar	20	0.25	52.9
Feb	3	0.04	7.5	Mar	21	0.28	58.6
Feb	4	0.03	6.6	Mar	22	0.27	56.1
Feb	5	0.03	6.1	Mar	23	0.27	56.6
Feb	6	0.03	5.9	Mar	24	0.29	59.7
Feb	7	0.03	5.9	Mar	25	0.30	63.1
Feb	8	0.03	6.7	Mar	26	0.33	68.1
Feb	9	0.09	17.9	Mar	27	0.36	74.1
Feb	10	0.09	17.8	Mar	28	0.36	74.1
Feb	11	0.06	11.7	Mar	29	0.36	74.5
Feb	12	0.05	9.9	Mar	30	0.36	75.4
Feb	13	0.04	8.7	Mar	31	0.39	82.3
Feb	14	0.04	8.0	Apr	1	0.42	88.0
Feb	15	0.04	7.7	Apr	2	0.43	89.5
Feb	16	0.04	8.3	Apr	3	0.04	9.2
Apr	4	0.44	92.4	May	21	1.48	309.1
Apr	5	0.46	95.7	May	22	1.35	280.7

Table H-1. Daily Sediment TMDL for the Tobacco River

Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)	Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)
Apr	6	0.49	101.4	May	23	1.28	267.1
Apr	7	0.58	121.2	May	24	1.26	262.7
Apr	8	0.71	147.9	May	25	1.24	258.3
Apr	9	0.77	161.1	May	26	1.24	258.3
Apr	10	0.81	168.0	May	27	1.28	267.1
Apr	11	0.86	178.5	May	28	1.28	267.1
Apr	12	0.87	182.2	May	29	1.22	253.9
Apr	13	0.93	193.2	May	30	1.12	232.6
Apr	14	0.94	197.0	May	31	1.12	232.6
Apr	15	1.08	224.4	Jun	1	1.10	228.5
Apr	16	1.18	245.3	Jun	2	1.04	216.4
Apr	17	1.08	224.4	Jun	3	0.96	200.8
Apr	18	1.06	220.4	Jun	4	0.89	185.8
Apr	19	1.12	232.6	Jun	5	0.81	168.0
Apr	20	1.10	228.5	Jun	6	0.76	157.8
Apr	21	1.14	236.8	Jun	7	0.71	147.9
Apr	22	1.26	262.7	Jun	8	0.65	135.6
Apr	23	1.30	271.6	Jun	9	0.61	126.2
Apr	24	1.35	280.7	Jun	10	0.55	115.5
Apr	25	1.53	318.9	Jun	11	0.49	102.7
Apr	26	1.68	349.2	Jun	12	0.45	93.9
Apr	27	1.51	314.0	Jun	13	0.43	89.9
Apr	28	1.41	294.7	Jun	14	0.44	91.4
Apr	29	1.46	304.3	Jun	15	0.44	92.4
Apr	30	1.41	294.7	Jun	16	0.44	91.7
May	1	1.35	280.7	Jun	17	0.44	91.4
May	2	1.32	276.2	Jun	18	0.42	87.3
May	3	1.30	271.6	Jun	19	0.37	76.8
May	4	1.35	280.7	Jun	20	0.32	67.4
May	5	1.39	290.0	Jun	21	0.29	60.7
May	6	1.44	299.5	Jun	22	0.28	58.4
May	7	1.48	309.1	Jun	23	0.26	54.9
May	8	1.51	314.0	Jun	24	0.25	51.3
May	9	1.48	309.1	Jun	25	0.22	46.2
May	10	1.48	309.1	Jun	26	0.20	41.7
May	11	1.46	304.3	Jun	27	0.18	37.8
May	12	1.46	304.3	Jun	28	0.16	33.8
May	13	1.39	290.0	Jun	29	0.15	30.7
May	14	1.41	294.7	Jun	30	0.13	28.0
May	15	1.46	304.3	Jul	1	0.13	26.7
May	16	1.53	318.9	Jul	2	0.12	24.1
May	17	1.60	333.9	Jul	3	0.11	22.8
May	18	1.63	339.0	Jul	4	0.10	20.4
May	19	1.68	349.2	Jul	5	0.09	18.6
May	20	1.60	333.9	Jul	6	0.08	16.9
Jul	7	0.07	15.4	Aug	22	0.01	1.3

Table H-1. Daily Sediment TMDL for the Tobacco River

Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)	Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)
Jul	8	0.07	14.1	Aug	23	0.01	1.3
Jul	9	0.06	12.9	Aug	24	0.01	1.3
Jul	10	0.06	11.7	Aug	25	0.01	1.3
Jul	11	0.06	11.5	Aug	26	0.01	1.3
Jul	12	0.05	10.8	Aug	27	0.01	1.3
Jul	13	0.05	9.8	Aug	28	0.01	1.3
Jul	14	0.04	9.2	Aug	29	0.01	1.2
Jul	15	0.04	9.1	Aug	30	0.01	1.2
Jul	16	0.04	8.3	Aug	31	0.01	1.2
Jul	17	0.04	7.5	Sep	1	0.01	1.2
Jul	18	0.03	6.8	Sep	2	0.01	1.1
Jul	19	0.03	6.3	Sep	3	0.01	1.2
Jul	20	0.03	5.9	Sep	4	0.01	1.2
Jul	21	0.03	5.6	Sep	5	0.01	1.1
Jul	22	0.02	5.1	Sep	6	0.01	1.1
Jul	23	0.02	4.8	Sep	7	0.01	1.1
Jul	24	0.02	4.5	Sep	8	0.01	1.1
Jul	25	0.02	4.1	Sep	9	0.01	1.1
Jul	26	0.02	4.0	Sep	10	0.01	1.1
Jul	27	0.02	3.7	Sep	11	0.01	1.1
Jul	28	0.02	3.5	Sep	12	0.00	1.0
Jul	29	0.02	3.3	Sep	13	0.01	1.1
Jul	30	0.01	3.0	Sep	14	0.01	1.1
Jul	31	0.01	2.9	Sep	15	0.00	1.0
Aug	1	0.01	2.7	Sep	16	0.00	1.0
Aug	2	0.01	2.6	Sep	17	0.01	1.1
Aug	3	0.01	2.5	Sep	18	0.01	1.1
Aug	4	0.01	2.4	Sep	19	0.01	1.3
Aug	5	0.01	2.3	Sep	20	0.01	1.4
Aug	6	0.01	2.2	Sep	21	0.01	1.3
Aug	7	0.01	2.1	Sep	22	0.01	1.3
Aug	8	0.01	2.0	Sep	23	0.01	1.2
Aug	9	0.01	1.9	Sep	24	0.01	1.2
Aug	10	0.01	1.8	Sep	25	0.01	1.1
Aug	11	0.01	1.7	Sep	26	0.01	1.1
Aug	12	0.01	1.7	Sep	27	0.01	1.1
Aug	13	0.01	1.6	Sep	28	0.01	1.1
Aug	14	0.01	1.6	Sep	29	0.01	1.1
Aug	15	0.01	1.5	Sep	30	0.01	1.1
Aug	16	0.01	1.5	Oct	1	0.01	1.1
Aug	17	0.01	1.5	Oct	2	0.01	1.1
Aug	18	0.01	1.5	Oct	3	0.01	1.2
Aug	19	0.01	1.4	Oct	4	0.01	1.2
Aug	20	0.01	1.4	Oct	5	0.01	1.2
Aug	21	0.01	1.3	Oct	6	0.01	1.3
Oct	7	0.01	1.2	Nov	22	0.02	3.9

Table H-1. Daily Sediment TMDL for the Tobacco River

Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)	Month	Day	Daily % of annual load	Tobacco River TMDL (tons/day)
Oct	8	0.01	1.2	Nov	23	0.02	3.8
Oct	9	0.01	1.2	Nov	24	0.02	4.0
Oct	10	0.01	1.2	Nov	25	0.03	5.2
Oct	11	0.01	1.2	Nov	26	0.05	11.4
Oct	12	0.01	1.3	Nov	27	0.05	10.4
Oct	13	0.01	1.5	Nov	28	0.03	6.8
Oct	14	0.01	1.4	Nov	29	0.02	5.2
Oct	15	0.01	1.4	Nov	30	0.03	5.6
Oct	16	0.01	1.4	Dec	1	0.05	9.8
Oct	17	0.01	1.5	Dec	2	0.04	7.8
Oct	18	0.01	1.6	Dec	3	0.03	7.0
Oct	19	0.01	1.5	Dec	4	0.04	7.8
Oct	20	0.01	1.5	Dec	5	0.05	9.5
Oct	21	0.01	1.5	Dec	6	0.06	12.2
Oct	22	0.01	1.5	Dec	7	0.04	8.6
Oct	23	0.01	1.5	Dec	8	0.03	6.6
Oct	24	0.01	1.6	Dec	9	0.03	5.5
Oct	25	0.01	1.6	Dec	10	0.02	4.8
Oct	26	0.01	2.0	Dec	11	0.02	4.9
Oct	27	0.01	2.2	Dec	12	0.03	5.7
Oct	28	0.01	2.1	Dec	13	0.03	6.2
Oct	29	0.01	2.2	Dec	14	0.03	5.8
Oct	30	0.01	2.2	Dec	15	0.03	6.3
Oct	31	0.01	2.0	Dec	16	0.03	6.2
Nov	1	0.01	2.3	Dec	17	0.03	5.7
Nov	2	0.01	2.6	Dec	18	0.03	5.6
Nov	3	0.01	2.6	Dec	19	0.03	5.2
Nov	4	0.01	3.1	Dec	20	0.02	4.6
Nov	5	0.02	3.8	Dec	21	0.02	4.0
Nov	6	0.02	4.4	Dec	22	0.02	3.7
Nov	7	0.02	3.8	Dec	23	0.02	3.7
Nov	8	0.03	5.3	Dec	24	0.02	3.8
Nov	9	0.02	4.7	Dec	25	0.02	3.7
Nov	10	0.02	4.9	Dec	26	0.02	3.6
Nov	11	0.02	4.9	Dec	27	0.02	4.6
Nov	12	0.03	5.7	Dec	28	0.03	6.9
Nov	13	0.04	8.2	Dec	29	0.03	5.2
Nov	14	0.03	6.7	Dec	30	0.02	4.1
Nov	15	0.03	5.5	Dec	31	0.02	3.8
Nov	16	0.02	4.5				
Nov	17	0.02					
Nov	18	0.02					
Nov	19	0.02					
Nov	20	0.02					
Nov	21	0.02					

Table H-2. Sediment TMDLs expressed as an average annual load (tons/year)

Stream Segment	Waterbody #	TMDL expressed as average annual load (tons/year)
DEEP CREEK, headwaters to mouth (Fortine Creek)	MT76D004_080	540
EDNA CREEK, headwaters to mouth (Fortine Creek)	MT76D004_030	510
FORTINE CREEK, headwaters to confluence with Graves Creek (mouth), which is the headwaters of the Tobacco River	MT76D004_020	10,900
LIME CREEK, headwaters to mouth (Fortine Creek)	MT76D004_050	510
SINCLAIR CREEK, headwaters to mouth (Tobacco River)	MT76D004_091	1,100
SWAMP CREEK, headwaters to the mouth (Fortine Creek)	MT76D004_040	1,500
THERRIAULT CREEK, headwaters to the Tobacco River	MT76D004_070	450
TOBACCO RIVER, confluence of Grave Creek & Fortine Creek to mouth (Lake Koocanusa)	MT76D004_010	20,600

APPENDIX I – RESPONSE TO PUBLIC COMMENT

One comment letter was received during the public comment period. The comments and DEQ's comment responses are presented below. Two minor editorial comments are not included. The original comment letter is held on file at DEQ and may be viewed upon request. Within the comments, KNF refers to the Kootenai National Forest and NFSL refers to National Forest System Lands.

Comment #1: At the meeting on August 11, 2011, I was pleased to hear the DEQ acknowledge the progress the KNF has made with regard to sediment reduction in the Tobacco Planning Area. As you are aware, the actions implemented on NFSL are more strictly regulated than those on private land. Therefore, data collected on NFSL does not represent the effects of similar activities on lands under different ownership. Given the Best Management Practice (BMP) work we do on our roads and in our timber management activities I would still like to see stream segment designations that reflect the change in ownership from Federal land to private land. I believe by doing this many segments of streams on Federal land would not warrant a TMDL and could in fact be removed from the 303D list.

> **DEQ Response to Comment #1:** We agree that in the Tobacco watershed, the existing land management practices within the National Forest boundaries are more protective of water quality than most land management practices elsewhere in the watershed. Nevertheless, the convention used by DEQ for splitting segments does not provide for adjustments based solely on ownership or impairment status. In some situations, two or more reaches within a segment were evaluated separately where the amount of available information was sufficient for each reach. For example, Edna and Fortine Creeks have evaluations focused on separate segment reaches. Even when reaches are evaluated separately, impairment for one reach is applied to the whole segment. Although identifying the specific reaches within a segment where the impairment occurs can help focus future monitoring to evaluate restoration progress, it is equally important to identify the complete watershed area where BMPs need to be applied and/or maintained to ensure continued stream health. The existing segment delineations in the Tobacco watershed helps promote this holistic approach to watershed management.

Comment #2: There is a question in my mind whether data gathered at pre-selected sites, rather than at randomly selected sites, should be extrapolated. However, if that is the method you choose to use, at minimum, I would like to see data gathered on NFSL being extrapolated only to the other NFSL and data gathered on private land being extrapolated only to the other private land. Based on the different management standards the ownerships are held to this is the only way I can think of to accurately portray the existing situation on the ground.

> **DEQ Response to Comment #2:** The use of a stratified design, whether it is based on Rosgen stream type or stream transport/depositional reaches, is a common approach for selecting sampling sites to evaluate sediment and habitat conditions in cold water streams in the Western United States. As described in the second paragraph of **Section 5.3.3**, streams were stratified "into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology." It is further noted that "although ownership is not part of the reach type category, because of the distribution of private and federal land within the watershed, most reach type categories contain predominantly either private or public lands."

Section 5.3.3 further states that "monitoring reaches were chosen with the goal of being representative of various reach characteristics, land use category, and anthropogenic influence." It is also noted that "there was a preference toward sampling those reaches where anthropogenic influences would most likely lead to impairment conditions since it is a primary goal of sediment TMDL development to further characterize sediment impairment conditions." This sample selection approach is independent of ownership and instead attempts to collect data along reaches where problems are likely to occur. Due to the number of assessment sites that time and resources allowed for sampling, DEQ determined that random selection of sites within a stratified reach category would not necessarily meet the goals of representativeness and impairment characterization described above

For bank erosion estimates and bank erosion extrapolation purposes, DEQ completed additional sampling to gather data from a larger subset of reach types. This data, along with the original targeted locations for the full suite of sediment and habitat parameters, helped increase the accuracy of the bank erosion estimates documented within **Appendix E**. Bank erosion extrapolation across ownership (i.e. between federal and private lands) is somewhat limited based the above discussion. Nevertheless, where such extrapolation does occur, we have determined that the stratification process provides a fair representation of ongoing and historical bank erosion impacts based on similar land use and other natural characteristics.

Comment #3: If appropriate I'd like to see the document state that Forest Service management, with BMP implementation, will not further contribute to the degradation of these streams. Where appropriate I would also like the document to state that the Forest Service has implemented BMPs on their roads and in the watershed and no additional sediment sources on NFSL have been found. To continue with our important Forest management work it is vital that we be able to show the public, stakeholders, critics, etc. that our science-based regulations are working and not contributing to the degradation of our waterways.

DEQ Response to Comment #3: Section 5.7.4 "Meeting the Intent of TMDL Allocations" includes the following language: "It is important to recognize that the first critical step toward meeting the sediment allocations involves applying and/or maintaining the land management practices or BMPs that will reduce sediment loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the sediment allocation for that location." **Section 5.7.4** further states that "it is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased sediment loading."

The sediment allocations for Forest Service management activities link directly to standard BMPs for road crossings, harvest activity and protection of riparian areas including prevention of bank erosion. If the Forest Service implements all applicable BMPs for future projects and existing infrastructure (e.g. appropriate road erosion BMPs and culverts upgrades), then the Forest Service will be meeting the sediment allocations and it is the assumption within this document that ongoing Forest Service management activity will not be contributing to stream degradation. Basically, we believe that when the Forest Service applies BMPs for new management activities, along with appropriate culvert upgrades as defined within **Section 5.7.2.3.3**, it is being protective of water quality. Most of our concerns on Forest Service lands link to historical practices or existing road networks. The results from this TMDL work indicate

that many or most stream reaches within Forest Service boundaries are generally in fair to good condition and are either at or closely approaching full support of all beneficial uses.

It is true that the Forest Service has implemented many BMPs to reduce sediment loading. During the 2008 assessment of a mix of private and federal road crossings, the majority of all identified road BMPs were associated with Forest Service road crossings as documented within **Appendix G, Section G5.2**. Forest Service road crossings also had the best performance regarding culvert flood passage capabilities as documented within **Appendix G, Section G4.2**. Based on our discussions with Forest Service staff, it is our understanding that the Forest Service has significantly increased BMP implementation for their road crossings since the 2008 TMDL road assessment work. Since the 2008 TMDL field assessment work, no additional formal assessment work has been completed. Therefore DEQ has not identified any additional sediment sources within Forest Service property beyond those documented within this TMDL document. DEQ agrees it is important to recognize the widespread BMP implementation and resulting improvements made by the KNF. The conclusions within this document represent an assumption of conditions throughout the watershed based on the subset of road crossings and culverts that were evaluated in 2008. At this time, we do not have sufficient information to make updated statements regarding presence or absence of sediment sources from National Forest Service lands.

Comment #4: Page 3-2: Lime Creek "*N*" for aquatic life and cold water fishery? There are fish in this stream.

DEQ Response to Comment #4: DEQ describes impairment as either partially supporting or not supporting based on assessment results. Not supporting is applied to not meeting a drinking water standard and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use. The above language has been added to **Section 3.1** to clarify this use of "not supporting" and "partially supporting" terminology.

As discussed in **Section 5.4.2.4**, DEQ's 2003 assessment of Lime Creek noted severe grazing impacts near the mouth of Lime Creek, thus resulting in a "not supporting" determination for aquatic life and coldwater fishery. As further discussed within the document and as noted by staff during TMDL development and during subsequent additional site visits, stream conditions have significantly improved along the lower reaches of Lime Creek as a result of improved land management practices by the Kootenai National Forest.

Comment #5: Page 5-3, 3rd full paragraph: Very nice description of how information gathered from low gradient reaches (typically private) may not be representative of higher gradient upstream reaches (typically USFS).

DEQ Response to Comment #5: No response necessary

Comment #6: Page 5-8, Table 5-3: W/D ratios can vary widely based on geology and/or other factors. Setting the target at 21 (for example) for both B and C channels is not appropriate. These channel types are not expected to have the same WD ratio. In Rosgen (1996) the average W/D for a C3 and C4 stream

was 33 and 29 respectively, well above the target in this document. In addition, Rosgen did not set upper limits with W/D. Having a high W/D does not necessarily mean a stream is in an unnatural state.

DEQ Response to Comment #6: DEQ agrees that W/D ratios can vary widely based on geology and/or other factors, which is why Rosgen values (which are derived across a wide range of settings) are used to define channel types and as a general guide, but regional or local reference values are preferred for setting targets. Most assessment reaches were identified as being potential B/C channels versus B or C with predominantly gravel substrate (i.e. particle size category 4), so it seemed easier for target application and interpretability to combine the target value for the B and C channel types and not set separate values by dominant particle size. Additionally, in the KNF reference dataset, the 75th percentile W/D for B channels was 21 and for C channels was 18. Since C channels typically do have a larger W/D ratio, the higher value (21) was chosen as the target for B/C channels with a bankfull width less than 30 feet.

Although we agree that an elevated width to depth (W/D) ratio value does not always mean a stream is in an unnatural state, we also recognize that an elevated width to depth (W/D) ratio is one of the more recognized measures of negative impact to a stream, especially when there are existing or historical human impacts to the stream channel or riparian corridor that appear to correspond to elevated W/D ratios. Therefore, W/D ratio is used as a target parameter consistent with the multiple measures approach defined within the second paragraph of **Section 5.4.1**.

Comment #7: Page 5-9: We are still unclear as to why certain quartiles of reference data distribution (75%, for example) are being used to set targets. Why wouldn't you set the target as the range of values observed in reference streams which are similar in hydrologic characteristics to each impaired stream? Also, why not break out percent fine sediment by channel type, just as you have done for W/D ratio. You would expect natural sediment levels to be quite different among the varying channel types.

DEQ Response to Comment #7: Each target value does indirectly represent a range. For example, a target value for percent fines of $\leq$ 15% represents a range of values from 0% to 15%. Defining a range is not necessary since, for this example, it is the upper limit, along with consideration regarding how much stream conditions are above this upper limit, that defines whether or not stream conditions appear healthy. Where targets values are defined by ($\geq$), the logic is the opposite in that the range is anywhere above the identified value.

As in our data review for W/D ratios, fine sediment values were evaluated by channel type. However, based on the similarity in values between B/C channel types in the reference dataset and the fact that most assessment reaches were identified as having a potential channel type dominated by the same particle size category (i.e. gravel), target values were not broken out by particle size. However, since E channels tend to have a greater percentage of fine sediment than B and C channels, separate target values were set for B/C channels and E channels. This approach to setting fine sediment targets is consistent with other sediment TMDLs completed by Montana DEQ, and the values are comparable to values from other reference datasets and literature.

Comment #8: Page 5-11. Target development for W/D ratio of small streams (<30 ft) uses KNF reference data, while those wider than 30 ft. use PIBO reference data. Why not use PIBO reference data for both to ensure consistency?

DEQ Response to Comment #8: Although the goal is to use the same reference data set for each parameter, the use of multiple reference data sets can sometimes be a more desirable approach based on influences such as sample size, stratification of reference stream results and/or assessment methodology. The KNF values for smaller streams (bankfull width < 30 ft) were preferred over the PIBO data because of the KNF data represents a more local regional reference data set, the KNF data has a significantly higher sample size of 94 versus the 44 for the PIBO data set, the values are consistent with sediment targets for similar stream sizes in other DEQ sediment TMDL documents, and because the KNF data provides the appropriate level of water quality protection based on results and observations regarding achievable width to depth ratio potential for the assessed streams.

Unfortunately the KNF reference sample size for larger streams (bankfull width > 30) is only 7, whereas the equivalent PIBO sample size is 47. Therefore, the 35 value from the PIBO data set was used for the target value. Although this value is higher (and less protective) than the 29 value from the smaller KNF data set, it is consistent with sediment targets for similar larger stream sizes in other DEQ sediment TMDL documents and is considered appropriately protective based on results and observations regarding achievable width to depth ratio potential for the assessed streams.

Additional language has been added to **Section 5.4.1.2** to help clarify the rational for W/D ratio target value selection.

Comment #9: Page 5-12. Trends in residual pool depth may be more meaningful than looking at absolute numbers.

DEQ Response to Comment #9: We agree that trends in residual pool depth, as well as other target parameters, would be useful in evaluating progress toward meeting a stream's ultimate potential. The numbers presented as target values within the document, as well as for any other target parameter, provide measures to help evaluate each stream's health based on our existing knowledge and available data. Adaptive management for target values, as discussed in **Section 5.9.1**, recognizes the potential for modifying target values as more information is obtained, particularly in regards to target achievability and/or a stream's potential. Trend data can contribute significantly toward this adaptive management approach. This is supported within the document where the **Section 5.4.1** discussion on water quality targets states: "for all water quality targets, future surveys should document stable (if meeting criterion) or improving trends". The recently collected data for TMDL development helps provide a baseline for future trend assessment work.