ST. REGIS WATERSHED
TOTAL MAXIMUM DAILY LOADS AND FRAMEWORK WATER QUALITY RESTORATION ASSESSMENT

Sediment and Temperature TMDLs

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EXECUTIVE SUMMARY

The St. Regis Watershed is located entirely in Mineral County, Montana, and encompasses 365 square miles (233,443 acres) of largely federally owned lands (**Figure 2-1**). Tributaries of the St. Regis River included in this document are Twelvemile, Silver, Big, Ward, Deer, Little Joe, North Fork Little Joe, and Savenac Creeks, along with several smaller tributaries. The St. Regis River has its headwaters at St. Regis Lakes approximately 3 miles southwest of Lookout Pass on Interstate 90 (I-90) near the Montana-Idaho border. The river flows in a generally southeasterly direction for nearly 39 miles before entering the Clark Fork River at St. Regis, Montana. The elevation at St. Regis Lakes is 5,590 feet, and the river joins the Clark Fork at an elevation of 2,640 feet. The highest point in the watershed is 7,297 feet along the basin's western boundary in the Bitterroot Mountains.

The Clean Water Act requires the development of TMDLs that will provide conditions that can support all identified uses. This document combines a generalized watershed restoration strategy along with creation of TMDLs. The designated water uses include drinking, culinary and food processing after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. Clean Water Act objectives include restoration and maintenance for all of these uses. In the St. Regis Watershed the most sensitive uses are the fishery and aquatic life.

A TMDL is a pollutant budget identifying the maximum amount of a particular pollutant that a water body can assimilate without causing applicable water quality standards to be exceeded. Section 303 of the Federal Clean Water Act and the Montana Water Quality Act (Section 75-5-703) require development of TMDLs for impaired water bodies that do not meet Montana water quality standards. Section 303(d) also requires identification of impaired water bodies on a list, referred to as the 303(d) List. This 303(d) List is updated every two years and submitted to the U.S. Environmental Protection Agency (U.S. EPA) by the Montana Department of Environmental Quality (DEQ[1]).

The whole length of the St. Regis River, from near Lookout Pass to the confluence with the Clark Fork River, is identified as impaired on Montana's 303(d) List. In addition, seven tributaries were listed in 1996 as threatened waterbodies, four of which are still considered impaired on Montana's current 303(d) List. This document focuses on sediment, temperature, and fishery habitat impairments in the St. Regis River watershed. TMDLs are provided for St. Regis River and Big, Little Joe, North Fork Little Joe, and Twelvemile Creeks.

Source assessments identify transportation, timber harvest, sources of bank erosion, and suburban activities as the primary sources of human caused pollutants in the St. Regis Watershed. Restoration strategies for the St. Regis River TPA focus on implementing road management BMPs; timber harvest BMPs; providing stream corridor shade and sediment buffers; suburban development BMPs; and other land, soil, and water conservation practices that relate to near stream channel and vegetation conditions.

[1] DEQ refers to the Montana Department of Environmental Quality unless otherwise noted.

The restoration process identified in this document is voluntary, cannot divest water rights or private property rights, and does not financially obligate identified stakeholders unless such measures are already a requirement under existing federal, state, or local regulations. Any recommendations for NPDES point sources provided in this document will be used for managing the point source in the future.

Restoration strategies identified in this document are intended to balance the varying uses of water while adhering to Montana's water quality and water use laws. This document should be considered dynamic by providing an "adaptive management strategy" approach to restore water quality in the St. Regis River Watershed. This water quality plan is intended to identify the knowledge we have at present and to identify a future path for water quality restoration. As more knowledge is gained through the restoration process and future monitoring, this plan may change to accommodate new science and information. Montana's water quality law provides an avenue for using the adaptive management process by providing for future TMDL reviews.

The state is required to support a voluntary program of reasonable land, soil, and water conservation practices. DEQ's approach to this program recognizes that the cumulative impacts from many nonpoint source activities are best addressed via voluntary measures with DEQ, other agencies, or other forms of professional assistance. This often applies to agricultural situations or small landowner activities along or near streams.Montana's voluntary program does not cover all nonpoint source activities since there are local, state, and/or federal regulations that apply to certain nonpoint source activities within Montana. Examples where a non-voluntary approach is applicable due to existing regulations include, but are not limited to, streamside management zone requirements for timber production, minimum septic design and location requirements, local zoning requirements for riparian or streambank protection, and compliance with 310 Law.

The document structure provides specific sections that address TMDL components and watershed restoration. **Sections 1.0 through 4.0** provide background information about the St. Regis River watershed, Montana's water quality standards, and Montana's 303(d) Listings. **Sections 4.0 and 5.0** provide TMDL targets and impairment status reports by water body. **Sections 6.0** (sediment) **and 7.0** (temperature) review specific pollutant source assessments, TMDLs, and allocations. Generalized restoration strategy and the follow-up monitoring approach are provided in **Sections 8.0 and 9.0**. **Section 10.0** is a review of stakeholder and public involvement during the TMDL process. Many of the detailed technical analyses are provided in appendices. **Table E-1** provides a very general summary of the water quality restoration plan and TMDL components discussed in this document.

Table E-1. Water Quality Plan and TMDL Summary Information

Impaired Water Body Summary	• Of the 8 water bodies originally listed on the 1996 303(d) List as threatened for water quality impairment, 5 water bodies are considered impaired and have TMDLs prepared in this document. Pollutants addressed by TMDLs include sediment and temperature modification. The following TMDLs are included in this Water Quality Restoration Plan: o Sediment –St. Regis River, Big Creek, Little Joe Creek, North Fork Little Joe Creek, and Twelvemile Creek. o Temperature – Big Creek, Twelvemile Creek, and St. Regis River.
Impacted Uses	• Coldwater fishery and aquatic life beneficial uses are negatively impacted from loss of aquatic habitat, temperature conditions and sedimentation.
Pollutant Source Descriptions	• Urban Activities: Riparian impacts from low density development on private lands, stream encroachment from structures; historical channelization for land and transportation development; private roads. • Roads and transportation: Forest, federal, and county roads. Sediment production from unpaved roads, stream encroachment from all road types, road sanding on paved road system. Abandoned railroad and state highway. • Agriculture: Historic and recent timber harvest. Very limited areas of grazing, cultivation, and irrigation. • Mining: Recreational Suction Dredge Permits. Historic placer mining.
TMDL Target Development Focus	• Sediment o Fine sediment in riffles and spawning substrate compared to reference condition. o Pool quality measures compared to reference conditions. o Channel conditions that affect sediment transport compared to reference condition. o Biological indicators compared to reference condition. o Streambank vegetation comparable to reference condition. o Presence of significant human caused sources. • Temperature o Montana's temperature standard. o Temperature conditions compared to naturally occurring conditions. o Canopy density, instream flow, channel width/depth ratio conditions compared to natural conditions that will cause standards to be exceeded.
Other Use Support Objectives (non-pollutant & non-TMDL)	• Improve native riparian vegetation cover. • Improve instream fishery habitat. • Eliminate unnatural fish passage barriers based on fishery goals.
Sediment TMDL and Allocation Summary	• Load allocations provided for forest roads, natural background, bank erosion sources (lumped category), cut slopes along freeway, freeway sanding, culvert failure, and mass wasting events. • An overall percent sediment load reduction is provided for the TMDL and is based on individual percent reduction allocations and natural background estimates. Estimated annual sediment load allocations to all significant source categories are also provided. Reductions are based on estimates of BMP performance. The annual TMDL is the sum of the allocations. Numeric sediment load-based daily TMDLs and daily allocations are also estimated and provided in **Appendix N**.
Temperature TMDLs and Load Allocations	• The temperature TMDLs are provided in surrogate measures because they relate directly to the standard and are most relevant for restoration of the resource. The surrogate allocations are the percent change in source categories (ie shade, width to depth ratios) needed to meet conditions that will meet the State's temperature standards. The TMDL is the combination of the allocations. Numeric heat load based Daily temperature TMDLs and daily allocations are also estimated and provided in **Appendix N**.

Table E-1. Water Quality Plan and TMDL Summary Information

Sediment and Temperature Restoration Strategy	• The restoration strategy identifies general restoration approaches for assessed sources. Addressing the sources in the restoration strategy will likely achieve TMDLs. An adaptive management component is also provided for determining if future restoration will meet targets provided in the document.

ACRONYMS

7DADMT .... 7 Day Average of Daily Maximum Temperatures
ARM .... Administrative Rules of Montana
BEHI .... Bank Erosion Hazard Index
BER .... Board of Environmental Review
BMPs .... Best Management Practices
BUD .... Beneficial Use Determination
CFR .... Code of Federal Regulations
cfs .... Cubic feet per second
CMP .... Corrugated Metal Pipes
DEQ .... Montana Department of Environmental Quality
DHES .... Montana Department of Environmental Sciences
EPA .... United States Environmental Protection Agency
FAR .... Functional at Risk
GAP .... Gap Analysis Program
HUC .... Hydrologic Unit Code
ITLs .... Instantaneous Thermal Loads
KNF .... Kootenai National Forest
LA .... Load Allocation
LNF .... Lolo National Forest
LoloSED .... Model derived from the Water Yield and Sediment Model
LWC ....
MBTRT .... Montana Bull Trout Restoration Team
MCA .... Montana Code Annotated
MDEQ .... Montana Department of Environmental Quality
MDHES .... Montana Department of Health and Environmental Sciences
MDT .... Montana Department of Transportation
MFISH .... Montana Fisheries Information System
MMI .... Multi-Metric Index
MOS .... Margin of Safety
MPDES .... Montana Pollutant Discharge Elimination System
NAIP .... National Agricultural Imagery Program
NBS .... Near Bank Stress
NOAA .... National Oceanic and Atmospheric Administration
NPDES .... National Pollutant Discharge Elimination System
NPS .... Non Point Source
NRCS .... Natural Resources Conservation Service
O/E .... Observed/Expected
PFC .... Proper Functioning Condition
PSF .... Percent Surface Fines
Qual2k .... Water Quality Model
RivPacs .... River Invertebrate Prediction and Classification System
RSI .... Riffle Stability Index
RUSLE .... Revised Universal Soil Loss Equation
SCD .... Sufficient Credible Data

TMDL .... Total Maximum Daily Load
TPA .... TMDL Planning Area
UAA .... Use Attainability Analysis
USFS .... United States Forest Service
USGS .... United States Geological Survey
W/D Ratio .... Width/Depth Ratio
WEPP .... Water Erosion Prediction Project
WLA .... Waste Load Allocation
WQA .... Water Quality Act
WQRP .... Water Quality Restoration Plan

SECTION 1.0
INTRODUCTION

1.1 Background and Purpose

Section 303(d) of the federal Clean Water Act and Section 75-5 of the Montana Water Quality Act provide authority and procedures for monitoring and assessing water quality in Montana's streams and lakes and for developing restoration plans for those waters not meeting state standards. This document presents a water quality restoration plan for the St. Regis River watershed, including the mainstem St. Regis River and several of its tributaries. This plan also defines all necessary Total Maximum Daily Loads (TMDLs) for pollutants of concern in the St. Regis Watershed as specified in the *Montana 303(d) List of Impaired and Threatened Water Bodies in Need of Water Quality Restoration*. A TMDL is the total amount of pollutant that a stream may receive from all sources without exceeding water quality standards. A TMDL may also be defined as a reduction in pollutant loading that results in meeting water quality standards.

Water quality impairments affecting the St. Regis River and the above tributaries include sediment, aquatic habitat alterations, and elevated water temperatures that negatively impact trout and other forms of aquatic life. The restoration plan outlined in this document establishes quantitative restoration goals for each impaired stream segment and for each category of offending pollutant. The plan provides recommendations for reducing pollutant loads and improving overall stream health and establishes a monitoring plan and adaptive management strategy for fine-tuning the restoration plan, thus ensuring its ultimate success in restoring water quality in the St. Regis Watershed.

1.2 Project Organization

Mineral County Conservation District, the Mineral County Watershed Council, the Montana Department of Environmental Quality, Lolo National Forest, and other agencies and stakeholders contributed to the development of this plan through their participation in the St. Regis Watershed TMDL technical work group. (The St. Regis TMDL planning area is located entirely in Mineral County, Montana, and encompasses 233,433 acres, most of which is federally owned.) Early in this project, the Mineral County Conservation District and the Mineral County Watershed Council assumed a leadership role in water quality restoration planning in the St. Regis Watershed. Both groups include a broad mix of local interests including landowners, businesses, and agency representatives. They have designated the St. Regis Watershed as one of their highest planning priorities.

In 2002, the Mineral County Conservation District applied for Section 319 funding to begin development of a St. Regis Watershed water quality restoration plan. The grant was approved later that year. At the same time, the U.S. Environmental Protection Agency provided grant funding to the Lolo National Forest to assist in the project. The Lolo National Forest is a primary landowner in the St. Regis Watershed managing roughly 212,000 acres, or about 91% of the total land area. Additional project funding and in-kind assistance were provided by the Montana Department of Environmental Quality; the Montana Department of Fish, Wildlife, and Parks; the

Montana Department of Transportation; and Land & Water Consulting, Inc., which has since merged with PBS&J.

In the summer of 2002, the St. Regis Watershed TMDL technical work group was established to oversee the various assessment activities and planning needed to complete this project. The group also coordinated public involvement aspects of the project, distributed informational newsletters, and hosted a number of public meetings and hearings on the project. The work group served as the primary clearinghouse for all aspects of plan development and will have a significant continuing role in its implementation.

1.3 Water Quality Restoration Planning Process

Development of a TMDL water quality restoration plan follows a series of successive steps, which are described below to provide the reader with a general understanding of the process that was used in developing the St. Regis plan.

The first step in developing a water quality restoration plan is to thoroughly evaluate and describe the water quality problems of concern. This includes understanding the characteristics and function of the watershed, documenting the location and extent of the water quality impairments, and identifying each of the contributing causes and sources of impairment. Pollution source assessments are performed at a watershed scale because all potential sources of the water quality problems must be considered when developing the restoration plan.

The next step in the process is to develop water quality targets, or restoration goals, for each impaired stream segment and for each pollutant of concern. These targets will be used as restoration benchmarks and will help to identify what improvements or restoration measures are needed throughout the watershed. The required pollutant reductions and corresponding restoration measures are then allocated across the watershed planning area. This allocation process may be applied on the basis of land use (e.g. forestry, urban, mining, transportation, etc.), land ownership (federal, state, private), sub-watersheds or tributaries, or any combination of these. Specific allocations are also established for future growth and development in the watershed and for any natural sources of impairment that may be present.

The pollutant allocations and restoration measures become the basis for a water quality restoration strategy, which may include a combination of non-point and point source pollution control measures. Montana has adopted a policy of voluntary compliance for addressing non-point sources of pollution emanating from private lands. As a result, non-point source control measures rely heavily on public education and other programs that encourage private landowners to apply appropriate land, soil, and water conservation practices. Point source pollution is regulated through a state-administered discharge permit program, and any point source allocations that are included in the restoration plan will become a mandatory component of the discharge permits.

Lastly, the water quality restoration plan must include a monitoring component designed to evaluate progress in meeting the water quality targets established by the plan and to ensure that the restoration measures are, in fact, implemented. The monitoring strategy also provides useful information to help fine-tune the restoration plan over the long-term. This process is called adaptive management. It is a frequent component of watershed-scale restoration plans because of the complexity of the water quality problems and the inherent uncertainties involved with establishing cause-and-effect relationships between pollution sources and their effects over such large geographic areas.

Taken together, the steps in the water quality restoration planning process described above constitute a water quality-based approach to water pollution control, which is also known as the Total Maximum Daily Load process.

SECTION 2.0
WATERSHED CHARACTERIZATION

This section of the St. Regis Watershed water quality restoration plan provides general background information about the watershed and sets the stage for a later discussion of water quality problems and the underlying historic, current, and projected future causes of impairment.

2.1 Location and Description of the Watershed

The St. Regis Watershed is located entirely in Mineral County, Montana, and encompasses approximately 365 square miles (233,443 acres) most of which is federally owned (**Figure 2-1**). Tributaries of the St. Regis River include Twelvemile, Silver, Big, Ward, Deer, Little Joe, North Fork Little Joe, and Savenac creeks, along with several smaller tributaries. The St. Regis River has its headwaters at the St. Regis Lakes approximately 3 miles southwest of Lookout Pass on Interstate 90 (I-90) near the Montana-Idaho border. The river flows in a generally southeasterly direction for nearly 39 miles before entering the Clark Fork River at St. Regis, Montana. The elevation at the St. Regis Lakes is 5,590 feet, and the river joins the Clark Fork at an elevation of 2,640 feet. The highest point in the watershed is 7,297 feet along the basin's western boundary in the Bitterroot Mountains.

The U.S. Forest Service, Lolo National Forest, has management responsibilities for approximately 91% of the watershed area, or 212,363 acres. Remaining land ownership is divided between private interests (17,230 acres, or 7.4%) and state-owned lands (3,850 acres, or 1.6%). Interstate 90 follows the river most of the way from its headwaters to its confluence with the Clark Fork River at St. Regis.

2.2 Physical and Biological Characteristics

2.2.1 Geological Setting

The St. Regis Watershed lies within the northern Rocky Mountains physiographic province and includes parts of the Coeur d'Alene Mountains of Idaho and the Bitterroot and Squaw Peak Ranges of western Montana. The terrain is characterized by steep, heavily forested mountains separating the linear intermontane valley occupied by the Clark Fork and St. Regis rivers.

Precambrian Belt clastic and carbonate-bearing rocks, which in descending order include the Prichard Formation (Pre-Ravalli Group); Burke, Revett, and St. Regis Formations (Ravalli Group); Wallace Formation (Piegan Group); and the Spruce, Lupine, Sloway, and Bouchard Formations (Missoula Group), make up most of the watershed's geology. In several localities, lower Paleozoic quartzite, shale, and limestone of probable Middle Cambrian age crop out. Tertiary gravel, sand, and silt deposits and Quaternary lacustrine silt, fluvial gravel, and alluvium are also present within the valley. Igneous rocks ranging in composition from diorite to diabase occur as dikes and sills.

The major geologic structural element is the Osburn fault zone, extending southeastward from the Coeur d'Alene, Idaho, district to Superior, Montana, and beyond, possibly as far southeast as Missoula. It is one of the structures in the Lewis and Clark line, described as a northwest tear fault zone of continental scale.

Lead, zinc, copper, and silver ore deposits occur as fissure filling or replacement deposits, of which most are related to the Lewis and Clark line, particularly the Osburn fault. Some ore deposits are associated with diorite dikes and sills.

Total ore production for the St. Regis-Superior area prior to about 1950 amounted to 248,345 tons, from which 7,932,958 pounds of lead, 8,086,827 pounds of zinc, and 2,046,963 pounds of copper were recovered. Placer gold recovered from Mineral County from the period 1904-1945 totaled $614,000 (Montana Water Resource Board, 1969).

2.2.2 Climate

Two National Oceanic and Atmospheric Administration (NOAA) stations were selected to represent climatic conditions in the St. Regis Watershed (St. Regis Ranger Station #247318 and Haugan 3E #243984). Unfortunately, the elevation range covered by the NOAA stations extends only from 2,680 feet at St. Regis to 3,100 feet at Haugan. It should be noted that elevations in the St. Regis Watershed extend to nearly 7,300 feet, and the selected stations do not fully represent meteorological conditions in higher elevation portions of the mountainous region. However, precipitation shows strong orographic effects even across this relatively small elevation change. Annual precipitation at St. Regis averages 20.31 inches/year with 55.8 inches of annual snowfall. Average annual precipitation at the slightly higher elevation station at Haugan averages 29.5 inches/year with 113.2 inches of annual snowfall (**Figure 2-2**). While elevation differences undoubtedly account for some of the variability in precipitation between these sites, weather patterns are also strongly influenced by the surrounding mountains. NOAA climate data were obtained from the Western Regional Climate Center at http://www.wrcc.dri.edu/summary/climsmmt.html.

Average annual precipitation and temperature patterns for the two stations are presented in **Figures 2-3 through 2-8**. Temperature patterns are similar for both stations, with July and August being the warmest months and December and January the coldest months. Summertime highs are typically in the mid-eighties Fahrenheit, and winter lows typically fall into the mid- to low-teens (**Table 2-1**). Precipitation records show that most precipitation at Haugan and St. Regis occurs in the form of snowfall during the months of November through March, followed by rain in May and June. Average annual precipitation at these two sites ranges from about 20 inches at St. Regis to nearly 30 inches at Haugan.

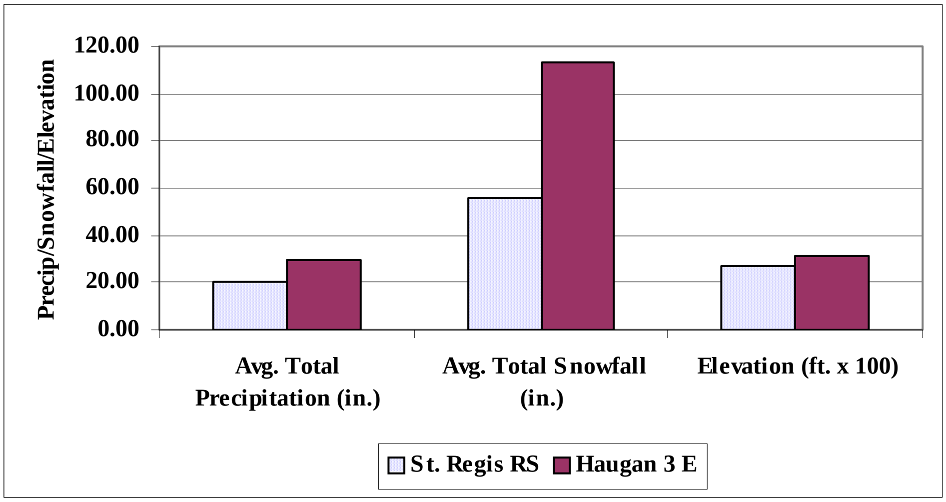

Figure 2-1. Average Annual Snowfall and Precipitation at the St. Regis Ranger Station and Haugan 3 E NOAA Climate Stations

Table 2-1. Average Minimum and Maximum Temperatures at the Haugan and St. Regis NOAA Climate Stations (Degrees F), 1912-2003

Station	Average January Min/Max Temperatures	Average July Min/Max Temperatures	Average Annual Min/Max Temperatures
Haugan 3 E	12.6/31.7	41.3/84.3	28.0/57.4
St. Regis R.S.	18.1/33.5	45.3/85.8	31.2/59.1

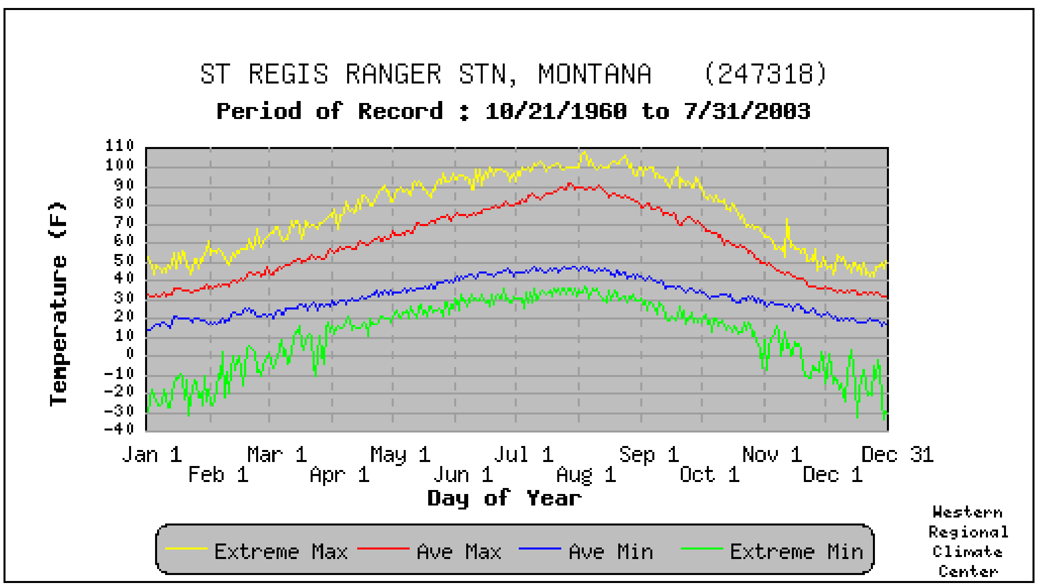

Figure 2-2. Daily Temperature Averages and Extremes (Degrees F) At the St. Regis RS NOAA Climate Station, 1960-2003

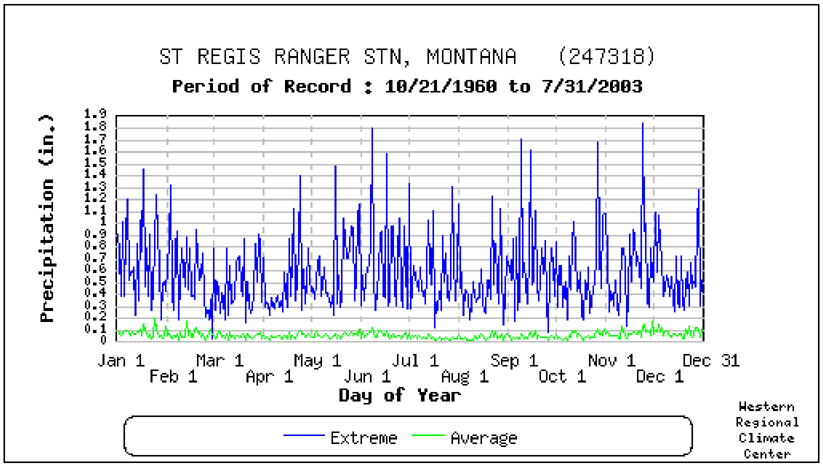

Figure 2-3. Daily Precipitation Averages and Extremes (Inches) At the St. Regis RS NOAA Climate Station, 1960-2003

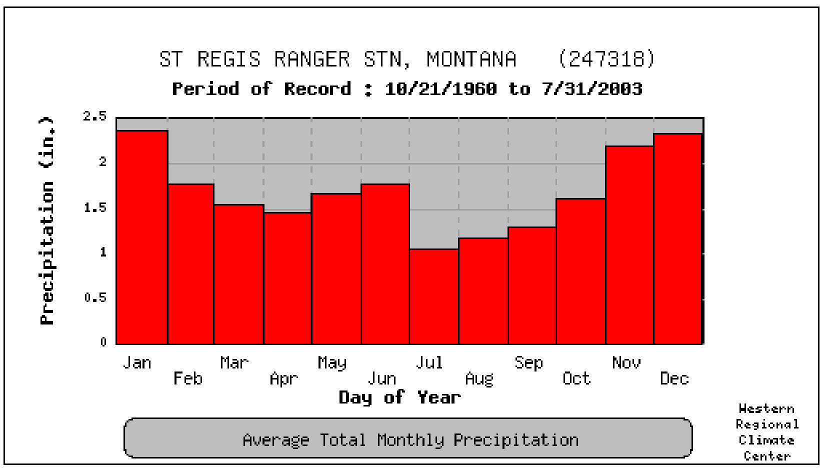

Figure 2-4. Monthly Average Total Precipitation (Inches) At the St. Regis RS NOAA Climate Station, 1960-2003

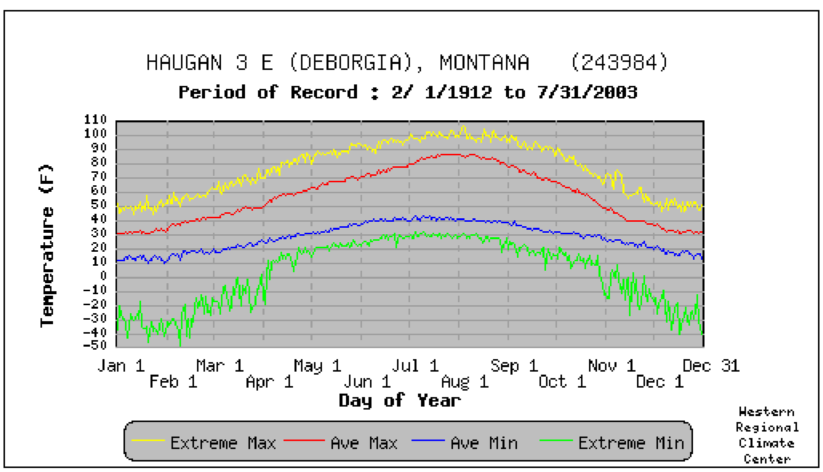

Figure 2-5. Daily Temperature Averages and Extremes (Inches) At the Haugan 3 E NOAA Climate Station, 1912-2003

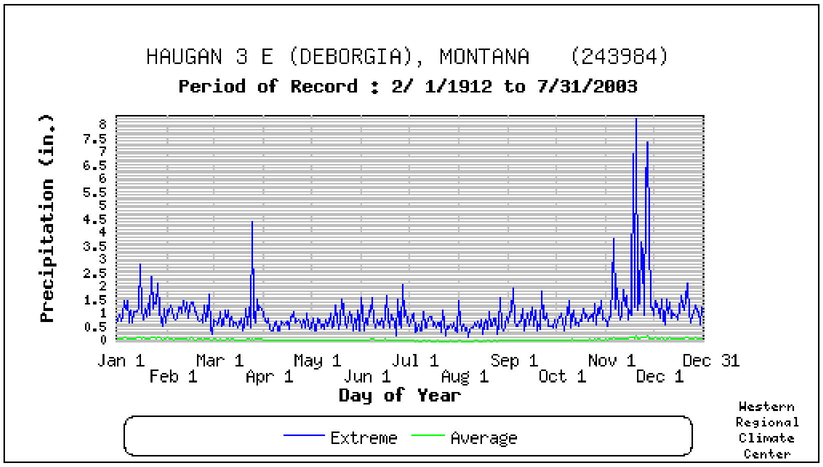

Figure 2-6. Daily Precipitation Averages and Extremes (Inches) At the Haugan 3 E NOAA Climate Station, 1912-2003

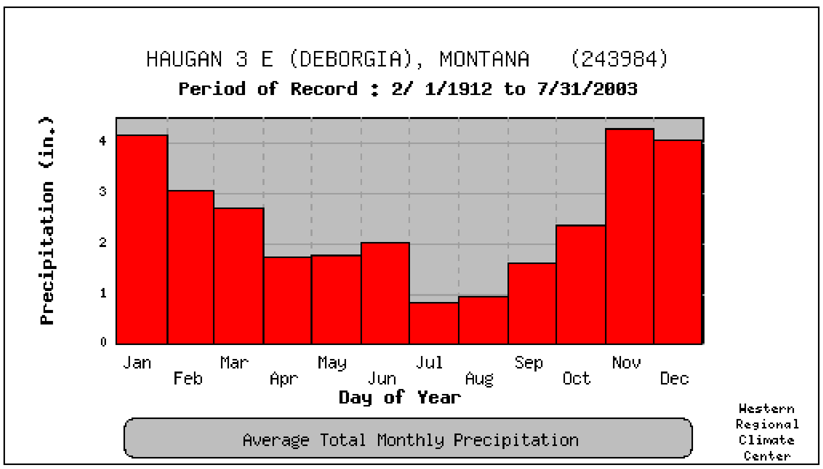

Figure 2-7. Monthly Average Total Precipitation (Inches) At the Haugan 3 E NOAA Climate Station, 1912-2003

2.2.3 Hydrology

The U.S. Geological Survey (USGS) water resources information database lists three streamflow gaging stations with current or historical flow data within the St. Regis Watershed (**Table 2-2**) (http://waterdata.usgs.gov/nwis/). Continuous long-term flow data were only available for one station, the St. Regis River near St. Regis, while periodic peak flow measurements were available at the remaining two stations, East Fork Timber Creek and North Fork Little Joe Creek. Monthly average streamflows for the St. Regis River, and peak flow measurement data for all three stations are presented in **Figures 2-9 and 2-10** to provide a general picture of seasonal streamflow characteristics in the St. Regis Watershed.

Table 2-2. Historical USGS Streamflow Gaging Stations in the St. Regis Watershed

USGS #	Station ID	Period of Record	Drainage Area (mi^2)
12353850	East Fork Timber Creek near Haugan, MT	1961-1979	2.7
12354000	St. Regis River near St. Regis, MT	1910-1917, 1958-1975, 2002-present	303
12354100	North Fork Little Joe Creek near St. Regis, MT	1960-1974	14.7

Average discharge patterns for the St. Regis River near St. Regis gaging station are presented in **Figure 2-9**. Except for during the spring runoff period, streamflows in the St. Regis River do not vary by a large margin and generally range from about 130 to 300 cfs. Spring high flows begin in April, the hydrograph peaks in May or early June, and the recessional limb begins in June. Peak flows are typically about ten-fold higher than base flow levels, although considerable year-to-year variation can be expected. Peak streamflows in the St. Regis River (**Figure 2-10**) reach 5,000 cfs with some frequency, and flows as high as 29,000 cfs have been recorded. The highest flows were recorded in December 1934 (34,000 cfs), May 1954 (11,000 cfs), and January 1974 (9,640 cfs). The winter floods in 1934 and 1974 were associated with rain-on-snow events. Peak flow events in the North Fork Little Joe Creek ranged from less than 100 cfs to almost 300 cfs.

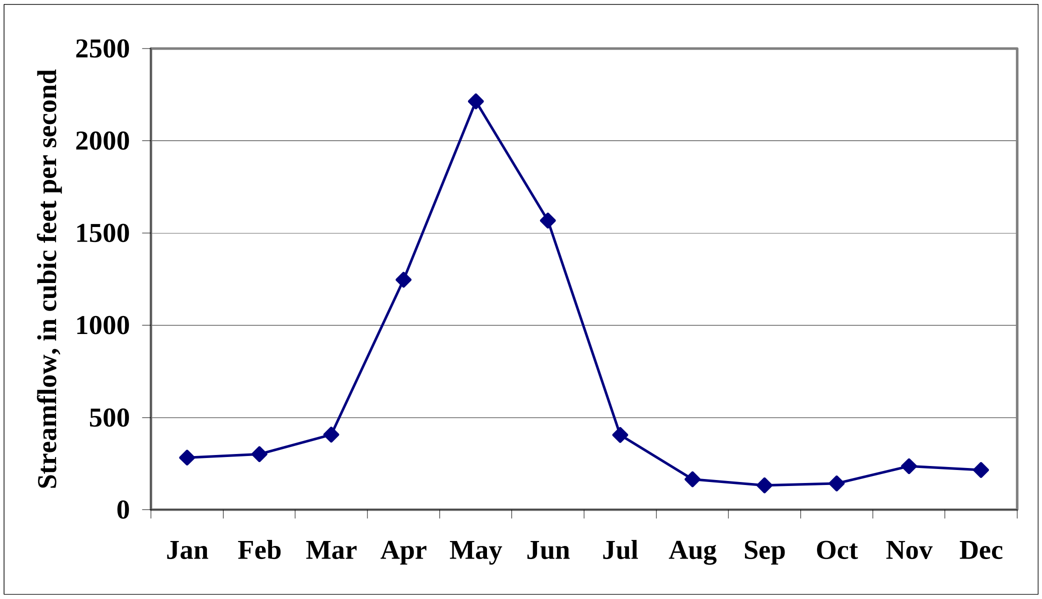

Figure 2-8. Average Monthly Streamflow for the St. Regis River near St. Regis, MT, 1910-2002 (USGS Gaging Station 12354000)

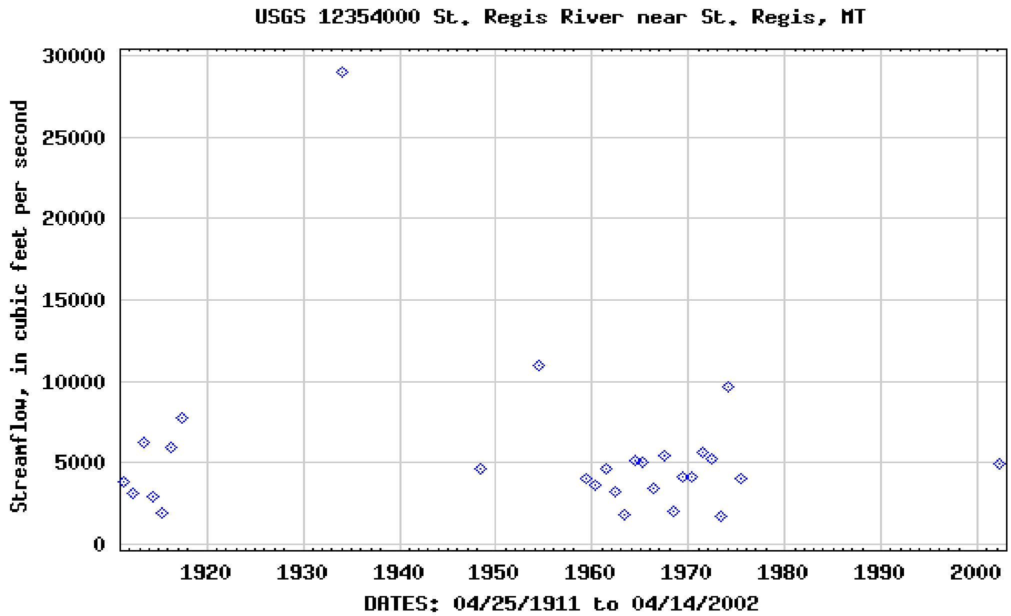

Figure 2-9. Peak Streamflows Measured in the St. Regis River near St. Regis, MT, 1910-2002 (USGS Gaging Station 12354000)

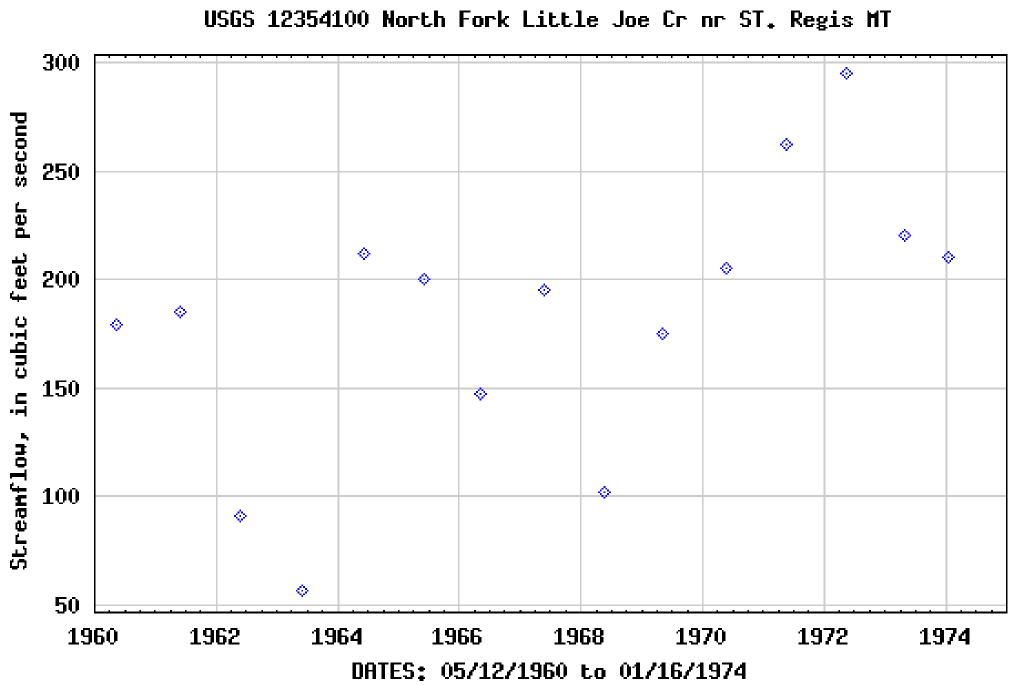

Figure 2-10. Peak Streamflows Measured In the North Fork Little Joe Creek near St. Regis, MT, 1960-1974 (USGS Gaging Station 12354100)

2.2.4 Topography

Topographic maps displaying the distribution of elevation, slope, and shaded relief were created for the St. Regis Watershed planning area. These data were obtained from the United States

Geological Survey's National Elevation Dataset for Montana, available at: http://nris.state.mt.us/nsdi/nris/ned.html.

Relief in the St. Regis Watershed varies from approximately 2,500 feet at the St. Regis River's confluence with the Clark Fork River at St. Regis to 7,500 feet in the Bitterroot Mountains (**Table 2-3**). Roughly half of the topography in the watershed occurs above 4,500 feet. Approximately 99% of lands in the St. Regis Watershed occur below 7,500 feet.

All slope categories, from flat (<1%) to extremely steep (≥100%), are present within the St. Regis Watershed (**Table 2-4**). In general, the topography of the watershed is steep with approximately 80% of the watershed area comprised of slopes greater that 25% in pitch. About one-third of the watershed area is comprised of lands with 25-45% slopes, and almost one-half of the watershed is comprised of lands with greater than 45% slopes.

Table 2-3. Elevation in the St. Regis Watershed

Elevation (ft)	Acres	Percent of Area	Cumulative Percentage
2,500 to 3,499	25,812	11.06	11.06
3,500 to 4,499	84,411	36.17	47.23
4,500 to 5,499	90,837	38.93	86.16
5,500 to 6,499	30,906	13.24	99.40
6,500 to 7,500	1,398	0.60	100.00
Totals	233,364	100%	

Table 2-4. Slope in the St. Regis Watershed

Slope (%)	Acres	Percent of Area	Cumulative Percentage
< 1%	917	0.39	0.39
1 to <5%	4388	1.88	2.27
5 to <10%	6600	2.83	5.10
10 to <25%	32112	13.76	18.86
25 to <45%	86807	37.20	56.06
45 to <100%	102382	43.88	99.94
≥ 100%	140	0.06	100.00
Totals	233,346	100%	

2.2.5 Stream Morphology

The St. Regis River has its headwaters at St. Regis Lakes approximately 3 miles southwest of Lookout Pass on Interstate 90. After flowing northeast for approximately 2.5 miles, the river intercepts the old Northern-Pacific Railroad grade and shortly thereafter the old Lookout Pass highway and I-90 road grades. The river then flows through the narrow St. Regis Canyon to its confluence with the Clark Fork River at the town of St. Regis.

The St. Regis River channel is heavily impacted throughout much of its 39-mile length. The river valley is a major transportation corridor. Over the last 100 years, two railroads, a two-lane highway, and a four-lane interstate highway have been crowded within the valley. The river has been relocated, straightened, and confined. Its natural meandering length has been reduced by approximately 20%.

The existing river with structurally armored banks and a shorter, steeper, straighter, bed has higher "stream power" or available energy. Because the banks are protected, this increased energy attacks the streambed and anything else mobile in the channel. Gravel-sized and smaller particles have been carried downstream for years and redeposited where the river gradient decreases and the valley becomes wider a couple of miles west of the town St. Regis. These gravel deposits are clearly visible from Interstate 90 between St. Regis and the Little Joe Road overpass.

Large woody debris material critical for fish habitat and channel structure is virtually absent from the river. Riparian trees were cleared for transportation corridors, used as fuel wood or in construction, or flushed downstream. The majority of the riparian area was either filled or otherwise altered for roads, railroads, or structures preventing regrowth of riparian trees.

Analysis of changes in the river's natural channel morphology and consequences to sediment transport dynamics, fish habitat components, and water temperature patterns are major components of the St. Regis Watershed pollution source assessment discussed in **Section 5.0** of this report.

2.2.6 Vegetation Cover

Information on vegetation cover within the St. Regis Watershed was obtained from Gap Analysis Program (GAP) data contained within the Montana 90-meter land cover database available from the Montana State Library Natural Resource Information System (http://nris.state.mt.us/nsdi/nris/gap90/gap90.html). The GAP vegetation classifications were developed by the U.S. Geological Survey from satellite imagery collected in the 1990s (**Table 2-5**). The vegetation classifications are highly detailed and attempt to differentiate individual species within general community types (i.e. ponderosa pine vs. coniferous forests). Subsequent ground-truthing has shown that GAP data have limitations, and the classification of individual species polygons are of variable quality. Nevertheless, GAP data represent the best vegetation classification information available at a landscape scale.

Approximately 90% of the St. Regis Watershed area is comprised of coniferous forest with some higher elevation meadows and parklands. The GAP data recognize eight distinct vegetation classifications within the overall forested area. These are mixed mesic, Douglas-fir, mixed subalpine, lodgepole pine, mixed mesic shrubs/forest, Douglas-fir/lodgepole pine, western larch, and montaine parklands/subalpine meadows (**Table 2-5**). The remaining 10% of the watershed area is composed of six other coniferous vegetation types and 19 other vegetation types. Within the entire St. Regis Watershed, riparian vegetation comprises less than 2% of the land area, and grasslands and urban, developed, and mined lands make up less than 1%.

Historical wildfires, most notably the great burn of 1910, have had a major influence on vegetation characteristics present today on the St. Regis Watershed. Most of the 1910 fires were stand replacing, and in the St. Regis drainage it appears that most of the burns occurred in the upper half of the watershed. Estimates provided by the Lolo National Forest suggest that about 42% (98,753 acres) of all lands within the St. Regis drainage burned during the 1910 fires. The initial fires, and subsequent salvage timber harvest and reforestation efforts, have been a factor in determining species distribution and age structures present today (Lolo National Forest, 2001).

Table 2-5. Vegetation Classification (GAP) Within the St. Regis Watershed

Gap Vegetation Type	Acres	Percent of Area	Cumulative Percentage
Mixed Mesic Forest	98,156	42.06	42.06
Douglas-fir	29,237	12.53	54.58
Mixed Subalpine Forest	27,730	11.88	66.47
Lodgepole Pine	26,427	11.32	77.79
Mixed Mesic Shrubs	11,104	4.76	82.55
Douglas-fir / Lodgepole Pine	7,725	3.31	85.86
Western Larch	5,725	2.45	88.31
Montane Parklands/ Subalpine Meadows	4,020	1.72	90.03
Mixed Xeric Forest	3,905	1.67	91.71
Rock	3,340	1.43	93.14
Western Hemlock	2,874	1.23	94.37
Grand Fir	2,137	0.92	95.28
Ponderosa Pine	1,907	0.82	96.10
Conifer Riparian	1,641	0.70	96.80
Mixed Riparian	1,143	0.49	97.29
Mixed Barren Sites	1,135	0.49	97.78
Grassland (low-moderate cover)	952	0.41	98.19
Western Red Cedar	944	0.40	98.59
Shrub Riparian	758	0.32	98.92
Mixed Broadleaf and Conifer Forest	748	0.32	99.24
Mixed Broadleaf Forest	575	0.25	99.48
Grassland (very low cover)	183	0.08	99.56
Broadleaf Riparian	181	0.08	99.64
Grassland (moderate-high cover)	175	0.08	99.71
Altered Herbaceous	166	0.07	99.79
Standing Burnt Forest	131	0.06	99.84
Graminoid and Forb Riparian	111	0.05	99.89
Water	100	0.04	99.93
Mixed Conifer and Broadleaf Riparian	71	0.03	99.96
Urban or Developed Lands	37	0.02	99.98
Mixed Whitebark Pine Forest	26	0.01	99.99
Mixed Xeric Shrubs	16	0.01	100.00
Mines, Quarries, Gravel Pits	8	0.00	100.00
Totals	233,390	100%	

2.2.7 Fisheries

This section provides a summary of fish species distribution in the St. Regis Watershed, as well as the status of species of special concern known to occur in the area.

The St. Regis Watershed provides habitat for bull, rainbow, brook, brown, and westslope cutthroat trout; mountain whitefish; and several species of suckers and sculpins (**Table 2-6**). Bull trout (*Salvelinus confluentus*) are native to the St. Regis River and its tributaries and, as part of the Columbia River Basin population, were listed as threatened under the Endangered Species Act in July 1998. The bull trout also appears on the State of Montana's Animal Species of

Special Concern list with a state rank of S2. An S2 rank is described as "imperiled because of rarity or because of other factors demonstrably making it very vulnerable to extinction throughout its range" (Carlson, 2001). It is also listed as a "sensitive species" by the U.S. Forest Service, which is defined as "those plant and animal species identified by a Regional Forester for which population viability is a concern as evidenced by (a) significant current or predicted downward trends in population numbers or density or (b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution (USDA 1995).

Table 2-6. Native and introduced fish species in the St. Regis Watershed

Native Fish Species
Bull trout (*Salvelinus confluentus*)
Westslope cutthroat trout (*Oncorhynchus clarki lewisi*)
Mountain whitefish (*Prosopium williamsoni*)
Longnose dace (*Rhinichthys cataractae*)
Mottled sculpin (*Cottus bairdi*)
Large-scaled sucker (*Catostomus macrocheilus*)
Longnose sucker (*Catostomus catostomus*)
Introduced Fish Species
Rainbow trout (*Oncorhynchus mykiss*)
Brown trout (*Salmo trutta*)
Brook trout (*Salvelinus fontinalis*)

Seven of the eight stream segments that appeared on the 1996 303(d) List have existing populations of bull trout (**Figure 2-1**). The entire St. Regis Watershed is identified as a core habitat area. Core habitat areas historically have and currently contain the strongest bull trout populations, and these habitats are essential to the continued existence of the species (MBTRT 1996). Additionally, all streams that are on either the 1996 or 2004 303(d) Lists have temperature and/or sediment listed as probable causes of impairment. Appropriate temperature and sediment regimes are both critical habitat requirements for bull trout (MBTRT 1996, Weaver and Fraley 1991).

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) are present in the entire St. Regis Watershed. Westslope cutthroat trout is included on the State of Montana's list of Animal Species of Special Concern (Carlson, 2001) with a state rank of S2. Westslope cutthroat trout are also listed as "sensitive" by the USFS and are given "special status" by the BLM, the latter defined as a "federally-listed Endangered, Threatened, or Candidate species or other rare or endemic species that occur on BLM lands."

Because of the above-described special designations, bull trout and westslope cutthroat trout will require special consideration during the development and implementation of the St. Regis water quality restoration plan as it pertains to existing or potential habitat areas and environmental requirements.

2.3 Cultural Characteristics

2.3.1 History of Settlement

The following discussion has been excerpted from the Mineral County Water Resources Survey and provides a summary of the history of human settlement in the St. Regis Watershed and adjacent areas of Mineral County (Montana Water Resources Board, 1969).

The area known as Mineral County was probably visited by the fur trappers and traders of the early 1800s, but the first recorded visitors were the Jesuit Missionaries during the 1840s. These included Fathers DeSmet, Cataldo, Grossi, and Ravalli. The country they saw was the heavily timbered slope and valleys of the Clark Fork of the Columbia and the St. Regis rivers.

In 1850, Major John Owen, a trader, inaugurated an annual trip to the Dalles traveling the route down the Clark Fork River, up the St. Regis River, and over Lookout Pass. In 1858 the possibilities of further settlement were enhanced when U.S. Army captain John Mullan arrived in the area to construct the military road that now bears his name. He spent the winter of 1859 in a camp near the present town of DeBorgia. The Mullan Road, as it was known, was completed to Walla Walla in 1861. In 1880 the area around the St. Regis House, in the present town of Saltese, started to develop with the opening of mines to the north along Packer Creek. The community of Silver City grew up around the old St. Regis House when the railroad came though in 1891. At this time the name of Silver City was changed to Saltese in honor of a Nez Perce chieftain.

With the completion of the Northern Pacific Railroad over the mountains to Wallace, Idaho, in 1891, the lumber and sawmill industry boosted the sagging economy of the area and a number of mill towns grew up around the sawmills. The most notable of these sawmill towns were Lothrop, Superior, DeBorgia, and St. Regis. The town of Lothrop has since disappeared from the scene.

In 1908, the Northern Pacific line finished the cut-off route between St. Regis and Paradise. At the same time the Milwaukee Railroad was building its line through the country. The activity of these two railroads gave St. Regis the impetus needed to establish a permanent community.

In the summer of 1910, a series of forest fires started in Idaho across the mountain from Saltese. By August of that year these fires had all coalesced creating a solid front. The wind carried the fire into western Montana, and sparks and coals were pushed far in advance, starting numerous fires ahead of the main body of the conflagration. Before the fire it was estimated that 28 years of potential timber harvest was available in the burned out area, and afterwards the accessible timber remaining was limited to four years of timber harvest. Subsequently, timber harvest declined until access roads could be built to the larger stands of virgin timber. In the year or two following the big fire, a nursery was established at Haugen to raise seedlings for replanting the burned over area. This nursery was rated as the largest of its kind in the world. The major species of trees raised were white pine, ponderosa pine, western larch, douglas fir, and engelmann spruce.

Agriculture has played only a minor role in the settlement and economy of Mineral County. The heavily timbered valleys and hillsides precluded any extensive development of farming and stock raising. Most of the valley bottoms are not extensive enough for any large scale ranching and farming operations.

2.3.2 Present Land and Water Uses

According to a 2001 estimate, Mineral County has a population of 3,843 people. Within the St. Regis Watershed, there is an estimated population of 500 in St. Regis, 100 in both Saltese and DeBorgia, and an estimated population of 50 in Haugen.

Current and historic land uses within the St. Regis Watershed include timber harvest, mining, and recreation. Approximately 91% of the watershed is federally-owned, less than 2% is state-owned and slightly more than 7% is privately owned lands. The majority of the watershed is mountainous with heavy coniferous timberlands. There is very little open grassland to support livestock grazing, and most historic land uses have centered around timber harvest for the lumber industry. The St. Regis drainage historically has been used as a transportation corridor, beginning with the Mullan Road, and continuing on to the Northern Pacific and Chicago, Milwaukee, St. Paul, and Pacific Railroads; State Highway 10; and Interstate 90.

Water uses in the St. Regis Watershed include fisheries and recreation, limited irrigation, municipal water supply, and hydropower production. Avista Corporation maintains a large senior water right for hydroelectric power production at Noxon Rapids and Cabinet Gorge dams on the Clark Fork River downstream of the confluence with the St. Regis River. While this water right is not within the St. Regis Watershed, it presents a limiting factor to junior water uses throughout much of the Clark Fork drainage, including the St. Regis River.

SECTION 3.0
TMDL REGULATORY FRAMEWORK

This section of the St. Regis Watershed water quality restoration plan describes the applicable water quality standards and reviews the water quality and water use-support status of St. Regis basin streams in relation to those standards. A review of the available water quality data is also provided for each threatened or impaired stream segment.

3.1 TMDL Development Requirements

Waters of the State of Montana must fully support beneficial uses associated with their classification and water quality standards (MCA 75-5-703, ARM 17.30.606-614 and 17.30.620-629). Beneficial water uses that apply to all Montana water bodies include cold or warm water fisheries, aquatic life, drinking water, contact recreation (e.g. swimming), and agricultural and industrial uses. DEQ determines the level of beneficial use-support of surface waters according to the following definitions:

> *A use is fully supported when all water quality standards applicable to that use are met. When one or more standards are not met due to human activities, the water body is either "not supporting" or "partially supporting" the beneficial use tied to that standard. A use that is currently fully supported but for which observed trends or proposed new sources of pollution indicate a high probability of future impairment may be rated as "threatened." Because the standards for determining use support are different for each use, the use-support determinations for the various uses of a waterbody are often not the same. Only those beneficial uses that apply to the particular water-use classification of a waterbody are evaluated for that waterbody* (DEQ, 2004a).

Water bodies that do not support, or are unlikely to support, all of their designated beneficial uses due to other than natural causes are classified as “water quality-limited” and are summarized on the Montana 303(d) List prepared by DEQ. 303(d) refers to a section of the federal Clean Water Act, which describes surface water quality monitoring and assessment requirements. The Montana 303(d) List provides a report of impaired and threatened water bodies in need of TMDLs for those impairment or threatened conditions that are linked to pollutants. These TMDLs, along with additional planning to address non-pollutant causes of impairment, will ensure the full support of all beneficial uses when implemented. The 303(d) List includes identification of the probable cause(s) of the water quality impairment problems (e.g. pollutants such as sediment, metals, or nutrients), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). The Montana 303(d) List is published biennially.

Prior to 2004, a 305(b) Report documenting waters listed as fully supporting beneficial uses and waters that lacked sufficient credible data was published along with the 303(d) List. In 2006, the 303(d) List was combined with the 305(b) Report into the *2006 Montana Water Quality Integrated Report*. The 2006 Integrated Report reflects water quality assessments conducted by DEQ as of December 2005. The 2006 Integrated Report incorporates new guidance from the United States Environmental Protection Agency (EPA) which requires total maximum daily loads (TMDLs) be developed for waters impaired by "pollutants," such as nutrients, sediment, or metals. TMDLs are not required for waters impaired solely by "pollution," such as flow alterations or habitat degradation (DEQ, 2004a).

Water bodies appearing on the 1996 and 1998 303(d) Lists were subsequently re-evaluated using more rigorous review criteria during the preparation of the 2000 and 2002 303(d) Lists and, most recently, the 2004 Integrated Report. The review criteria were revised as a result of 1997 amendments to the Montana Water Quality Act pertaining to the 303(d) Listing and water quality restoration planning processes. The 1997 changes require the consideration of "all currently available data," and a determination that adequate data of sufficient quality are available for a particular stream, before a 303(d) Listing decision can be made. DEQ has developed specific decision criteria for evaluating "sufficient credible data" and for making "beneficial use determinations" (DEQ, 2002). Sufficient credible data (SCD) is defined under Montana Law as *"chemical, physical, or biological monitoring data, alone or in combination with narrative information, that supports a finding as to whether a water body is achieving compliance with applicable water quality standards"* (75-5-103 MCA).

The 2004 303(d) List is the most recently approved list by DEQ, but, by federal court order, DEQ must also address all pollutant waterbody combinations appearing on the 1996 303(d) List. Total Maximum Daily Loads must be developed for all pollutants appearing on either the 2004 and 1996 303(d) Lists, except where the later listing represents a refinement of the original listing (based on sufficient and credible data), the sufficient credible data indicates that the basis for the original listing was in error, or that water quality standards are presently being attained and a listing is no longer valid.

3.2 Water Bodies and Pollutants of Concern

A St. Regis TMDL planning area has been established by DEQ. A total of eight individual stream segments in the St. Regis Watershed appeared on the 1996 303(d) List, while six segments appeared on the 2006 303(d) List (**Table 3-1, Figure 2-1)**. As mentioned earlier in this section, all necessary TMDLs must be completed for all pollutant/water body combinations appearing on the 1996 303(d) List. Following the reassessment efforts in 2001, Deer and Ward creeks were determined to be in full support of all designated water uses, and they were removed from the 2002 303(d) List. The St. Regis River's status remained unchanged from the 1996 listing, while the status of four streams – Twelvemile, Big, Little Joe, and North Fork Little Joe creeks – changed from "threatened" for coldwater fisheries uses in 1996 to "partially supporting" coldwater fisheries and aquatic life in 2006. The status of Silver Creek changed from 'threatened" for coldwater fisheries in 1996, to "partially supporting" coldwater fisheries in 2006.

Table 3-1. Stream Segments in the St. Regis TMDL Planning Area That Appear On Montana's 303(D) List of Impaired Waters, and Their Associated Levels of Beneficial Use-Support

Water body & Stream Description	Water body #	Use Class	Year	Aquatic Life	Coldwater Fishery	Drinking Water	Swimmable (Recreation)	Agriculture	Industry
St. Regis River from headwaters to the mouth (Clark Fork River)	MT76M003-010	B-1	1996	P	P	X	X	X	X
			2006	P	P	F	F	F	F
Twelvemile Creek from headwaters to the mouth (St. Regis River)	MT76M003-020	B-1	1996	X	T	X	X	X	X
			2006	P	P	F	F	F	F
Silver Creek from headwaters to the mouth (St. Regis River)	MT76M003-030	A-1	1996	X	T	X	X	X	X
			2006	F	P	F	F	F	F
Big Creek from the East and Middle Forks to the mouth (St. Regis River)	MT76M003-040	B-1	1996	X	T	X	X	X	X
			2006	P	P	F	F	F	F
Deer Creek from headwaters to the mouth (St. Regis River)	MT76M003-050	B-1	1996	X	T	X	X	X	X
			2006	F	F	F	F	F	F
Ward Creek from headwaters to the mouth (St. Regis River)	MT76M003-060	B-1	1996	X	T	X	X	X	X
			2006	F	F	F	F	F	F
Little Joe Creek from the North Fork to the mouth (St. Regis River)	MT76M003-070	B-1	1996	X	T	X	X	X	X
			2006	P	P	F	F	F	F
North Fork Little Joe Creek from headwaters to the mouth (Little Joe Creek)	MT76M003-080	B-1	1996	X	T	X	X	X	X
			2006	P	P	F	F	F	F

F= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X** = Not Assessed.

Water quality impairment causes in the St. Regis Watershed reflected on the 2006 303(d) List included sediment (siltation), temperature, habitat related impairments, and flow alterations (**Table 3-2**). Probable sources of impairments identified on the 2006 list include runoff and other impacts from transportation corridors, silviculture, removal of riparian vegetation, bank modification/destabilization, channelization, and other habitat modifications.

Table 3-2. Probable Causes and Sources of Impairment for 303(D)-Listed Stream Segments in the St. Regis TMDL Planning Area

Water body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
St. Regis River	Other habitat alterations	Highway/road/bridge construction	Other flow regime alterations	Channelization
	Siltation	Silviculture	Alteration in stream-side or littoral vegetative covers	Highway/road/bridge runoff
			Sedimentation/Siltation	Highways, Roads, Bridges, Infrastructure
			Water Temperature	Loss of Riparian Habitat
				Streambank Modifications/destabilization

Table 3-2. Probable Causes and Sources of Impairment for 303(D)-Listed Stream Segments in the St. Regis TMDL Planning Area

Water body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Twelvemile Creek	Other habitat alterations	Highway/road/bridge construction	Sedimentation/Siltation	Silviculture Activities
	Siltation	Silviculture	Water Temperature	Loss of Riparian Habitat
			Physical Habitat Substrate Alterations	Forest Roads
				Channelization
				Highway/road/bridge runoff
				Highways, Roads, Bridges, Infrastructure
Silver Creek	Thermal modifications	Agriculture	Other flow regime alterations	Highways, Roads, Bridges, Infrastructure
		Irrigated crop production		Flow Regulation/modification
				Impacts from Hydrostructure
Big Creek	Thermal modifications	Highway/road/bridge construction	Sedimentation/Siltation	Loss of Riparian Habitat
		Silviculture	Water Temperature	Channelization
				Streambank Modifications/destabilization
Deer Creek	Thermal modifications	Agriculture	(fully supporting uses)	(fully supporting uses)
		Irrigated crop production		
Ward Creek	Other habitat alterations	Agriculture	(fully supporting uses)	(fully supporting uses)
	Thermal modifications	Highway/road/bridge construction		
		Irrigated crop production		
Little Joe Creek	Other habitat alterations	Highway/road/bridge construction	Other habitat alterations	Highways, Roads, Bridges, Infrastructure
				Natural Sources
	Siltation	Silviculture	Sedimentation/Siltation	Streambank Modifications/destabilization
North Fork Little Joe Creek	Other habitat alterations	Highway/road/bridge construction	Sedimentation/Siltation	Construction
	Siltation			Highway/road/bridge construction

3.3 Applicable Water Quality Standards

Water quality standards include the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a water body. The ultimate goal of this water quality restoration plan, once implemented, is to help ensure that all designated beneficial uses are fully supported and all standards are met for streams in the St. Regis Watershed, particularly those identified as impaired on the 303(d) List. Water quality standards form the basis for the targets described in **Section 4**. Pollutants addressed in this Water Quality Restoration Plan include sediment and thermal modifications. This section provides a summary of the applicable water quality standards for each of these pollutants.

3.3.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single use or group of uses to a water body based on the potential of the water body to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, and recreation and wildlife. The Montana Water Quality Act (WQA) directs the Board of Environmental Review (BER, i.e., the State) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (Administrative Rules of Montana (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 water body must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or non-point source discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet 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 3-3.** Within the St. Regis TPA, Silver Creek is classified as A-1, while Big Creek, Little Joe Creek, North Fork Little Joe Creek Twelvemile Creek, and the St. Regis River are classified as B-1.

Table 3-3. Montana Surface Water Classifications and Designated Beneficial Uses

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

3.3.2 Standards

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy that currently applies to the numeric criteria.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ, 2004b). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., life long) 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 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 water body.

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

The standards applicable to the list of pollutants addressed in the St. Regis TPA are summarized one-by-one below.

3.3.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 3-4.** 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 3-4**).

Table 3-4. Applicable Rules and Definitions for Sediment Related Pollutants

Rule(s)	Standard
17.30.602(28)	"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.
17.30.602(19)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural.
17.30.602(24)	"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.
17.30.622(3) & 17.30.623(2)	No person may violate the following specific water quality standards for waters classified A-1 or B-1.
17.30.622(3)(f) & 17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.622(3)(d)	No increase above naturally occurring turbidity or suspended sediment is allowed in A-1 except as permitted in 75-5-318, MCA.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is 5 NTU for B-1 except as permitted in 75-5-318, MCA.
17.30.637(1)(a & d)	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; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.

3.3.2.2 Temperature Standards

In practical terms, the temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable rate at which temperature changes (i.e., above or below naturally occurring) can occur to avoid fish and aquatic life temperature shock.

For waters classified as A-1 or B-1, the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67º Fahrenheit) is 1°F and the rate of change cannot exceed 2°F per hour. If the natural occurring temperature is greater than 67ºF, the maximum allowable increase is 0.5ºF (ARM 17.30.622(e) and ARM 17.30.623(e).

3.3.3 Reference Approach for Narrative Standards

When possible, a reference site approach is used to determine the difference between an impacted area and a "natural" or least impacted water body. The reference site approach is the preferred method to determine natural conditions, but, when appropriate reference sites are not easily found, modeling or regional reference literature values are used.

SECTION 4.0
WATER QUALITY TARGETS

4.1 Water Quality Targets and Supplemental Indicators

To develop a TMDL, it is necessary to establish quantitative water quality targets and supplemental indicators. This document outlines water quality targets for sediment/habitat and temperature impairments in the St. Regis TPA. TMDL water quality targets must represent the applicable numeric or narrative water quality standards that provide full support of all associated beneficial uses. For pollutants with established numeric water quality standards, the water quality standard is used directly as the TMDL water quality target. For pollutants with only narrative standards, the water quality target must be a measurable interpretation of the narrative standard. In the St. Regis TPA, sediment/siltation pollutants have narrative standards and will require the selection of appropriate TMDL water quality targets and supplemental indicators. Montana's temperature standards are described as a maximum allowable deviation from naturally occurring conditions. To interpret the temperature standard, additional water quality targets and supplemental indicators will be selected.

Since there is no single parameter that can be applied to provide a direct measure of beneficial use impairment associated with sediment and temperature, a suite of water quality targets and supplemental indicators have been selected to be used in combination with one another. The water quality targets are considered to be the most reliable and robust measures of the pollutant. The proposed supplemental indicators are typically not sufficiently reliable to be used alone as a measure of impairment. These are used as supplemental information, in combination with the water quality targets, to provide better definition of potential impairments exerted by a pollutant. In some cases when a number of supplemental indicators are exceeded concurrently, they may support conclusions that narrative standards are being exceeded and follow-up monitoring or a TMDL may be needed. When this is the case, a detailed rationale for the pollutant-impairment linkage will be provided.

As described in the one-by-one discussions of individual pollutants presented in the following paragraphs, there is a documented relationship between the selected water quality targets and beneficial use support, and sufficient reference data is available to establish a threshold value representing "naturally occurring" conditions where all reasonable land, soil, and water conservation practices are in place. In addition to having a documented relationship with the suspected impaired beneficial use, the water quality targets have direct relevance to the pollutant of concern. Exceedences of water quality targets (based on sufficient data) indicate water quality impairment. The water quality targets will be used to assess the ultimate success of future restoration efforts.

The supplemental indicators provide supporting and/or collaborative information when used in combination with the targets. Additionally, some of the supplemental indicators are necessary to determine if exceedences of water quality targets are the result of natural versus anthropogenic causes. However, the proposed supplemental indicators are often not sufficiently reliable to be used alone as a measure of impairment because (1) the cause-effect relationship between the supplemental indicator(s) and beneficial use impairments is weak and/or uncertain, (2) the supplemental indicator(s) cannot be used to isolate impairments associated with individual pollutants (e.g., differentiate between an impairment caused by excessive levels of sediment versus high concentrations of metals), or (3) there is too much uncertainty associated with the supplemental indicator(s) to have a high level of confidence in the result. In some cases, a suite of supplemental indicators may point to a narrative standard that is likely not being attained.

4.2 Linking Pollutants to a Beneficial Use

The beneficial use impairment determinations presented in **Section 5.3** are based on a weight-of-evidence approach in combination with the application of best professional judgment. The weight-of-evidence approach is applied as follows. If none of the water quality targets are exceeded, the supplemental indicators are then investigated. If a combination of supplemental indicators suggests that narrative standards are exceeded, a TMDL may be written or more monitoring may be identified for future TMDL formation. If a target is exceeded, supplemental indicators are also investigated before it is automatically assumed that the exceedence represents human-caused impairment. This is also the case where the supplemental indicators assist by providing collaborative and supplemental information, and the weight-of-evidence of the complete suite of water quality targets and supplemental indicators is used to make the impairment determination. Ultimately, the weight of evidence approach is a tool to determine if narrative water quality standards are being met or exceeded.

4.3 Sediment

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

4.3.1 Effects of Sediment on Aquatic Life and Cold Water Fisheries

Erosion and sediment transport and deposition are natural functions of stream channels. Sediment deposition builds streambanks and floodplains through flooding. Riparian vegetation and natural in-stream barriers such as large woody debris, beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive erosion is taking place due to altered channel morphology or riparian vegetation, excess sediment is likely deposited or transported. Coarse or fine sediment may impair use by depositing in critical aquatic habitat areas.

Increases in fine sediment have been linked to land management activities, and research has shown a statistically significant inverse relation between the amount of fine sediment <6.4 mm in spawning beds and successful salmonid fry emergence (Reiser and Bjornn, 1979, Chapman and McLeod, 1987, Weaver and Fraley, 1991, McHenry et al., 1994, and Rowe et al., 2003). Successful emergence of bull trout and westslope cutthroat trout fry decreases as fine sediment increases (Weaver and Fraley 1991, 1993). Overall, there was 39-44% emergence success for bull trout and 34-39% emergence success for westslope cutthroat trout with 20-30% fines in gravels. Emergence success dropped to 26% as fine sediments approached 40% for both species (Weaver and Fraley 1993). Fry emergence studies indicate that increases in sediment within these two species' spawning areas will have a continuous increasing negative effect as fine sediment increases. This means that there is not a specific amount of sediment in fish spawning areas that can be used as a target because any increases in fine sediment will likely have negative impacts on fry emergence. Reference conditions that approximate naturally occurring sediment levels will be used for fish rearing targets.

The following sediment criteria are used in a weight of evidence approach. If any of the targets or indicators, alone or in combination, indicate that Montana's sediment related water quality standards are exceeded, a TMDL will be provided. Montana's sediment standards are provided in **Section 3.3.2**.

4.3.2 Sediment Targets

The proposed water quality targets and supplemental indicators for sediment are summarized in **Table 4-1** and are described in detail in the paragraphs which follow.

Table 4-1. Sediment Targets for the St. Regis River TPA

Water Quality Targets	**Criteria**
% fines ≤6.3 mm in McNeil core samples*	Mean of 4 samples/site ≤28%
Mean riffle stability index	>45 and <75
Pools/mile	B&C stream types with a bankfull width <20' wide : ≥77
	B stream types with a bankfull width >20'&<35' wide : ≥52
	B stream types with a bankfull width >35'&<45' wide: ≥29
	C stream types with a bankfull width >20'&<45' wide : ≥16
Grid-toss % surface fines <6mm in pool-tails outs	≤8.0
% of fine sediment <2mm in riffles based on pebble count	<20%
Supplemental Indicators	**Criteria**
Width/depth ratio	A stream types: ≤12
	B stream types: ≤23
	C stream types: ≤20
	St. Regis below Haugan: ≤30
LWD/mile	B&C stream types with a bankfull width <20' wide : ≥163
	B&C stream types with a bankfull width >20'&<35' wide : ≥112
	B&C stream types with a bankfull width >35' wide: ≥104
Sinuosity	≥1.2
Proper functioning condition (PFC) riparian assessment	"Proper Functioning Condition" or "Functional-at Risk" with an upward trend
Macroinvertebrates	Mountain MMI >63
	1.2>RIVPACS>0.80
Anthropogenic sediment sources	No significant sources present

**Applied only to St Regis River upstream of Saltese and to all listed tributary streams.*

4.3.2.1 Channel Morphology and Substrate Measurement Targets

McNeil Cores in Spawning Gravels
Spawning gravel composition in the St. Regis River and its tributaries was examined using McNeil core samples. McNeil core samples measure long-term changes in fine sediment in channel substrate independent of variation in annual runoff. Sample locations included six sites on the St. Regis River and seven tributary sites, for a total of 13 sample sites. McNeil core samples were conducted in identified and potential spawning gravels located in pool tail-outs. Four McNeil core samples were collected at each location, and a mean value was derived for each site.

Potential least-impacted sites included Ward, Deer, and Savenac creeks which are described on the 2004 303(d) List as fully supporting their beneficial uses. A site on the South Fork Little Joe Creek was also chosen as a potential least-impacted site due to observed bull trout redds by Lolo National Forest fisheries biologists. South Fork Little Joe is not a reference watershed; this site is located above most of the road impacts observed in the South Fork Little Joe Watershed. While Savenac Creek is not listed as impaired, a high percent of fine sediment in both McNeil core samples and grid-toss samples, along with evidence of historic human impacts in the lower portions of the drainage, excluded it from consideration as a least-impacted site. Thus, Ward Creek, Deer Creek, and South Fork Little Joe Creek were used to develop water quality targets for McNeil cores. McNeil core samples from these three streams had a mean of 24.7% sediment finer than 6.3 mm in size. Mean values of 21.6, 24.8, and 27.8% finer than 6.3 mm were found in South Fork Little Joe, Ward, and Deer creeks respectively (**Appendix A**). The 75th percentile from these streams was 27.8% less than the 6.3 mm sediment size class. Reference condition investigations conducted in other TMDL planning areas, including Bobtail Creek, Blackfoot River headwaters, and the Grave Creek Watershed, all found similar levels of levels of fines in spawning redds. Thus, a water quality target of ≤28% finer than 6.3 mm is established as a water quality target for the St. Regis River upstream of Saltese and for tributaries within the St. Regis Watershed (**Table 4-1**). If conditions are currently under 28%, then an adaptive management approach should be applied to assure that the percent fine sediment in spawning gravels does not exceed the existing level since increasing fine sediment in spawning gravel has a generally negative relationship with fry emergence.

Riffle Stability Index
The riffle stability index provides an estimate of sediment supply in a watershed. Kappesser (2002) found that riffle stability index values between 40 and 70 in B-channels indicate that a stream's sediment transport capacity is in dynamic equilibrium with its sediment supply. Values between 70 and 85 indicate that sediment supplies are moderately high, while values greater than 85 are suggestive of excessively sediment-loaded streams. The scoring concept applies to any streams with riffles and depositional bars. Riffle stability index values were determined primarily in C-channels in the St. Regis Watershed. Riffle stability index values of 75 and greater were documented in managed subwatersheds within the St. Regis River drainage. Watersheds were considered to be "managed" if roads existed above a stream survey site. Other managed and unmanaged subwatersheds within St. Regis drainage produced riffle stability index values of between 46 and 75 (**Appendix B**). The results indicated that there was more mobile bedload in managed areas of the St. Regis Watershed as compared to less developed stream segments. Riffle

stability index values of zero were found in confined reaches of the St. Regis River and its tributaries that resulted from proximity of hill slopes, encroachment by roads, and the presence of riprap and/or meander cutoffs. In these situations, the riffle stability index values indicated that the sediment transport capacity was in excess of the sediment supply. The lowest non-zero value (46) was measured in a least-impacted portion of the St. Regis River headwaters.

The riffle stability index water quality target for the St. Regis River and tributary watersheds is greater than 45 and less than 75 based on Kappesser's research and local reference conditions for least-impacted stream segments (**Table 4-1**). These targets are applicable to all sections of river. However, stretches with extensive riprap or natural confinement may never develop gravel bars and may always have values of zero. This target should not be used as an indicator of increased sediment yield. It does provide a link between stream channel changes and sediment sorting and transport. Therefore, it should be used along with other indicators to determine if sediment transport may be affected along with the presence of human sediment sources and sediment linkage to impacted use.

Pool Frequency

Pool frequency varies based on the type of channel and the size of the stream. The majority of the St. Regis River downstream of Saltese can be described as a pool-riffle channel characterized by a sequence of bars, pools, and riffles (Montgomery and Buffington 1997). A pool-riffle channel is equivalent to the Rosgen C-type channel. Reaches described as Rosgen F-type channels currently resemble plane-bed channels. Plane-bed channels are characterized by long stretches of relatively featureless bed in which pools and bars form as the result of obstructions (Montgomery and Buffington 1997). These reaches are likely the result of channelization along the St. Regis River. Reaches upstream of Saltese and in the tributaries can be described as pool-riffle channels, step-pool channels, and cascades that would be expected to have greater pool frequencies (Montgomery and Buffington 1997).

An assessment of pool frequency was conducted utilizing the entire dataset from the St. Regis Watershed. Based the entire dataset, there was a median of 112 pools per mile in B-type streams and 41 pools per mile in C-type streams within the St. Regis TPA. Pool frequency in Rosgen B-type streams ranged from 30 to 572 pools per mile at the 25th and 75th percentile respectively. Pool frequency in Rosgen C-type streams ranged from 13 to 153 pools per mile at the 25th and 75th percentile respectively. However, most of these streams have been modified to the extent that they probably do not represent appropriate reference conditions.

Instead, regional reference data was used for the development of pool frequency targets. Specifically, the Lolo National Forest (LNF) dataset for undeveloped streams, the Libby Ranger District of the Kootenai National Forest (KNF) reference dataset, and reference data collected during the Swan TMDL are used as applied in the Grave Creek TMDL (DEQ 2005). An assessment of undeveloped streams on the LNF indicated Rosgen B stream types averaged 39 pools per mile, while Rosgen C stream types averaged 37 pools per mile. On the KNF, Rosgen B and C stream types between 10 and 20 feet wide ranged from 77 to 118 pools per mile at the 25th and 75th percentiles respectively. There was very little difference in pool spacing in these smaller channels. On the KNF, Rosgen B stream types between 20 and 32 feet wide ranged from 52 to 71 pools per mile at the 25th and 75th percentiles respectively, while C stream types between 20 and 32 feet wide ranged from 16 to 44 pools per mile at the 25th and 75th percentiles respectively. Thus, a target of at least 77 pools per mile for streams <20 feet wide is established for both Rosgen B and C stream types, while a pool frequency target of at least 52 pools per mile is established for B-type streams between 20 and 35 feet wide, based on the KNF reference dataset. In the Swan River TPA, Rosgen B and C stream types between 35 and 45 feet wide had a range of 29 to 47 pools per mile at the 25th and 75th percentiles respectively. Based on this dataset, a pool frequency target in channels between 35 and 45 feet wide of at least 29 pools per mile is established for B stream types. A pool frequency target of at least 16 pools per mile is established for C stream types between 20 and 45 feet wide.

For stream widths greater that 45 feet, a numeric target expressed as pools per mile is not established due to a lack of reference data. However, a pool frequency of at least two pools for each meander wavelength would be expected under natural conditions in meandering stream channels (C stream types), while step-pool channels (B stream types) would be expected to have more pools.

Percent Surface Fines

The U.S. Forest Service conducted 25 habitat surveys in "undeveloped" watersheds in the Lolo National Forest, which were defined as roadless upstream of the survey site, between 1989 and 1995. A 49-point grid-toss sample based on methods developed by Kramer et al. (1991) was conducted over the entire stream reach including both pools and riffles (Riggers et al. 1998). Based on this assessment, it was determined that least-impacted conditions for percent surface fines for streams draining metasedimentary geologies in the Lolo National Forest averaged 7.6% in B channels and 8.0% in C stream channels at the reach scale (Riggers et al. 1998).

The percent surface fines less than 6 mm was assessed near each McNeil core sample site in the St. Regis Watershed using a 49-point grid. This assessment found that the percent surface fines data collected using the grid-toss method was correlated with data collected using the McNeil core sampler. Exceptions include Deer Creek (which had a fairly low McNeil core value, but the second highest grid-toss value) and Twelvemile Creek (which had one of the higher McNeil core values and a fairly low grid-toss value). Excluding these two sites, the other McNeil core samples sites with results <28% finer than 6.3mm, which is the established water quality target, all had grid-toss values of <8% finer than 6 mm. Thus, a grid-toss value of ≤8% finer than 6 mm is established as a supplemental indicator for the percent of surface fines in pool tail-outs in the St. Regis TPA. This value will also be used to assess existing data collected in lateral scour pools.

A supplemental indicator of <20% of the substrate finer than 2 mm in riffles as collected with a Wolman pebble count is established based on the requirements of aquatic macroinvertebrates (Relyea et al. 2000). However, this value may be reduced once additional pebble count data from reference streams within the St. Regis TPA is collected. Regional reference data from the Yaak (EPA and KNF unpublished data as reported in the Grave Creek TMDL) indicated that the percent of fine sediment <6.35mm in riffles based on pebble counts had mean values ranging from 10-13% in Rosgen B3, B4, C3, and C4 streams. Thus, it is anticipated that the future supplemental indicator value for the amount of fine sediment <2mm could be in the 10-20% range.

4.3.2.2 Supplemental Indicators

Width/Depth Ratio
The bankfull width to average bankfull depth ratio (W/D ratio) of the stream channel is a fundamental aspect of channel morphology and provides a measure of channel stability. Changes in the width/depth ratio can be used as an indicator of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the W/D ratio increases, streams become wider and shallower. An increase in the width/depth ratio also suggests an excess of sediment that the stream can not transport easily, usually coarse sizes (MacDonald et al. 1991). The depth of the stream channel decreases as sediment accumulates, which is compensated for by an increase in channel width as the stream attempts to regain a balance between sediment load and transport capacity. Accelerated bank erosion and an increased sediment supply often accompany increases in the width/depth ratio (Rosgen et al. 1996).

Riggers et al. (1998) suggested that W/D ratios should be between 3 and 12 for A-type stream channels, between 12 and 22 for B-type stream channels, and between 10 and 33 for C-type channels located in metasedimentary geologies in the Lolo National Forest (**Table 4-2**). However, the Riggers study applied normal statistics to a non-normal distributed data which was skewed toward the higher end of the distribution. The suggested high end of the Riggers et al. (1998) reference W/D ratios are thus likely too high because of statistical errors, especially for the C-type streams. A smaller reference dataset from the Kootenai National Forest indicates that reference W/D ratios should be slightly lower than the Lolo National Forest data analysis. Width/Depth ratios target levels will be based on these two studies but using results based on nonparametric statistics.

Supplemental indicator values for width/depth ratios will be ≤23 for B-type streams, and ≤20 for C-type streams in the St. Regis TPA. An exception to these applications will be the St. Regis River below Haugan. Width to depth ratios naturally increase when stream order increases. St. Regis River's W/D ratio indicator below Haugan will be set at ≤30 to account for this natural variability.

Table 4-2: Width-to-Depth Ratio Reference Sources and Results

Data Source	Stream Types & Other Stratification	Suggested Reference Condition W/D Ratios
Lolo National Forest Reference Streams (Riggers, et al., 1998) (recommended ranges based on reference data sets)	B3 & B4 C3 & C4	12 – 22 10 – 33

Table 4-2: Width-to-Depth Ratio Reference Sources and Results

Data Source	Stream Types & Other Stratification	Suggested Reference Condition W/D Ratios
Kootenai National Forest Reference Data	B3 (stream widths 18 ± 9 ft)	20.9 ± 9.0 (n = 34)
	B4 (stream widths 13 ± 4 ft)	19.4 ± 6.9 (n = 22)
	C3 (stream widths 26 ± 4 ft)	16.0 ± 7.4 (n = 4)
	C4 (stream widths 15 ± 3 ft)	14.7 ± 3.2 (n = 3)

Large Woody Debris

Large woody debris plays a significant role in the creation of pools, especially in smaller stream channels. Hauer et al. (1999) observed that single pieces of large woody debris situated perpendicular to the stream channel or large woody debris aggregates form the majority of pools in a study conducted in northwestern Montana.

An assessment of large woody debris per mile was conducted utilizing the entire dataset from the St. Regis Watershed. Based the entire dataset, there was a median of 111 pieces of large woody debris per mile in B-type streams and 73 pieces of large woody debris per mile in C-type streams within the St. Regis TPA. Large woody debris in Rosgen-B type streams ranged from 30 to 602 pieces per mile at the 25th and 75th percentiles respectively. Large woody debris in Rosgen C-type streams ranged from 29 to 203 pieces per mile at the 25th and 75th percentiles respectively. In addition, the three reaches of the St. Regis River assessed as "proper functioning condition" had a mean of 104 pieces per mile. However, most of these streams have been modified to the extent that they probably do not represent appropriate reference conditions.

Instead, regional reference data was used for the development of large woody debris targets. Specifically, the Lolo National Forest (LNF) dataset for undeveloped streams, the Libby Ranger District of the Kootenai National Forest (KNF) reference dataset, and reference data collected during the Swan TMDL were used as applied in the Grave Creek TMDL (DEQ 2005). Active large woody debris was found in undeveloped streams on the LNF at an average of 156 pieces per mile in 3rd and 4th order streams (Riggers et al. 1998). For streams ranging from 10 to 20 feet wide on the KNF, large woody debris was found to range from 163 to 371 pieces per mile at the 25th and 75th percentiles respectively when Rosgen B and C stream types were combined. For streams ranging from 20 to 35 feet wide on the KNF, large woody debris was found to range from 112 to 443 pieces per mile at the 25th and 75th percentiles respectively when Rosgen B and C stream types were combined. For Rosgen B and C streams ranging from 35 to 45 feet in the Swan TPA, large woody debris ranged from 104 to 210 pieces per mile at the 25th and 75th percentiles respectively. Thus, a large woody debris target of at least 163 pieces per mile is established for Rosgen B and C stream types between 10 and 20 feet wide and at least 112 pieces per mile for Rosgen B and C stream between 20 and 35 feet. A supplemental indicator of at least 104 pieces per mile is established for streams wider than 35 feet (**Table 4-1**).

Sinuosity
Extensive channelization along the mainstem of the St. Regis River has reduced the ability of the river to access the floodplain. A supplemental indicator value for sinuosity of at least 1.2 is established for the mainstem of the St. Regis River and the listed tributaries based on work by Rosgen et al. (1996) (**Table 4-1**). This supplemental indicator is not applicable in naturally confined valley types that can not support this high of stream sinuosity.

Riparian Condition
Interactions between the stream channel and the riparian vegetation along the stream banks are a vital component in the support of the beneficial uses of cold water fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies large woody debris that influences sediment storage and channel morphology. Riparian vegetation provides shading, cover, and habitat for fish. Extensive riparian vegetation reduces temperature fluctuations and stream bank erosion.

The Proper Functioning Condition (PFC) method is a qualitative procedure for “assessing the physical functioning of riparian-wetland areas” (Prichard 1998). The hydrologic processes, riparian vegetation characteristics, and erosion/deposition capacities of streams are evaluated for a selected stream reach. The final rating is a professional judgment call based on responses to a series of yes/no questions. The possible ratings for a reach are “proper functioning condition” (PFC), “functional - at risk” (FAR), or “non-functional” (NF). Alternative riparian assessment techniques that employ similar methodologies, such as the DEQ Stream Reach Assessment, may also be applied. For listed streams in the St. Regis TPA, riparian areas should be in proper functioning condition or in functioning-at-risk conditions, but showing an improving trend.

Macroinvertebrates
Siltation exerts a direct influence on benthic macroinvertebrate assemblages through several mechanisms. These include limiting preferred habitat for some taxa by filling in interstices or spaces between gravel. In other cases, fine sediment limits attachment sites for taxa that affix to substrate particles. 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 bioassessments scores are an assessment of the macroinvertebrate assemblage at a site and are used by DEQ to evaluate impairment condition and beneficial use support. The advantage to these bioindicators is that they provide a measure of support of associated aquatic life, an established beneficial use of Montana’s waters.

In 2006, DEQ adopted impairment thresholds for bioassessment scores based on two separate methodologies. The Multi-Metric Index (MMI) method assesses biologic integrity of a sample based on a battery of individual biometrics. The River Invertebrate Prediction and Classification System (RIVPACS) method utilizes a probabilistic model based on the taxa assemblage that would be expected at a similar reference site. Based on these tools, DEQ adopted bioassessment thresholds that were reflective of conditions that supported a diverse and biologically unimpaired macroinvertebrate assemblage, and therefore a direct indication of beneficial use support for aquatic life.

The MMI is organized based on the different ecoregions within Montana. Three MMIs are used to represent the various Montana ecoregions: Mountain, Low Valley, and Plains. Each region has specific bioassessment threshold criteria that represent full support of macroinvertebrate aquatic life uses. The St. Regis Watershed falls within the Mountain MMI region. The MMI score is based upon the average of a variety of individual metric scores. The metric scores measure predictable attributes of benthic macroinvertebrate communities to make inferences regarding aquatic life condition when pollution or pollutants affect stream systems and in-stream biota. For the Multi-Metric Index, individual metric scores are averaged to obtain the final MMI score, which ranges between 0 and 100. The impairment threshold is 63 for the Mountain MMI. This value is established as a supplemental indicator for sediment impairments in the St. Regis TPA. The impairment threshold (10^{th} percentile of the reference dataset) represents the point where DEQ technical staff believed macroinvertebrates are affected by some kind of stressor that is contributing to impairment (e.g. loss of sensitive taxa).

The RIVPACS 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. The RIVPACS model provides a single dimensionless ratio to infer the health of the macroinvertebrate community. This ratio is referred to as the Observed/Expected (O/E) value. Used in combination, the results suggest strong evidence that a water body is either supporting or non-supporting its aquatic life uses for aquatic invertebrates. The RIVPACS impairment threshold for all Montana streams is any O/E value <0.8. However, the RIVPACS model has a bidirectional response to nutrient impairment. Some stressors cause macroinvertebrate populations to decrease right away (e.g. metals contamination) which causes the score to decrease below the impairment threshold of 0.8. Nutrient enrichment may actually increase the macroinvertebrate population diversity before eventually decreasing below 0.8. An upper limit was set to flag these situations. The 90^{th} percentile of the reference dataset was selected (1.2) to account for these situations, and any value above this score is defined as impaired unless specific circumstances can justify otherwise. However, RIVPACS scores >1.0 are considered unimpaired for all other stressor types. A supplemental indicator value RIVPACS score of >0.80 and <1.2 is established for sediment impairments in the TPA. A score of greater than 1.2 does not necessarily indicate a problem, but when combined with other data may present support for nutrient impacts.

Anthropogenic Sediment Sources

In order to make accurate impairment decisions, it is important to consider all potentially significant pollutant sources. Doing so helps differentiate between natural and human caused conditions. If target/indicator values are exceeding the proposed threshold values, yet no significant human sources exist, then natural condition may be the cause. Additionally, as a basic part of watershed restoration and protection, all significant controllable human caused pollutant sources should be addressed. The goal of the St. Regis TMDL project is that no significant controllable human caused sediment sources should exist in the watershed if sediment is impairing any use.

The first step in determining significant human caused sediment sources during TMDL projects is use of aerial photography, conferring with local land managers, and field reconnaissance. If sediment sources are deemed potentially significant during this process, they are assessed for numeric loading for the TMDL source assessment. The TMDL source assessment along with the preliminary steps are considered during the consideration of significant human caused sources.

4.4 Temperature

Canopy density, stream channel geometry, and temperature thresholds that relate to the most sensitive beneficial use, along with the Administrative Rules of Montana, will be applied as water quality goals and supplemental indicator criteria for stream segments listed as impaired due to thermal modifications in the St. Regis TPA. Special temperature considerations are warranted for the bull trout and the westslope cutthroat trout, which are both found in the St. Regis TPA. Temperatures that support these species are used for estimating if state temperature standards are exceeded in the streams of interest because these species are or were once present in the St. Regis Watershed. Temperatures that support these species may be used to help estimate naturally occurring temperature conditions along with temperature influencing factors such as shade, groundwater influences, channel geometry, stream discharge, and stream aspect when a model is not used to complete this task. The temperature thresholds that support these species are not provided as absolute targets because the streams in the St. Regis Watershed may not naturally have the ability to support these temperatures.

4.4.1 Effects of Increased Temperatures on Aquatic Life and Cold Water Fisheries

Factors influencing stream temperature include solar radiation, the canopy density of riparian vegetation, channel morphology, stream discharge, and stream aspect. Interactions between the stream channel and the riparian vegetation along the stream banks are a vital component in the support of the beneficial uses of coldwater fisheries and aquatic life. Shade provided by riparian vegetation decreases the amount of solar radiation reaching the channel and reduces stream temperature fluctuations. Native fish in this area include cutthroat trout and bull trout. These species are likely the most sensitive use regarding stream temperatures.

4.4.2 Temperature Targets

The proposed water quality targets and supplemental indicators for temperature are summarized in **Table 4-3** and are described in detail in the paragraphs which follow. These targets apply to the St. Regis River, Big Creek, and Twelvemile Creek, which are the three water bodies in the St. Regis TPA that require TMDLs for temperature/thermal modifications. Although, the allocation section of the St. Regis temperature TMDL will effectively call for a watershed wide application of the canopy density criteria for thermal load allocations to tributaries.

Table 4-3. Temperature Targets for the St. Regis River TPA

Water Quality Target	Criteria
Montana Water Quality Standard for Temperature	The maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67º Fahrenheit) is 1°F and the rate of change cannot exceed 2°F per hour. If the natural occurring temperature is greater than 67ºF, the maximum allowable increase is 0.5ºF (ARM 17.30.622(e), ARM 17.30.623(e)).
Meet the Water Temperature Target Above or Meet All of the Surrogate Targets Below:	
Canopy density	≥60% on St. Regis River ≥65% in all tributaries where shrub canopy naturally dominates stream banks. ≥90% in headwater zones where trees naturally dominate the canopy along stream banks.
Channel width/depth ratio	A stream types: ≤12 B stream types: ≤23 C stream types: ≤20
Supplemental Indicator (not a target)	
Seasonal Maximum, 7-Day Average of Daily Maximum Temperatures (7DADMT)	St. Regis River downstream of Saltese: ≤59ºF
	St. Regis River upstream of Saltese and all tributary streams: ≤54ºF

4.4.4.2 Temperature Targets

Montana's Water Quality Standard

Water quality targets for temperature are established at a level necessary for the long term viability of the bull trout while also considering the state water quality standards. The Administrative Rules of Montana specify that waters of Montana classified as A-1 or B-1 by the State of Montana, a 1ºF maximum increase above naturally occurring water temperature is allowed within the range of 32-66ºF; within the naturally occurring range of 66-66.5ºF, no discharge is allowed which will cause the water temperature to exceed 67ºF; and where the naturally occurring water temperature is 66.5ºF or greater, the maximum allowable increase in water temperature is 0.5ºF (ARM 17.30.622 (3)(e), ARM 17.30.623 (2)(e)). Temperature monitoring and modeling indicate that naturally occurring stream temperatures in the St. Regis TPA likely fall within the coolest of the ranges specified by ARM 17.30.622 (3)(e) (32F to 66F) and thus the maximum allowable increase above naturally occurring temperatures is 1ºF . This rule is adopted as one of the water quality targets for temperature for all streams in the St. Regis TPA.

Temperature, shade, and stream flow monitoring, along with associated temperature modeling was used to estimate how stream temperatures deviate from naturally occurring levels for two tributaries. However, because the modeling was not completed for the whole watershed, the naturally occurring temperature range in the St. Regis River is not understood as well as it is in modeled tributaries. Because modeling was not feasible at a watershed scale, a suite of surrogate targets is used for the St. Regis River along with inferences from modeled areas for comparison to Montana's water temperature standard.

As described above, Montana's water quality standard for temperature addresses a maximum allowable increase above the "naturally occurring" temperature to protect the existing temperature regime for fish and aquatic life (see **Section 3.3).** For Big and Twelve Mile creeks, the QUAL2K model was used to assess existing stream temperatures relative to the Montana standard. The QUAL2K model was used to determine if anthropogenic disturbances within the watershed have increased the water temperature above the "naturally occurring" level. Stream temperature and riparian shading data collected in the summer of 2006 was used to calibrate the QUAL2K model for existing conditions. The potential to reduce stream temperatures by increasing riparian shading and in-stream flows through the application of all reasonable land, soil, and water conservation practices was then modeled to assess temperature impairments and develop TMDL load allocations. The relationship between anthropogenic disturbance and water quality impairments as described in ARM 17.30.623(e) was evaluated with the following definitions since almost all water temperature measurements were below 66°F, and temperatures found above 66°F are not likely to be naturally occurring:

> *If simulated stream temperatures derived from the model using the existing riparian shade data deviate by less than 1ºF from stream temperatures derived using the potential riparian shade, then anthropogenic sources are assumed to not be causing or contributing to violations of the A-1 and B-1 water temperature standards and the stream is not considered impaired due to anthropogenic (or anthropogenically induced) thermal modifications.*

> *If simulated stream temperatures derived from the model using the existing riparian shade data deviate by greater than 1ºF from stream temperatures derived using the potential riparian shade, then anthropogenic sources are assumed to be causing or contributing to violations of the relevant A-1 and B-1 water temperature standards and the stream is considered impaired due to anthropogenic thermal modifications.*

Although the QUAL2K model provides a reasonable method of interpreting the Montana water quality standard for temperature in the listed tributary streams, its ability to predict accurately temperature differences of less than 1ºF has not been fully evaluated. For this reason, the surrogate target suite should also be included as performance measures for Big and Twelvemile creeks. Supporting temperatures of sensitive fish species should also be considered but modeling indicated some areas of these streams may not naturally support these temperatures during all timeframes.

Inferences from the modeling effort on the tributaries to the St. Regis River will help support conclusions about naturally occurring temperatures on the St. Regis River. Surrogate targets comparisons and comparisons to tributary modeling will be used to loosely estimate impairment based on Montana's temperature standard.

Canopy Density
Canopy density on stream banks is an indictor of the amount of stream-side shading provided by the riparian vegetation. Lower canopy densities allow more direct radiation to reach the stream channel, which leads to increased stream temperatures and greater fluctuations in stream

temperature both daily and seasonally. Decreasing the amount of forest or shrub cover can increase the incident solar radiation, which leads to an increase in peak summer temperatures.

Least impacted conditions along the St. Regis River indicate overall canopy density along the stream banks at the sub-reach scale ranges from 60-65%, with canopy density along the left bank ranging from 45-60% and canopy density along the right bank ranging from 60-75%. Thus, a surrogate target value for canopy density of ≥60% is provided for the St. Regis River. However, potential conditions may need to be adjusted locally along the St. Regis River based on the proximity of the interstate, since some reaches will not be able to attain target criteria due to road encroachment.

Tributary riparian canopy density and associated effective shade conditions were assessed in detail during source assessment work in Big and Twelvemile creeks. Reference conditions in steeper stream channel, naturally forested streambank conditions were 90% or better. In least impacted and reference areas were shrub growth dominated streambanks an average of 65% canopy density over the stream was measured.

The canopy density targets do not reflect a landscape with fire or severe tree kill from insects. If these occur in the St. Regis watershed, canopy density targets should not be expected in all riparian zones, especially those affected by fire. Adaptive management efforts would be necessary to determine approaches for determining naturally occurring canopy density in the watershed if these shade influences occur.

Width/Depth Ratio

Lower channel bankfull width to average bankfull depth ratios (W/D ratios) are associated with the presence of deep pools that provide better thermal protection for cold water fish (Riggers et al. 1998). A decrease in depth increases the thermal exchange rate with air (Beschta and Platts 1986), while an increase in width allows greater inputs of solar radiation, which can lead to higher stream temperatures. Width/depth ratios used as supplemental indicator criteria for sediment impairments (**Section 4.3.2.1**) are also applied as supplemental indicator criteria for temperature impairments. Most temperature models indicate that stream channel dimension is the least sensitive factor when considered along side shading and stream flow conditions. Even so, in some circumstances it is a significant contributing factor for heating in-stream water.

Stream Discharge and Point Sources

The St. Regis Watershed has no appreciable irrigation diversions that would significantly reduce the thermal assimilative capacity of streams. There are no permanent point sources that would provide significant heat in the St. Regis Watershed. Therefore no surrogate targets are proposed for these influences on temperature.

Highest 7-Day Average of the Daily Maximum Temperature (supplemental indicator)

Special consideration is warranted in the St. Regis River TPA for bull trout, which are listed as threatened under the Endangered Species Act (USFWS 1999). Bull trout have some of the lowest "upper thermal limits" and growth optima of North American salmonids. Bull trout experience optimum growth at 55.7ºF (13.2ºC) (Selong et al. 2001) under laboratory conditions. A study conducted in Idaho found bull trout selected the coldest water available when temperatures ranged from 46.4-59.0ºF (8-15ºC) (Bonneau and Scarnecchia 1996). A model developed by Dunham et al. (2003) predicts less than 50% occurrence of bull trout until maximum daily temperatures decline to approximately 57.2-60.8ºF (14-16ºC). A high probability of occurrence (75%) occurs when maximum daily temperatures decline to approximately 51.8-53.6ºF (11-12ºC). Bull trout are most likely to use waters with maximum daily temperatures less than or equal to 53.6ºF (12ºC) (Dunham et al. 2003). A review of bull trout temperature requirements as summarized by the U.S. Fish and Wildlife Service (USFWS) in "A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale" (1998) is excerpted below:

> *Stream temperatures…may be particularly important characteristics of suitable habitats. Bull trout have repeatedly been associated with the coldest stream reaches within basins. Goetz (1994) did not find juvenile bull trout in water temperatures above 12.0°C. The best bull trout habitat in several other Oregon streams was where water temperature seldom exceeded 15°C (Buckman et al. 1992; Ratliff 1992; Ziller 1992). Temperature also appears to be a critical factor in the spawning and early life history of bull trout. Bull trout in Montana spawned when temperatures dropped below 9-10°C (Fraley and Shepard 1989). McPhail and Murray (1979) reported 9°C as the threshold temperature to initiate spawning for British Columbia bull trout. Temperatures fell below 9°C before spawning began in the Metolius River, Oregon (Riehle 1993). Survival of bull trout eggs varies with water temperature (McPhail and Murray 1979). They reported that 0-20%, 60-90%, and 80- 95% of the bull trout eggs from British Columbia survived to hatching in water temperatures of 8-10°C, 6°C, and 2-4°C respectively. Weaver and White (1985) found that 4-6°C was needed for egg development for Montana bull trout.*

Stream temperature data collected in the St. Regis Watershed from 2001 to 2003 and in 2006 by the U.S. Forest Service and DEQ reported the number of days where the temperature exceeded 50ºF (10ºC), 59ºF (15ºC), and 70ºF (21ºC). These data are presented in greater detail in **Section 5.0** of this report, as well as in **Appendices C and D**. The 50ºF value represents conditions conducive to bull trout spawning, while the 59ºF value represents conditions conducive to Bull trout rearing, both of which correspond to the "Functioning at Risk" level in the USFWS matrix (**Table 4-4**). Temperature data collection efforts in the St. Regis TPA have focused on characterizing maximum summer temperatures and no data are available from the fall, winter, and early spring when incubation and spawning occur. For this reason, fishery impact discussion in this document in relation to bull trout is limited to the rearing and migration life history stages, USFWS temperature guidelines from the "Functioning Appropriately" column of **Table 4-3** were used to assist with determining naturally occurring although they are not an absolute target since many streams may not naturally be able to support these specific temperatures year round. Montana's temperature standard is based on an allowable increase above naturally occurring stream temperatures and assessing the hottest weather periods will provide protection during other timeframes due to the nature of heat sources in the watershed.

While the USFWS has determined that these temperatures are required by bull trout at various stages of their life history, the extent to which such temperatures were historically found in streams of the St. Regis TMDL is currently uncertain. It is possible that in some streams or sections of streams, naturally occurring temperatures periodically exceeded the levels recommended by USFWS under natural background conditions. Modeling conducted in support of temperature TMDLs in the St. Regis TPA and discussed in greater detail in (**Appendix C**) provides an estimate of the extent to which current temperatures have departed from naturally occurring temperatures. The use of temperature thresholds which support bull trout propagation will only be used as supporting evidence for estimated natural background temperatures and are not an absolute target.

A water quality supplemental indicator is established for the St. Regis River based on the 7 day average of the daily maximum temperature recorded over the warmest week of the season. This is known as the 7-Day Average of the Daily Maximum Temperature (7DADMT) and describes the annual peak in the 7-day average of the daily maximum temperatures. The 7DADMT usually occurs between mid-July and mid-August in Montana streams. Based on information collected on bull trout temperature requirements as summarized by the USFWS (1998), along with work conducted by Dunham et al. (2003), a water temperature indicator of ≤54ºF (12ºC) 7DADMT is set for the mainstem of the St. Regis River upstream of Saltese (**Table 4-4**). This temperature target is geared toward protecting bull trout rearing in the headwaters of the St. Regis River. A water temperature indicator of ≤59ºF (15ºC) 7DADMT is set for the middle and lower mainstem of the St. Regis River downstream of Saltese. This temperature indicator is geared toward assuring the St. Regis River is a suitable migration corridor for bull trout. These use-based temperature indicators are not targets because modeling on a number of tributaries indicates these temperatures may not be naturally feasible. Also, two of the reference tributaries with north facing watersheds do not always meet these temperature thresholds, although they come close.

Table 4-4. U.S. Fish and Wildlife Service matrix for assessing temperature impacts to bull trout (modified from USFWS 1998)

	Life History Stage	Functioning Appropriately	Functioning at Risk	Functioning at Unacceptable Risk
7 day average maximum temperature	**Incubation (Fall, Winter, Early Spring)**	2-5ºC (35.6-41.0ºF)	<2ºC or >6ºC (<35.6ºF or >42.8ºF)	<1ºC or >6ºC (<33.8ºF or >42.8ºF)
	Spawning (Fall)	4-9ºC (39.2-48.2ºF)	<4ºC or >10ºC (<39.2ºF or >50.0ºF)	<4ºC or >10ºC (<39.2ºF or >50.0ºF)
	Rearing (Year Round)	4-12ºC (39.2-3.6ºF)	<4ºC or >13-15ºC (<39.2ºF or >55.4-59.0ºF)	>15ºC (>59ºF)
	Migration (Year Round)	never exceed 15ºC (59ºF)	sometimes exceed 15ºC (59ºF)	regularly exceed 15ºC(59ºF)

Temperature Target Application

Consideration of targets and supplemental indicators may differ slightly with the amount of data available for the stream of concern but a general approach for applying temperature targets and indicators was followed. Generally, the first consideration was to evaluate if temperature conditions are above the 54ºF or 59ºF depending on anticipated fishery use. This assessment utilized a continuous temperature data set collected during the warmest timeframe of the year. If the applicable temperature threshold is met, the most sensitive uses are likely met. If these temperature thresholds are not met, the shade and geomorphologic conditions should be investigated. If these surrogate target thresholds are met then naturally occurring temperature conditions are likely occurring and no temperature TMDL is needed. If shade and geomorphic targets are not met and it is anticipated or shown via modeling that >1ºF variation has been caused, then the stream is impaired. If impaired, as watershed conditions approach surrogate targets, additional modeling or other analysis can be performed to adjust these targets as necessary to ensure ultimate compliance with the water quality standard, which is the primary target in **Table 4-3**.

SECTION 5.0
EXISTING CONDITIONS AND TARGET COMPLIANCE

This section presents summaries and evaluations of all available water quality data for St. Regis TPA water bodies appearing on the Montana 1996 and subsequent 303(d) Lists. The weight of evidence approach described earlier in **Section 4.2**, using a suite of water quality targets and supplemental indicators, has been applied to verify and/or reconsider each of the 1996 listed water quality impairments. Supporting documentation is provided on a water body-by-water body basis.

5.1 Big Creek

The 1996 303(d) List reported Big Creek from the East and Middle Forks to the mouth was threatened for coldwater fisheries uses. The probable cause of impairment was thermal modifications. Probable sources of impairment included highway/road/bridge construction and silviculture. In 2006 Big Creek was listed as partially supporting aquatic life and coldwater fisheries. The probable causes of impairment include sedimentation/siltation and water temperature. Probable sources of impairment include channelization, loss of riparian habitat, and streambank modifications/destabilization.

5.1.1 Sediment

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Big Creek as "functioning at unacceptable risk" due to sediment. The Big Creek watershed was identified as having a road density of 2.5 miles/mile^2, with 37% of the streams having roads within 300 feet of the banks, a third of which are within 125 feet of the stream (Hendrickson and Cikanek 2000).

In August 2001, DEQ performed physical, chemical, and biological water quality assessments at two sites on Big Creek. The upper sample site was just below the confluence with the West and East forks, while the lower site was approximately a half mile above the mouth. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements.

Based on the 2001 assessment, DEQ reported the upper assessed site was a Rosgen B3 stream type with a width/depth ratio of 16.7 and an entrenchment ratio of 2 based on an assessment in 2001, which is meeting the supplemental indicator width/depth value of ≤22 for Rosgen B-type streams. The percent of sediment <2mm was meeting the preliminary supplemental indicator value of <20% at both sites, with a value of 2.8% at the upper site and 0% at the lower site. The upper site was rated as "at risk" from the perspective of riparian integrity. Notations were made about channel downcutting, a lack of old age willow stands, and inadequate material for energy dissipation (i.e. woody debris). Field notes indicated that there was limited fish habitat. The lower site was also rated as "at risk" from the perspective of riparian integrity. Notations were made that the channel had been rerouted due to erosion and that the new channel lacked diverse and stabilizing riparian vegetation. Riparian disturbance was indicated by the presence of noxious weeds.

In 2002 and 2003, physical measurements were performed on Big Creek by USFS and DEQ to quantify existing conditions relative to sediment related impairments. A brief review of the results is presented below. Additional information can be found in **Appendix B.**

Sediment impairments in the mainstem of Big Creek were expressed by high riffle stability index values, slightly excessive fine sediment in lateral scour pool tails, and potentially over-widened channel conditions. A riffle stability index value of 85 exceeded the water quality target of <75, suggesting excess sediment loads between the three forks area and the confluence (**Table 5-1**). The percent of fine sediment <2mm in riffles remained below the preliminary supplemental indicator value of <20% with 3.1% and 5.0%. A percent surface fines value of 8.8 in lateral scour pools slightly exceeded the supplemental indicator criteria of ≤8%. Bankfull widths of 36.1, 41.0, and 60.3 feet along the mainstem suggest a somewhat overwidened condition; an appropriate bankfull width for this reach is more likely in the range of 20-45 feet, for which the pool frequency target is ≥16 pools per mile. Two pool frequency measures 55 and 45 were above the targeted pools per mile. Both of these measurements suggest that the pool frequency target is currently being met. Large woody debris per mile was meeting the supplemental indicator criteria of at least 104 pieces/mile for streams at least 35 feet wide with a value of 329 pieces/mile. The channel sinuosity was 1.2, which meets supplemental indicator criteria.

The water quality target of ≤28% sediment less than 6.3 mm was exceeded with a McNeil core value of 39.2% in West Fork Big Creek just upstream of the confluence with East Fork Big Creek and the formation of the Big Creek mainstem, while the grid-toss percent surface fines accompanying the McNeil core averaged 11%, which exceeds the target value of ≤8%. These two measurements are not directly applicable to Big Creek, but do suggest that the West Fork Big Creek is a potential source of sediment to the mainstem of Big Creek. The fine sediment measure in Big Creek was slightly over the target McNeil Core samples taken at a site approximately 2 miles upstream of the mouth in 2003 had an average percent fines less than 6.3 mm of 39.2, well in excess of the target of ≤28%. Over widened channel conditions on Big Creek may also contribute to a situation where the stream channel is not efficiently moving sediments.

Table 5-1. Big Creek Physical Assessment Data

Survey Reach	Bankfull Width	Width/ Depth Ratio	Stream Type	Grid-toss % PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	McNeil Core % Surface Fines <6.3mm	Sinuosity	RSI	Pools/ Mile	LWD/ Mile
LNF Hydro 3 (Mainstem)	41.0	24.1	C3	8.8	5		1.2	85	55	
LWC XS1(Mainstem)	36.1	18.1	C4		3.1				45	329
LWC XS2(Mainstem)	60.3	31.7	C4							
Lower West Fork				11.4		38.6				

5.1.2 Macroinvertebrates

Macroinvertebrate data were collected at two sites in Big Creek in 2001. At site C04BIGCR01, the Mountain MMI was 72.4, meeting the supplemental indicator value of >63 for impairments, while the RIVPACS O/E score of 0.75 just failed to meet the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04BIGCR02, the Mountain MMI was 76.9, meeting the supplemental indicator value of >63, and the RIVPACS O/E score was 0.96, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.1.3 Periphyton

The 2001 periphyton bioassessments showed good biological integrity at both sites. At the upper site, sample results suggested the potential for elevated organic loading and nutrient enrichment (Bahls 2002). These results may be due an upstream beaver dam complex.

5.1.4 Fish Populations

The Montana Interagency Stream Fishery database rated Big Creek as “average” relative to its suitability for trout residence, spawning, and rearing. Natural impairments cited include temperature, low nutrients, and low amounts of aquatic invertebrates, while road construction and timber harvest practices were listed as activities influencing the fishery. The trend for aquatic habitat quality was rated as “static” and aesthetics were rated as “average” (MFWP 1985). Recent fishery investigation indicates that brook trout and cutthroat trout are the predominant game fish species present (pers. com. Knotek). The overall habitat and resource value assigned to Big Creek was described as “outstanding” (MFISH 2004).

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described bull trout and westslope cutthroat trout populations as “depressed” in Big Creek (Hendrickson and Cikanek 2000). A limited survey completed by GT Consulting in November of 1997 found no redds in a reach of Big Creek with public access (GT Consulting 1999).

5.1.5 Temperature

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Big Creek as “functioning at risk” due to temperature (Hendrickson and Cikanek 2000). This assessment was based mostly on aerial photo review and qualitative data.

The Lolo National Forest in cooperation with DEQ deployed one thermograph on Big Creek in 2001 from the middle of July to the middle of October. The site was located about half a mile upstream from the mouth. The 2001 temperature data documented a maximum temperature of 66.3°F on August 7, and the highest weekly maximum temperature (7DADMT) was 65.4°F, both well above the indicator threshold of 54°F.

In 2006, DEQ deployed ten thermographs in the Big Creek watershed, including two in the mainstem of Big Creek. The thermographs were deployed on July 11, 2006, and retrieved on September 11 and 12, 2006. At the upper Big Creek site, located just below the confluence of the east and west forks of Big Creek, the highest temperature was 59.5°F and the 7-day highest weekly maximum temperature (7DADMT) was 59.0°F. Both exceeded the indicator of 54°F. At the lower Big Creek site located near the mouth of the stream in the vicinity of the railroad bridge, the maximum temperature was 65.8°F, and the 7-day highest weekly maximum temperature (7DADMT) was 65.0°F. Both exceeded the indicator of 54°F. Throughout the remainder of the monitoring network in the Big Creek Watershed (including the east, west, and middle forks) maximum temperatures ranged from a low of 58.2°F at the mouth of the west fork to a high of 66.8°F in the west fork above the middle fork. Temperatures in Big Creek exceed critical thresholds for bull trout. Results from all sites in the 2006 Big Creek Watershed temperature monitoring network are summarized in **Tables 5-2a and b** and in **Appendix C.**

Temperature, stream discharge, effective shade, and canopy cover data were used to run the QUAL2K model to evaluate temperatures in Big Creek relative to Montana's water quality standards. The maximum temperatures predicted in the model scenario for increased shading and decreased thermal inputs from tributaries were compared to the maximum temperatures predicted by the model for the existing shade conditions. The QUAL2K model results indicated that stream temperature along the mainstem of Big Creek could be decreased by greater than 1ºF by increasing the amount of shade (**Appendix C**). A slight additional reduction in stream temperature could be achieved by decreasing temperatures on tributary streams. Warm water inputs from the East Fork and West Fork were also identified as sources of increased stream temperatures to Big Creek. Much of the human thermal impacts from the three forks of Big Creek are reset by a large beaver complex that appears to promote groundwater infiltration which emerges in Big Creek downstream as cooled water. Because of the beaver complex and groundwater interaction, activities in the headwaters do not translate to significant heating in the lower watershed. Even so, the heating due to human activities from the beaver complex to the mouth appears to cause a violation of Montana's temperature standards. Localized riparian and stream channel impacts do influence temperature along Big Creek below the confluence of the three forks.

Table 5-2a. 2006 Temperature Data Summary for Big Creek Watershed

Site Name	**Seasonal Maximum**		**Seasonal Maximum 7-Day Averages**	
	Date	**Value**	**Date**	**Daily Maximum**
West fork Big Creek upper site	07/24/06	66.4	07/25/06	65.7
West fork above Middle fork "notch"	07/23/06	66.8	07/25/06	66.0
West fork at mouth, above east fork	07/24/06	58.2	07/23/06	57.7
Middle Fork-upper site at upstream end of meadow	07/24/06	63.1	07/25/06	62.1
Middle fork above West fork	07/24/06	65.2	07/24/06	64.5
EF Big Creek	07/23/06	61.7	07/25/06	60.7
East Fork above mouth	07/24/06	60.8	07/25/06	60.2
EF Big Creek, lower most fork	07/24/06	62.3	07/25/06	61.5
Big Creek below E and W forks	07/24/06	59.5	07/25/06	59.0
Big Creek by railroad bridge	07/24/06	65.8	07/25/06	65.0

Table 5-2b. Continued 2006 Temperature Data Summary for Big Creek Watershed

Site Name	Days > 50 F	Days > 59 F	Days > 70 F
530220- West fork Big Creek upper site	64	34	0
530250-West fork above Middle fork "notch"	64	54	0
584786-West fork at mouth, above east fork	62	0	0
530247-Middle Fork-upper site at upstream end of meadow	63	14	0
584807-Middle fork above West fork	63	21	0
530225-EF Big Creek	64	9	0
530206-East Fork above mouth	63	7	0
530219-EF Big Creek, lower most fork	63	11	0
530232-Big Creek below E and W forks	63	2	0
530209-Big Creek by railroad bridge	63	46	0

5.1.6 Big Creek Water Quality Status Summary

Big Creek is listed as impaired due to sediment and temperature on the 2006 303(d) List. Available sediment and habitat data suggest that fine sediment deposition within Big Creek is impairing the cold water fishery and aquatic life beneficial uses. Temperature data from both 2001 and 2006, as well as temperature modeling results, also support the conclusion that Big Creek is impaired due to elevated temperatures. As a result, TMDLs will be developed for sediment and temperature in the Big Creek Watershed.

5.2 Deer Creek

The 1996 303(d) List reported Deer Creek from its headwaters to its mouth was threatened for coldwater fisheries uses. The probable cause of impairment was thermal modifications. Probable sources of impairment included agriculture and irrigated crop production. In 2006, Deer Creek was determined to be fully supporting all of its designated beneficial uses.

5.2.1 Sediment

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Deer Creek as “functioning at unacceptable risk” due to sediment based on a qualitative assessment of watershed conditions, primarily related to roads. The Deer Creek watershed was identified as having a road density of 2.2 miles/mile^2, with 35% of the stream having roads within 300 feet of the banks a third of which are within 125 feet of the stream (Hendrickson and Cikanek 2000).

In August of 2001, DEQ performed physical, chemical, and biological water quality assessments at two sites on Deer Creek. The upper sample site was about three miles below the headwaters, while the lower site was near the mouth. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements. A third site was sampled for water column measurements below an old placer operation and above the confluence with Cromie Creek.

Based on the 2001 assessment, DEQ reported the headwaters site was an entrenched Rosgen A3 stream type, while the lower site was a Rosgen D3 stream type, The potential of the lower site was a Rosgen C stream type according to the assessment team, suggesting an overwidened condition, and thus the width/depth ratio supplemental indicator value of ≤33 for Rosgen C-type streams was likely not being met. This appeared to be a localized impact most likely due to the lower portion of Deer Creek responding to St. Regis River degradation (downcutting) from transportation effects. The percent of surface sediment <2mm was meeting the preliminary target value of <20% at both sites, with a value of 0% at the upper site and 6.7% at the lower site. The headwaters site was rated as "sustainable" from the perspective of riparian integrity and scored 100% of the potential criteria. Notations were made about abundant woody debris. The lower site was rated as "at risk" from the perspective of riparian integrity. Notations were made about channel braiding, which was thought to be caused by a local base level change on the St. Regis River and an unstable riparian area.

During 2002 the USFS collected R1/R4 fisheries habitat data along two reaches of Deer Creek. Eroding bank frequency and the amount of undercut bank are comparable to undeveloped watersheds. Large woody debris count results vary greatly by reach. McNeil core data collected in 2003, during a separate effort at a site approximately 1 mile upstream of the mouth, indicated that the fine sediment <6.3 mm comprised 27.4% of the sample, meeting the target of <28%. The associated percent surface fines using a grid toss in the same pool tail location as the McNeil core was 22.4% fines <6.3 mm.

5.2.2 Macroinvertebrates

Macroinvertebrate data were collected at two sites in Deer Creek in 2001. At site C04DEERC01, the Mountain MMI was 81.9, meeting the supplemental indicator value of >63 for impairments. The RIVPACS O/E score of 1.18 also met the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04DEERC03 where very localized stream channel degradation may be occurring due to impacts on the St. Regis River, the Mountain MMI was 57.5, falling below the supplemental indicator value of >63. The RIVPACS O/E score was 1.0, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.2.3 Periphyton

The 2001 DEQ periphyton bioassessment showed good biological integrity at both sites (Bahls 2002).

5.2.4 Fish Populations

The Montana Interagency Stream Fishery database rated Deer Creek as "moderate" relative to its suitability for bull trout and Westslope cutthroat trout habitat. The trend for aquatic habitat quality was rated as "static" and aesthetics were rated as "above average" (MFWP 1985). Recent fishery investigation indicates that brook trout and cutthroat trout are the predominant game fish species present (pers. com. Knotek). The overall habitat and resource value assigned to Deer Creek was "outstanding" (MFISH 2004).

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described bull trout and westslope cutthroat trout populations as “depressed” in Deer Creek (Hendrickson and Cikanek 2000).

5.2.5 Temperature

The Lolo National Forest in cooperation with DEQ deployed one thermograph on Deer Creek in 2001 from the middle of July to the middle of October near the mouth **(Appendix D)**. The 2001 temperature data documented a maximum temperature of 57.9°F on August 7, and the 7-day highest weekly maximum temperature (7DADMT) was 57.3°F, which is above the indicator of 54°F for bull trout rearing, but below the 59°F indicator for adult thermal habitat. Temperature data were collected again in 2002 and 2003, with 7DADMTs reaching 55.9°F and 57.4°F respectively. Although the 54°F indicator for bull trout rearing was not always met near the mouth, an aerial photo (2005 NAIP) and field reconnaissance thermal source assessment effort indicated limited thermal sources in the watershed that can be restored using reasonable land, soil, and water conservation practices. The aerial photo assessment that was conducted as part of the of the Endangered Species Act bull trout consultation identified Deer Creek as having one of the most dense riparian canopies in the St. Regis Watershed. Although there are some limited historic impacts to riparian shade on several of Deer Creek’s smaller tributaries, the mainstem canopy is generally healthy where thermal impacts would be the greatest from riparian disturbance. Inferences from temperature modeling results that assessed tributary impacts to Twelvemile Creek suggest that this level of harvest on Deer Creek’s tributaries is not likely to increase temperatures above Montana’s temperature standard because the main stem has a very robust riparian canopy. Also, most of the tributary harvest occurred at least a decade ago and riparian shade on the small tributaries recovers more quickly than on larger streams because of the relation of stream width and canopy height (i.e. shrubs or small trees can provide more shade on a small stream than a large stream). Additionally, a few lakes in the headwaters of tributaries may contribute to what appears to naturally occurring temperatures in excess of the <54°F indicator.

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Deer Creek as “functioning at risk” due to temperature, but this assessment was based on a coarse scale assessment of watershed conditions. (Hendrickson and Cikanek 2000).

5.2.6 Deer Creek Water Quality Status Summary

Deer Creek was listed on the 1996 303(d) List as impaired due to temperature. The 54°F indicator for bull trout rearing was not always met at the monitoring location near the confluence with the St. Regis River, so conditions that influence stream temperature were investigated. An aerial photo and field reconnaissance thermal source assessment effort indicated robust shade conditions along the stream. By using inference from the reconnaissance and temperature modeling results that assessed tributary impacts to Twelvemile Creek, it was concluded that the level of harvest on Deer Creek’s tributaries is not likely to increase temperatures above

Montana's temperature standard because the main stem of Deer Creek has a very robust riparian canopy. Although there are limited historic areas with riparian shade impacts, mostly on small tributaries, the mainstem canopy is healthy where thermal impacts would be the greatest from riparian disturbance. Deer Creek is near its naturally occurring temperature condition. Therefore, a temperature TMDL will not be completed for Deer Creek. Riparian tree harvest BMPs identified in **Section 8** should be followed throughout this watershed to ensure that temperature conditions do not degrade in the future.

5.3 Little Joe Creek

The 1996 303(d) List reported Little Joe Creek from the North Fork to the mouth was threatened for coldwater fisheries uses. Probable causes of impairment included siltation and other habitat alterations. Probable sources of impairment included highway/road/bridge construction and silviculture. In 2006, Little Joe Creek was listed as partially supporting aquatic life and coldwater fisheries. Probable causes of impairment include sedimentation/siltation, physical substrate habitat alterations, and alteration in stream-side or littoral vegetative covers. Probable sources of impairment include construction and highway/road/bridge construction, natural sources, and streambank modifications/destabilization.

5.3.1 Sediment

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Little Joe Creek as "functioning at unacceptable risk" due to sediment. The Little Joe Creek watershed was identified as having a road density of 2.5 miles/mile^2, with 37% of the stream having roads within 300 feet of the banks about half of which are within 125 feet of the stream (Hendrickson and Cikanek 2000).

In August of 1989, DEQ performed a non-point source assessment along the entire length of Little Joe Creek, and then in July of 2001 the agency performed physical and biological water quality assessments at two sites on Little Joe Creek. The lower sample site in 2001 was approximately one third of a mile above the mouth, while the upper site was less than a half mile below confluence with the North and South Forks of Little Joe Creek. The assessments included field measurements, photo documentation, and a riparian survey. No water was present at the upper sample site, so sampling for aquatic insects, algae, and water column measurements occurred only at the lower site. The dewatered condition was created by water loss to subsurface flow.

DEQ reported the lower site was a Rosgen C3 stream type with a width/depth ratio of 15-20 and an entrenchment ratio of 2 based on an assessment in 2001. This width/depth ratio was meeting supplemental indicator criteria of ≤33 for Rosgen C-type streams. The percent of sediment <2mm was meeting the target value of <20% at both sites, with a value of 2.7% at the upper site and 0.9% at the lower site. Side channels were noted during this assessment. The upper site was rated as "sustainable" from the perspective of riparian integrity. Notations were made about channel incisement, deposition of large cobbles and gravels, and undesirable road impacts on the stream. The lower site was rated as "at risk" from the perspective of riparian integrity. Notations were made about the occurrence of channel downcutting and active lateral bank erosion. Riparian disturbance was indicated by the presence of noxious weeds.

During the 1989 assessment by DEQ, potential sediment sources identified were a mass wasting area and roads. An extensive road network was noted in the watershed, though roads were usually of “adequate” distance from stream. It was noted that riparian disturbance was generally limited to areas where a road was close to the stream. Stable banks, gravel bar development, and areas of scour were noted. Some water loss to subsurface flow was suggested.

In 2002 and 2003, physical measurements were performed on Little Joe Creek to quantify existing conditions relative to sediment related impairments. A brief review of the results is presented below. Additional information can be found in **Appendix B.**

Sediment impairments in Little Joe Creek were expressed as high riffle stability index values, a high amount of fine sediment <2mm in riffles and high bankfull width/depth ratios. A riffle stability index value of 92 exceeded the water quality target of <75, suggesting excess sediment loads (**Table 5-3**). With a value of 28.1, the percent of fine sediment <2mm in riffles exceeded the target of <20%. Grid toss percent surface fines <6mm measurement were made at two locations. At 4.1% and 1.4%, both met the target value of <8.0. The mainstem of Little Joe Creek contained a Rosgen C4 channel with a maximum width/depth of 34.2, which exceeded the supplemental indicator value of ≤33. Bankfull channel widths ranged from 36.8 to 81.5 feet, indicating that a numeric pool frequency does not apply likely due to overridden conditions, though pool frequency values of 37, 38, and 77 pools per mile were reported. Two measurements of large woody debris per mile found a range of conditions, with 1,204 pieces per mile in one assessment and 48 pieces per mile from a second assessment. The lower value falls below the supplemental indicator value of at least 104 pieces per mile for streams greater than 35 feet wide. The channel sinuosity was 1.14, which was below the supplemental indicator criteria of >1.2.

Table 5-3. Little Joe Creek Physical Assessment Data

Survey Reach	Bankfull Width	Width/ Depth Ratio	Stream Type	Grid-toss % PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	Sinuosity	RSI	Pools/ Mile	LWD/ Mile
LNF Hydro 1	36.8	26.5	C4	4.1	4	1.14	92	77	
LWC XS1	66.4	34.2	C4		28.1			38	1204
LWC XS2	81.5	32.6	C4						
LWC XS3	44.8	18.7	C4						
LNF Fish 2			C4	1.4				37	48

It should be noted that no McNeil core samples were collected in Little Joe Creek due to a lack of appropriate spawning gravels. However, McNeil core samples collected on both the South Fork and North Fork of Little Joe Creek provide indicators of upstream sediment loads. McNeil core samples were meeting water quality targets in both tributary streams, with percent fines <6.3mm of 21.7 in the South Fork and 28.0 in the North Fork. However, the sample site on the

South Fork Little Joe was relatively high in the watershed and may not accurately represent anthropogenic disturbance between the sample site and the confluence with the North Fork.

5.3.2 Macroinvertebrates

Macroinvertebrate data were collected at one site in Little Joe Creek in 2001. At site C04LJOEC02, the Mountain MMI was 54.0, failing to meet the supplemental indicator value of >63 for impairment, while the RIVPACS O/E score of 0.95 did meet the supplemental indicator value of 1.2>RIVPACS>0.8.

5.3.3 Periphyton

The 2001 DEQ periphyton bioassessment showed good biological integrity at the lower site. A very low siltation index value was reported (Bahls 2002).

5.3.4 Fish Populations

Little Joe Creek is considered important spawning habitat for Westslope cutthroat trout and bull trout. However, a bull trout redd survey in October of 1995 conducted by the U.S. Forest Service did not find any bull trout redds. A separate, limited survey conducted in November of 1997 by GT Consulting found no redds in the first 1000 feet upstream of the mouth (GT Consulting 1999). The Montana Interagency Stream Fishery database recorded trout species presence, but did not rate Little Joe Creek relative to its suitability for trout residence, spawning or rearing. Reported issues included excess siltation, road construction, and timber harvest practices. The trend for aquatic habitat quality was rated as “deteriorating,” yet aesthetics were rated as “above average” (MFWP 1985). Recent fishery investigation indicates that bull trout, brook trout, and cutthroat trout are the predominant game fish species present (pers. com. Knotek). Bull trout redds have been observed from 2002-2005 in both the South Fork and North Fork Little Joe Creeks (pers. com. Knotek). An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described the Westslope cutthroat trout population of Little Joe Creek as “strong,” while the bull trout population was considered “depressed” (Hendrickson and Cikanek 2000).

5.3.5 Temperature

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Little Joe Creek as “functioning at risk” due to temperature (Hendrickson and Cikanek 2000).

The Lolo National Forest in cooperation with DEQ deployed one thermograph on Little Joe Creek in 2001 from the middle of July to the middle of October near the mouth. The 2001 temperature data documented a maximum temperature of 53.8°F on August 7. The temperature never exceeded 54°F, which is the upper limit for bull trout rearing suggested by USFWS. The highest weekly maximum temperature (7DADMT) was 53.4°F, meeting the indicator of 54°F. Temperatures in Little Joe Creek were monitored again in 2002 and 2003, with 7DADMTs of 50.9 and 52.0, respectively meeting the indicator of 54°F. Little Joe Creek is likely this cold because the entire stream flows subsurface upstream of this site and emerges as cooled groundwater.

5.3.6 Little Joe Creek Water Quality Status Summary

Little Joe Creek is listed as impaired due to sedimentation/siltation and habitat related listings on the 1996 and 2006 303(d) List. Assessments conducted in 2002 and 2003 revealed several exceedences of water quality targets and supplemental indicators. These exceedences relate to fine sediment deposition and lack of channel function that likely impact sediment transport. Low amounts of pool habitat likely impact the fishery. Fine sediment appears to impact the fishery and macroinvertebrate populations, and forest roads are a significant source of sediment in the Little Joe Creek watershed. As a result, a TMDL will be developed for sediment in the Little Joe Creek Watershed.

5.4 North Fork Little Joe Creek

The 1996 303(d) List reported North Fork Little Joe Creek from the headwaters to the mouth was threatened for coldwater fisheries uses. Probable causes of impairment included siltation and other habitat alterations. The probable source of impairment was highway/road/bridge construction. In 2006, North Fork Little Joe Creek was listed as partially supporting aquatic life and coldwater fisheries. The probable cause of impairment was sedimentation/siltation. The probable source of impairment was highway, road, bridges, and infrastructure.

5.4.1 Sediment

In July of 2001, DEQ performed physical, chemical, and biological water quality assessments at two sites on North Fork Little Joe Creek. The lower sample site was approximately a half mile above the confluence with the mainstem of Little Joe Creek, while the upper site was approximately seven miles upstream of the lower site. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements.

Based on an assessment in 2001, DEQ reported the upper site was a Rosgen B3 stream type with a width/depth ratio of 10. The lower site was also a Rosgen B3 stream type with a width/depth ratio of 20. Both sites were meeting the width/depth ratio supplemental indicator criteria of ≤22 for Rosgen B-type streams. The percent of sediment <2mm was meeting the target value of <20% at both sites, with a value of 13.7% at the upper site and 0.8% at the lower site. A third pebble count conducted at site “1.5” had a value of 4.4% <2mm, which was also meeting the target criteria. The 13.7% value was the highest amount of fine sediment <2mm found within the St. Regis TPA during DEQ monitoring in 2001. The upper site was rated as “sustainable” from the perspective of riparian integrity and scored 100% of the potential criteria. Notations were made about abundant woody debris, healthy riparian vegetation, and beneficial shading. The lower site was rated as “at risk” from the perspective of riparian integrity. Notations were made about upstream entrenchment causing deposition at the site, unstable streambanks, and inadequate material available for energy dissipation. Field notes indicated that shading was adequate, but bare ground was present in the riparian area and that stream flows diminished due to discharge to ground water.

A 1997 Lolo National Forest report indicated that an unidentified reach on North Fork Little Joe Creek had a higher fraction of surface fines with a greater representation of particles 100 mm or greater when compared to streams of similar Rosgen stream type and geology. High road densities in the watershed and numerous stream crossings were theorized to be responsible for this difference (Rosquist and Sytle 1997).

In 2002 and 2003, physical measurements were performed on North Fork Little Joe Creek by USFS and LWC to quantify existing conditions relative to sediment related impairments. A brief review of the results is presented below. Additional information can be found in **Appendix B.**

A riffle stability index value of 78 exceeded the water quality target of <75 at one site; at a second site the RSI was 75, right at the target; and at 55 at a third location was below the target **(Table 5-4)**. A riffle stability value of zero at the forth site indicates a lack of bars and potential channelization, though it is unclear if this is the result of natural or anthropogenic sources. The McNeil core value of 27.6% fines than 6.3 mm is meeting target conditions of ≤28% but the sampling location is above many of the road impacts in the watershed and near the target criteria. Also, this section of the stream has natural energy to transport sediment. A grid-toss percent surface fines value of 7.5 accompanying the McNeil core sample was meeting target criteria of ≤8, but also near the criteria. Pebble counts conducted in riffles ranged from 14% to 19% fines <2mm, nearing the target limit. North Fork Little Joe Creek ranged from a Rosgen C3/4b to a C4 stream type with width/depth ratios ranging from 10.4 to 19.6, thus remaining below supplemental indicator criteria for both Rosgen B and C stream types. Pool frequency values ranged from 0 to 335 pools per mile, indicating some reaches were not meeting water quality targets. Width to depth ratios met supplemental indicator conditions at all monitoring locations. Large woody debris ranged from 84 to 264 pieces per mile which indicates that conditions approximate the minimum supplemental indicator value.

Table 5-4. North Fork Little Joe Creek Physical Assessment Data

Survey Reach	Bankfull Width (feet)	Width/ Depth Ratio	Stream Type	Grid-toss % PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	McNeil Core % Surface Fines <6.3mm	RSI	Pools/ Mile	LWD/ Mile
LNF Hydro 1	18.6	19.6	C4	75.5	18		78	0	
LNF Hydro 1a	21.7	10.4	C4b	14.3	19		55	335	
LNF Hydro 2	18.1	12.8	C3b	4.1	15		0	0	
LNF Hydro 4	20.2	16.9	C4b	0.0	14		75	300	
LNF Fish 1			C4	1.3				55	84
LNF Fish 4			C4	1.6				146	264
0.5 miles above conf. with South Fork				7.5		28.0			

5.4.2 Macroinvertebrates

Macroinvertebrate data were collected at two sites in the North Fork of Little Joe Creek in 2001. At site C04NFLJC01, the Mountain MMI was 80.7, meeting the supplemental indicator value of >63 for impairments. The RIVPACS O/E score of 1.14 also met the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04NFLJC02, the Mountain MMI was 73.7, meeting the supplemental indicator value of >63, and the RIVPACS O/E score was 1.12, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.4.3 Periphyton

The 2001 DEQ periphyton bioassessments showed good biological integrity at the lower site. At the upper site, low diatom diversity and species richness were reported, though natural conditions (scour) were thought to be responsible (Bahls 2002).

5.4.4 Fish Populations

The Montana Interagency Stream Fishery database rated reaches of North Fork Little Joe Creek as “average” or “below average” relative to its suitability for trout residence, spawning and rearing. Problems were caused by a lack of spawning areas, inadequate pool frequencies, a lack of undercut banks, bedload transport, siltation, and road construction. Problem sources included roads and timber harvest practices. The trend for aquatic habitat quality was rated as “static” or “deteriorating” and aesthetics ratings ranged from “above average” to “below average” (MFWP 1985). Recent fishery investigation indicates that bull trout, brook trout, and cutthroat trout are the predominant game fish species present (pers. com. Knotek). Bull trout redds have been observed from 2002-2005 in both the South Fork and North Fork Little Joe Creeks (pers. com. Knotek). The overall habitat and resource value assigned to North Fork Little Joe Creek is outstanding (MFISH 2004).

5.4.5 Temperature

The Lolo National Forest in cooperation with DEQ deployed one thermograph on North Fork Little Joe Creek in 2001 from the middle of July to the middle of October near the mouth **(Appendix D)**. The 2001 temperature data documented a maximum temperature of 56.6°F on August 13, and the highest weekly maximum temperature (7DADMT) was 56.0°F, which is slightly above temperature supplemental indicator of <54°F. Although the 54°F indicator was not always met at this monitoring site near the mouth, an aerial photo and field reconnaissance thermal source assessment effort indicates limited thermal sources in the watershed that can be restored using reasonable land, soil, and water conservation practices.

5.4.6 North Fork Little Joe Creek Water Quality Status Summary

North Fork Little Joe Creek is listed as impaired due to sedimentation/siltation on the 2006 303(d) List. Assessments conducted by DEQ in 2001 and USFS during 2002-2003 indicated that the stream is generally nearing its target and supplemental indicator values upstream of some road impacts. It is likely the road network is increasing sediment below the sites that had borderline sediment conditions and likely causes impacts to fish spawning. McNeil core and percent fine grid tosses should be assessed below areas with heavier road impacts to better understand impairment status. Most other targets and supplemental indicators, as well as macroinvertebrate and periphyton communities, are meeting set goals. A sediment TMDL will be developed for the watershed because there is uncertainty in the impairment condition of the fishery and because fine sediment conditions are borderline in spawning areas above some of the more significant road impact areas.

5.5 Silver Creek

The 1996 303(d) List reported Silver Creek from its headwaters to its mouth was threatened for coldwater fisheries uses. The probable cause of impairment was thermal modifications. Probable sources of impairment included agriculture and irrigated crop production. In 2006, Silver Creek was listed as partially supporting coldwater fisheries uses. The probable cause of impairment was flow alterations and is due to a culvert (which is not a pollutant) acting fish passage barrier.

5.5.1 Sediment

This information is provided to assist in sediment source assessment for the St. Regis River. An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Little Joe Creek as “functioning at unacceptable risk” due to sediment but this assessment was based on a qualitative assessment of watershed conditions. (Hendrickson and Cikanek 2000).

In July of 2001, DEQ performed physical, chemical, and biological water quality assessments at two sites on Silver Creek. The upper sample site was just below the outlet of Silver Lake, while the lower site was approximately a half mile above the mouth. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements

DEQ reported Silver Creek was a Rosgen C3 stream type at the upper site, which is just downstream of Silver Lake, but quickly becomes a steep Rosgen A2 stream type with an approximate width/depth ratio of 2.5, which was meeting the supplemental indicator criteria of ≤12 for Rosgen A-type streams. The lower site was a Rosgen B2 stream type with a width/depth ratio of 5-10 and an entrenchment ratio of 2-3, which was meeting the supplemental indicator criteria of ≤23 for Rosgen B-type streams. The percent of sediment <2mm was meeting the target value of <20% at both sites, with a value of 10.7% at the upper site and 1.9% at the lower site. The upper site was rated as “sustainable” from the perspective of riparian integrity and scored 100% of the potential criteria. The lower site was also rated as “sustainable” from the perspective of riparian integrity and scored 96% of the potential criteria. Notations were made about abundant woody debris, healthy riparian vegetation, and beneficial shading.

5.5.2 Macroinvertebrates

Macroinvertebrate data were collected at two sites in Silver Creek in 2001. At site C04SLVRC01, the Mountain MMI was 46.4, failing to meet the supplemental indicator value of >63 for impairments The RIVPACS O/E score of 0.61 also failed to meet the supplemental indicator value of 1.2>RIVPACS>0.8. It is likely that the lake influence from just upstream affects the aquatic insect community. At site C04SLVRC02, the Mountain MMI was 60.6, failing to meet the supplemental indicator value of >63, while the RIVPACS O/E score was 0.94, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.5.3 Periphyton

The 2001 DEQ periphyton bioassessments showed good biological integrity at the upper site, while natural disturbance was thought to influence biological integrity at the lower site (Bahls 2002).

5.5.4 Fish Populations

The Montana Interagency Stream Fishery database recorded trout species presence, but did not rate Silver Creek relative to its suitability for trout residence, spawning, or rearing. The trend for aquatic habitat quality was rated as “static” and aesthetics were rated as “average” (MFWP 1985). Recent fishery investigation indicates that brook trout and cutthroat trout are the predominant game fish species present (pers. com. Knotek). The overall habitat and resource value assigned to Silver Creek is “outstanding” (MFISH 2004).

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described bull trout and Westslope cutthroat trout populations as “depressed” in Silver Creek (Hendrickson and Cikanek 2000).

A culvert near the mouth of Silver Creek acts as a fish barrier. Silver Creek makes a 90-degree turn to flow into the culvert which has a vertical junction that then immediately drops Silver Creek several feet. Because of the vertical drop and high velocities through the undersized structure, the culvert is a definite fish barrier.

5.5.5 Temperature

The Lolo National Forest in cooperation with DEQ deployed two thermographs on Silver Creek in 2001 from the middle of July to the middle of October near the mouth. One site corresponded with the upper Silver Creek assessment site described above, while the other site was located at the forest boundary near the mouth. At the upper site, the 2001 temperature data documented a maximum temperature of 72.6°F on August 14, and the 7-day highest weekly maximum temperature (7DADMT) was 71.3°F, which exceeds the supplemental indicator of 54°F However, the elevated stream temperature at this site appear to be a natural condition due to heating of the water in Silver Lake. At the lower site, the 2001 temperature data documented a maximum temperature of 63.1°F on August 14, and the 7DADMT was 62.1°F, which exceeded the supplemental indicator of 54°F. However, as is the case at the upper site, elevated temperatures appear to result largely from heating of Silver Lake, which is the source of Silver Creek. The thermographs were deployed again at both locations in 2002, with 7DADMTs reaching 64.5°F at the upper site near the lake outlet and 58.6°F at the lower site near the mouth. Aerial photo review indicates few, if any, human caused sources of heating in the watershed. Roads were generally built away from the stream network, and there were not signs of tree harvest in riparian areas in aerial photos.

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Silver Creek as “functioning at risk” due to temperature, but this assessment was based on a coarse scale assessment of watershed conditions. (Hendrickson and Cikanek 2000).

5.5.6 Silver Creek Water Quality Status Summary

Silver Creek appears on the 2006 303(d) List as impaired due to other flow regime alterations, but was listed as threatened for thermal modifications on the 1996 303(d) List. The culvert at the mouth of Silver Creek is the primary reason for the 2006 listing. Monitoring in 2001 and 2002 indicated elevated temperatures in Silver Creek, though it was determined that this was a natural condition due to heating of the water in Silver Lake. A reconnaissance and aerial photo effort indicated that there has been little human impact to riparian shade in the watershed. Stream flows, and thus thermal buffering capacity, are also not affected by human activity. Since elevated stream temperatures are the result of natural processes, it was concluded that Silver Creek is not impaired due to thermal modifications. No TMDL is needed for Silver Creek. The culvert should be assessed for removal or upgrade. Riparian tree harvest BMPs identified in **Section 8** should be followed throughout this watershed to ensure that temperature conditions do not degrade in the future. Future urban and recreational development should not decrease stream shade.

5.6 Twelvemile Creek

The 1996 303(d) List reported Twelvemile Creek from its headwaters to its mouth was threatened for coldwater fisheries uses. Probable causes of impairment included siltation and other habitat alterations. Probable sources of impairment included highway/road/bridge construction and silviculture. On the 2006 303(d) List, Twelvemile Creek was listed as partially supporting aquatic life and coldwater fisheries uses. Probable causes of impairment include sedimentation/siltation, physical substrate habitat alterations, and water temperature.

5.6.1 Sediment

In August of 2001, DEQ performed physical, chemical, and biological water quality assessments at one site on Twelvemile Creek about a half mile above the East Fork and near the Cabin City Campground. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements.

In 2001, DEQ reported Twelvemile Creek was a Rosgen B3 stream type with a width/depth ratio of 17 and an entrenchment ratio of 2. This site was meeting the width/depth ratio supplemental indicator value of ≤23 for Rosgen B-type streams. The percent of sediment <2mm was meeting the target value of <20% at the site, with a value of 3.3%. The site was rated as "at risk" from the perspective of riparian integrity. Notations were made about former channel downcutting which had begun to stabilize, disturbance to riparian vegetation including the presence of noxious weeds and a shortage of deep rooted species, and inadequate material available for energy dissipation (i.e. woody debris). Field notes indicated that fast moving water limited fish habitat.

A short report on Twelvemile Creek was generated by DEQ staff based on field observations near the mouth of Rock Creek in the fall 2002. The report described the deposition of "unnatural" rock piles in a straightened stretch of Twelvemile Creek. This was thought to be linked to increased channel scour. Lack of access to the creek's floodplain was also documented by cutbank erosion.

A draft TMDL report for the Twelvemile Creek watershed was produced by Land & Water Consulting in November of 2002. Preliminary conclusions identified roads as substantial contributors of in-stream sediment. Eighty-two out of 182 road crossings surveyed were identified as contributing sediment to the stream (Land and Water 2002). Rather than working to finalize the Twelvemile Creek TMDL, DEQ decided to address it within the St. Regis River TMDL.

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Twelvemile Creek as "functioning at risk" due to sediment. The Twelvemile Creek watershed was identified as a road density of 3.4 miles/mile^2, with 34% of the stream having roads within 300 feet of the banks, almost half of which are within 125 feet of the stream (Hendrickson and Cikanek 2000). In 2002 and 2003, physical measurements were performed by USFS and LWC on Twelve Mile Creek to quantify existing conditions relative to sediment related impairments. A brief review of the results is presented below. Additional information can be found in **Appendix B.**

The water quality target of ≤28% sediment <6.3 mm was exceeded with a McNeil core value of 32.8%. A riffle stability index value of 88 at one of the assessment sites exceeded the water quality target of <75, suggesting excess sediment loads (**Table 5-5**). Grid-toss percent surface fines accompanying McNeil cores averaged 7.8%, and was even lower elsewhere in the stream, meeting the target value of ≤8% in all cases. The percent of fine sediment <2 mm in riffles was above the target value of <20% at 2 of 3 locations where it was measured and, at 0%, was below the target at the third. The mainstem of Twelvemile Creek contained Rosgen B3, C3, and C4 stream types at various cross-sections, with bankfull widths ranging from 7.9 to 42.7 across the 5 sites where it was measured. Width/depth supplemental indicator values were exceeded at only one of these site, where the ratio was 42.7. Pool frequency values of 335 and 440 pools per mile were meeting water quality targets, but at other locations pool frequencies were below the indicator at only 18 and 14 per mile. At a fifth location the pool count was 41 per mile; it is unclear what pool target is applicable for this reach since there were both Rosgen B and C stream types and channel width varied from 27.3 to 59.8 feet. A large woody debris frequency was measured at 3 locations and ranged from 70 to 195 pieces per mile, meeting supplemental indicator criteria in all cases. Sinuosity in the lower 1.5 miles of Twelvemile Creek was 1.12, which was below the supplemental indicator criteria of ≥1.2 and is likely a result of channelization associated with road development.

Table 5-5. Twelvemile Creek Physical Assessment Data

Survey Reach	Bankfull Width	Width / Depth Ratio	Stream Type	Grid-toss % PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	McNeil Core % Surface Fines <6.3mm	Sinuosity	RSI	Pools / Mile	LWD / Mile
LNF Hydro 1	21.5	12.3	C4	4	22		1.12	88	335	
LNF Hydro 2	16.4	7.9	C4		23		1.5	57	440	
LWC XS1	32.2	15.3	B3		0				41	195
LWC XS2	59.8	42.7	C3							
LWC XS3	27.3	17.1	C3							
LNF Fish 1			C3	4					18	70.4
LNF Fish 2			C3	7.5					14	131.2
Potential spawing reach near old mil				7.8		32.8				

5.6.2 Macroinvertebrates

Macroinvertebrate data were collected at one site in Twelvemile Creek in 2001. At site C04TLVMC01, the Mountain MMI was 64.6, failing to meet the supplemental indicator value of >63 for impairments. The RIVPACS O/E score of 0.90 met the supplemental indicator value of 1.2>RIVPACS>0.8.

5.6.3 Periphyton

The 2001 DEQ periphyton bioassessment showed good biological integrity, though the siltation index and percent abnormal cells were slightly elevated (Bahls 2002).

5.6.4 Fish Populations

A 1965 Fish, Wildlife and Parks report identified 59 artificial structures placed in Twelvemile Creek from 1931 to 1964 for improvement of fisheries habitat (Opheim et al.1965). The habitat enhancements appeared to positively affect westslope cutthroat trout populations, but effects on bull and brook trout were not discernable.

The Montana Interagency Stream Fishery database rated reaches of Twelvemile Creek as “average” or “below average” relative to its suitability for trout residence, spawning, and rearing. Problems were caused by a lack of spawning areas, inadequate pool frequencies, lack of undercut banks and bank cover, and road construction. Human sources included roads and timber harvest practices. The trend for aquatic habitat quality was rated as "static" or "deteriorating" and aesthetics were rated as "average" (MFWP 1985).

Recent fishery investigation indicates that brook trout and cutthroat trout are the predominant game fish species present (pers. com. Knotek). The entire stream is protected by the Northwest Power Planning Council Protected Areas Program to preserve critical fish and game habitat. Although the last mile of the stream is listed in the report as a reach of chronic dewatering concern, no supporting data were located and dewatering is not currently a problem in the stream. The overall habitat and resource value assigned to Twelvemile Creek is "outstanding" (MFISH 2004).

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described bull trout and Westslope cutthroat trout populations as "depressed" in Twelvemile Creek (Hendrickson and Cikanek 2000).

5.6.5 Temperature

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Twelvemile Creek as "functioning at risk" due to temperature (Hendrickson and Cikanek 2000).

The Lolo National Forest in cooperation with DEQ deployed two thermographs on Twelvemile Creek in 2001 from the middle of July to the middle of October. The upper site corresponded with the DEQ assessment site near the Cabin City Campground, while the lower site was close to the mouth and below the confluence with the East Fork. The 2001 temperature data documented a maximum temperature of 67.2°F at the upper site on August 7, and the 7-day highest weekly maximum temperature (7DADMT) was 66.1°F, exceeding the indicator of 54°F. The 2001 temperature data documented a maximum temperature of 64.2°F at the lower site on August 7, and the 7DADMT was 63.5°F, which also exceeded the indicator of 54°F, although this is a south facing watershed and this temperature may not be naturally achievable. Temperature data was collected again in 2002 and 2003 at several sites, and temperatures exceeded the 7DADMT indicator at all locations in both years.

In 2006, DEQ deployed nine thermographs in the Twelvemile Creek watershed, including six in the mainstem of Twelvemile Creek. The thermographs were deployed on July 12, 2006, and retrieved on September 10, 2006. Maximum temperatures ranged from a low of 55.6 °F at the headwaters location to a high of 68.1°F at the site near Rock Creek in the lower watershed. The 7-day 7DADMT in Twelvemile Creek ranged from 54.5°F to 67.1°F, exceeding the supplemental indicator of 54°F at all locations. Results from all sites in the 2006 Twelvemile Creek Watershed temperature monitoring network are summarized in **Tables 5-6a and b** and in **Appendix C.**

Temperature and canopy cover data were used to run the QUAL2K model to evaluate temperatures in Twelvemile Creek relative to Montana's water quality standards. The maximum temperatures predicted in the model scenario for increased shading and decreased tributary inputs were compared to the maximum temperatures predicted by the model for the existing shade conditions. The QUAL2K model results indicated that stream temperature could be decreased by greater than 1ºF by increasing shade along the mainstem of Twelvemile Creek. Additional stream temperature reductions could be achieved by decreasing temperatures on tributary streams. This result suggests that Twelvemile Creek is exceeding Montana's water quality standard, and that reduced shading resulting from riparian anthropogenic disturbance is partially responsible for the increase in stream temperatures.

Table 5-6a. 2006 Temperature Data Summary for the Twelvemile Creek Watershed

Site Name	Seasonal Maximum		Seasonal Maximum 7-Day Averages	
	Date	Value	Date	Daily Maximum
Twelvemile Cr. above Trapper Cabin @ mile marker 8	07/23/06	55.6	07/25/06	54.5
Twelvemile Cr. above Mineral Mt. Cr.	07/24/06	62.7	07/25/06	61.8
Twelvemile Cr. above Flatrock	07/23/06	65.5	07/25/06	64.2
Twelvemile Creek above east fork	07/23/06	67.8	07/25/06	66.6
Twelvemile Cr. Upstream of Rock Cr.	07/23/06	68.1	07/25/06	67.1
Twelvemile at mouth	07/23/06	67.7	07/25/06	66.7
Flat Rock Cr. Above bridge under moss covered log	07/24/06	61.6	07/25/06	60.8
East fork Twelvemile	07/15/06	45.2	07/25/06	44.9
Rock Creek mouth	07/15/06	55.4	07/25/06	54.9

Table 5-6b. Continued 2006 Temperature Data for the Twelvemile Creek Watershed

Site Name	Days >	Days >	Days >
	50 F	59 F	70 F
Twelvemile Cr. above Trapper Cabin @ mile marker 8	45	0	0
Twelvemile Cr. above Mineral Mt. Cr.	61	10	0
Twelvemile Cr. above Flatrock	61	24	0
584847-Twelvemile Creek above east fork	61	42	0
Twelvemile Cr. Upstream of Rock Cr.	61	50	0
Twelvemile at mouth	61	43	0
Flat Rock Cr. Above bridge under moss covered log	61	8	0
East fork Twelvemile	0	0	0
Rock Creek mouth	61	0	0

5.6.6 Twelvemile Creek Water Quality Status Summary

Twelvemile Creek is listed as impaired the 2006 303(d) List due to sedimentation/siltation, other physical substrate habitat alterations, and thermal modifications. Assessments conducted in 2002 and 2003 revealed several exceedences of sediment targets and supplemental indicators. Data from several other evaluations suggest siltation in spawning areas, and low pool quality within Twelvemile Creek is impairing the cold water fishery beneficial use. Monitoring data from 2001, 2002, 2003, and 2006 as well as temperature modeling results support the listing for temperature impairments. Significant human caused sediment and temperature sources are present. As a result, TMDLs for temperature and sediment will be developed for the Twelvemile Creek Watershed.

5.7 Ward Creek

The 1996 303(d) List reported Ward Creek from its headwaters to its mouth was threatened for coldwater fisheries uses. Probable causes of impairment included thermal modifications and other habitat alterations. Probable sources of impairment included agriculture, highway/road/bridge construction, and irrigated crop production. In 2006, the segment was determined to be fully supporting all of its designated uses, and it was removed from the 303(d) List.

5.7.1 Sediment

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Ward Creek as "functioning at risk" due to sediment. The Ward Creek watershed was identified as having a road density of 3.6 miles/mile^2, with 32% of the stream having roads within 300 feet of the banks, almost half of which are within 125 feet of the stream (Hendrickson and Cikanek 2000).

In August of 2001, DEQ performed physical, chemical, and biological water quality assessments at two sites on Ward Creek. The upper sample site was a little over a half mile above the confluence with Gold Creek, while the lower site was at the mouth. The assessments included field measurements, photo documentation, a riparian survey, sampling for aquatic insects and algae, and water column measurements.

In 2001, DEQ found the upper site of Ward Creek was a B3 stream type with a width/depth ratio of 9 and an entrenchment ratio of 2. The lower site was described as an A3 stream type with a width/depth ratio of 23 and entrenchment ratio of 2. The width/depth ratio in the A3 reach exceeded the supplemental indicator criteria of ≤12 for Rosgen A-type streams, while the width/depth ratio in the B3 reach was meeting the supplemental indicator criteria of ≤23 for Rosgen B-type streams. Field notes indicated that the stream appeared to be "naturally straight" at both sites. The percent of sediment <2mm was meeting the target value of <20% at both sites, with a value of 7.3% at the upper site and 0.9% at the lower site. The upper site was rated as "sustainable" from the perspective of riparian integrity and scored 100% of the potential criteria. Notations were made about abundant woody debris and decent fish habitat. The lower site was also rated as "sustainable" from the perspective of riparian integrity, and scored 85% of the potential criteria. Notations were made about the absence of young willows, bank undercutting, and that fish habitat was sparse.

McNeil core samples collected near the mouth in 2003 had an average percent fines less than 6.3 mm of 24.1, meeting the target of ≤28%. The Forest Service measured percent fines in pool tail areas using a grid toss method during 2002 R1/R4 fisheries assessments. The results were approximately equivalent or were much lower than the Lolo National Forest undeveloped watershed dataset. Pool abundance was variable, likely due to high amounts of woody debris that affects pool formation. Pool quality was lower than reference but also could be affected by large amounts of woody debris creating small pocket pools that were counted in the assessment.

5.7.2 Macroinvertebrates

Macroinvertebrate data were collected at two sites in Ward Creek in 2001. At site C04WARDC01, the Mountain MMI was 79.5, meeting the supplemental indicator value of >63 for impairments, while the RIVPACS O/E score of 1.29 just failed to meet the supplemental indicator value of 1.2>RIVPACS>0.8. Although RIVPACS values above 1.2 can indicate two different scenarios. The first scenario, which likely applies to upper Ward Creek is that the site is a very high quality reference site. The other scenario, which does not apply to Upper Ward Creek, is an enriched nutrient condition. At site C04WARDC02, the Mountain MMI was 74.6, meeting the supplemental indicator value of >63, and the RIVPACS O/E score was 0.96, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.7.3 Periphyton

The 2001 DEQ periphyton bioassessment showed good biological integrity at both sites, though the siltation index was slightly elevated at the lower site (Bahls 2002).

5.7.4 Fish Populations

The Montana Interagency Stream Fishery database recorded trout species presence, but did not rate Ward Creek relative to its suitability for trout residence, spawning, or rearing. The trend for aquatic habitat quality was rated as “static” and aesthetics were rated as “above average” (MFWP 1985). A 1992 Fish Wildlife and Parks report described the status of bull trout in Montana and identified Ward Creek as an important bull trout stream, though it was unknown whether the stream supported resident and/or ad fluvial populations (Thomas 1992). Recent fishery investigation indicates that cutthroat trout are the predominant game fish species present (pers. com. Knotek). The overall habitat and resource value assigned to Ward Creek is “outstanding” (MFISH 2004).

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described bull trout and Westslope cutthroat trout populations as “depressed” in Ward Creek (Hendrickson and Cikanek 2000). Lolo National Forest fisheries biologists identified limited bull trout spawning in Ward Creek during 2007.

5.7.5 Temperature

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described Ward Creek as “functioning at risk” due to temperature (Hendrickson and Cikanek 2000).

The Lolo National Forest in cooperation with DEQ deployed one thermograph on Ward Creek in 2001 from the middle of July to the middle of October near the mouth. The 2001 temperature data documented a maximum temperature of 55.1°F on August 7 and the highest weekly maximum temperature (7DADMT) was 54.5°F**,** which approximates the 54 °F indicator. Thermographs were redeployed in 2002 and 2003 and measured 7DADMT values of 55.1 and

56.3 respectively. Although these temperatures are slightly higher than the indicator, 2005 NAIP aerial photo review indicates that stream canopy is healthy along the stream corridor except for limited road encroachment and very limited historic clear cut areas in riparian zones. Tributary riparian areas also have adequate riparian canopy, suggesting that human impacts probably have not altered the natural temperature regime of Ward Creek to a significant extent.

5.7.6 Ward Creek Water Quality Status Summary

Temperature data, along with an aerial photo review and field reconnaissance of heat sources indicates that Ward Creek is not impaired due to temperature conditions. Data collected by DEQ and the Lolo National Forest in 2001 supports the conclusion to remove Ward Creek from the 303(d) List for thermal modifications. No indication of impairment from sediment, metals, or nutrients was observed. Riparian tree harvest BMPs identified in **Section 8** should be followed throughout this watershed to ensure that temperature conditions do not degrade in the future.

5.8 St. Regis River

The 1996 303(d) List reported the St. Regis River was partially supporting aquatic life and cold water fisheries uses. Probable causes of impairment included siltation and other habitat alterations. Probable sources of impairment included highway/bridge/road construction and silviculture. In 2006, the St. Regis River was listed as partially supporting aquatic life and cold water fisheries uses. Probable causes of impairment include sedimentation/siltation, water temperature, other flow regime alterations, and alteration in stream-side or littoral vegetative covers. Probable sources of impairment include construction, highway/road/bridge infrastructure and runoff, channelization, loss of riparian habitat, and streambank modification/destabilization.

5.8.1 Sediment

In July and August of 2001, DEQ performed comprehensive chemical, physical, and biological water quality assessments at four sites along the St. Regis River. The assessments included riparian surveys, aquatic insect, algae and water sampling, field measurements, and photo documentation. Site 1 was located in the headwaters near Lookout Pass, Site 2 was located downstream of the town of Saltese, while Sites 3 and 4 were located between Ward Creek and the mouth, with Site 4 being near the mouth.

During the 2001 assessment of the St. Regis River, DEQ found the river alternated between Rosgen B, C, and F stream types. In the headwaters, Site 1 was a Rosgen B3 stream type with a width/depth ratio of 8. Downstream of Site 1, the stream was observed to be an F2/3 stream type with a width/depth ratio of 40 and an entrenchment ratio of 9. Downstream of Saltese, Site 2 was a C3 stream type with a width/depth ratio of 50. Site 3 was a Rosgen C2/3 stream type with a width/depth ratio of 20. Site 4 was a B3 stream type with a width to depth ratio of 70. Based on the high width/depth ratio, it was suggested that this reach may have the potential of being a Rosgen C stream type. A width/depth ratio of 50 at Site 2 exceeded the supplemental indicator value of ≤33 for Rosgen C-type streams, while a width/depth ratio of 70 at Site 4 exceeded the supplemental indicator value of ≤22 for Rosgen B-type streams. At sites 1 and 4, width/depth ratios were within expected ranges. The percent of sediment <2mm was meeting the preliminary supplemental indicator value of <20% at all sites, with a values of 0% at the uppermost and lowermost sites, and values of 5.5 and 2.9 at Sites 3 and 4, respectively. Three out of the four sites assessed by DEQ in 2001 were rated as "sustainable" from the perspective of riparian integrity, while the uppermost site was rated "at risk". Notations were made about the effects of I-90, the old state highway, and the railroad grade on channel integrity, width/depth ratios, pool frequency, the amount of cover and shading, and the densities of large woody debris.

An assessment of bull trout habitat issues prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act described the St. Regis River as riffle-dominated with "very little habitat heterogeneity" due to constriction of the river by Interstate 90 and the railroad. In the St. Regis Watershed overall, the analysis of the amount of stream length encroached upon by roads within 300' and 125' shows that 33% of stream lengths in the St. Regis Watershed have roads within 300', and 15% of the streams are encroached by roads within 125'. Nine out of twelve of the HUC 6 tributary watersheds to the St. Regis have greater than 30% of their streams' length encroached upon by roads within 300' (Hendrickson and Cikanek 2000).

In 1990, contractors to Montana Department of Health and Environmental Sciences (MDHES) performed standardized field based non-point source stream reach assessments on each of five reaches of the St. Regis River from its headwaters to the confluence with the Clark Fork River. The assessments provided qualitative appraisals of adjacent land uses, stream channel and bank characteristics, riparian vegetation, water appearance, potential non-point pollution sources, and presence or absence of best management practices. Widespread impacts associated with the railroad and highway transportation corridor were observed throughout the surveyed sections of the river. These included extensive channel straightening, channel encroachment, placement of rock riprap, impacts from bridge and culvert installations, high channel width/depth ratios, loss of riparian vegetation, and a lack of pool habitat (Roberts 1990).

Previous work conducted by the Montana Fish and Game Commission and the Superior Ranger District of the Lolo National Forest indicated that at least 1.3 miles of total stream length have been lost along the St. Regis River due to the development of the transportation corridor. In 1963, the Montana Fish and Game Commission found 17.9 miles of riprap along the banks of the St. Regis River and 5.4 miles of relocated channel that removed natural meanders, resulting in a loss of 0.9 miles of total river length. This report indicated that as much as 68% of the entire St. Regis River had been altered prior to the construction of Interstate 90 (Alvord and Peters 1963). A report by the Superior Ranger District of the Lolo National Forest addressing probable impacts of the construction of Interstate 90 on the St. Regis River upstream of Saltese predicted an additional 0.4 miles of stream would be lost due to channel alterations (Howse 1969).

In 2002 and 2003, physical measurements were performed on the St. Regis River by USFS and LWC to quantify existing conditions relative to sediment related impairments. A brief review of the results is presented below. Additional information can be found in the **Appendix E.**

The assessment of sediment impacts to stream habitat in the St. Regis River indicates there are two types of problems affecting beneficial use support, excess sediment loads/channel aggradation and loss of sinuosity/channel degradation. Stream channels in naturally functioning systems tend toward a state of dynamic equilibrium with the amount of discharge and sediment load from the watershed. Sediment impacts within the St. Regis River can be described as a state of disequilibrium between the discharge, sediment load, and transport capacity of the stream channel. Sections of the stream channel that have been confined by riprap have increased transport capacities capable of flushing higher amounts of sediment through the system. These channelized reaches are characterized by entrenched channels with scour conditions in which sediment is rapidly transported downstream. The impact in these degrading reaches is the result of a high transport capacity relative to the sediment load. Sediment transported through channelized reaches is deposited and accumulates in lower gradient, unchannelized reaches. The impact in these aggrading reaches is the result of a low transport capacity relative to the sediment load, which results in excess sediment deposition in the form of bars, leading to braided channel conditions locally. Braided conditions are also characterized by lateral migration and accelerated bank erosion which is then producing more sediment.

Ten reaches of the St. Regis River delineated for assessment purposes were combined based on stream type and valley type to facilitate the following discussion. Stream reaches were numbered progressing upstream from the confluence with the Clark Fork River and assessments were conducted along 10% of each reach (**Table 5-7**).

Table 5-7. St. Regis River Reaches

Reach	Description	Stationing	Length (Feet)	Assessment Reach	Length (Feet)
1	Clark Fork River to Twomile Creek	0 - 23,300	23,200	16,500-18,800	2,300
2	Twomile Creek to Ward Creek	23,200 - 42,500	19,300	23,600-25,500	1,900
3	Ward Creek to Twelvemile Creek	42,500 - 68,500	26,000	65,400-68,000	2,600
4	Twelvemile Creek to Deer Creek	68,500 - 91,500	23,000	81,000-83,300	2,300
5	Deer Creek to Haugan	91,500 - 114,000	22,500	104,200-106,500	2,300
6	Haugan to Saltese	114,000 - 138,500	24,500	130,500-133,000	2,500
7	Saltese to Taft	138,500 - 162,100	23,600	142,000-144,400	2,400
8	Taft to Hanaker Creek	162,100 - 178,500	16,400	166,600-168,200	1,600
9	Hanaker Creek to Northern Pacific Railroad Grade	178,500 - 196,700	18,200	179,00-180,800	1,800
10	Northern Pacific Railroad Grade to St. Regis Lake	196,700 - 210,500	13,800	Not assessed	

Reaches 1, 4, and 5

Reaches 1, 4, and 5 contained Rosgen C-type channels flowing through a wide valley. Wide valleys with gentle slopes containing a meandering river with a well-developed floodplain and alluvial terraces characterized these reaches. Only one McNeil core sample was collected in these reaches due to an overall lack of appropriate spawning habitat. A McNeil core value of 20.5% <6.3 mm in reach 4 was meeting the water quality target of ≤28%. Riffle stability index values ranged from 81 to 93 in these three reaches, with all values exceeding the water quality target of <75, which suggests increased sediment loads (**Table 5-8**). Mid-channel bars and braiding within Reaches 1 and 5 also indicated aggrading conditions and a potential shift to a Rosgen D-type channel locally. The percent of sediment <2mm in riffles ranged from 0 to 16.0, meeting the water quality target of <20% at all locations. A grid-toss percent surface fines value of 4.6 associated with the reach 4 McNeil core sample was meeting the target criteria of ≤8 in pool tail-outs. High bankfull width/depth ratios in these relatively unconfined reaches indicated excess sediment loads entering these sections, with 6 out of 7 measurements exceeding the supplemental indicator value of ≤30.

Since bankfull channel widths generally exceeded 45 feet in reaches 1, 4, and 5, a water quality target of 16 pools per mile applies, with measured pool frequency ranging from 9 to 63 pools per mile. Large woody debris was primarily associated with mid-channel bars in these reaches, though several large woody debris aggregates were found in reach 4. Overall, large woody debris ranged from 71 to 230 pieces per mile, with reaches 1 and 5 falling below the supplemental indicator criteria of at least 104 pieces of large woody debris per mile.

Sinuosity in these relatively unconfined reaches ranged from 1.08 to 1.20, with reaches 2 and 4 falling below the supplemental indicator of ≥1.2. In addition, riparian vegetation assessments found "non-functioning" conditions in reach 5, while reach 1 was "functioning-at-risk" and reach 4 was in "proper functioning condition."

Reaches 2, 3, 6, and 7

Reaches 2, 3, 6, and 7 contained Rosgen Bc and F-type stream channels flowing through steeper and more confined valleys found between Twomile Creek and Twelvemile Creek and between Haugan and Taft. Moderately steep valleys with moderately sloping hill sides that tend to confine the stream channel characterized reaches 2, 3, 6, and 7. These reaches are naturally somewhat confined, though the development of the transportation corridor has increased overall channel confinement and altered the St. Regis River into an entrenched Rosgen F-type channel along much of its length. Since the conversion from B to F stream types is anthropogenically induced, reaches with Rosgen F stream types will be assessed based on criteria for Rosgen B stream types. It may not be feasible to convert the Rosgen F channels back to B channels in many areas therefore these targets may be revised in the future.

Only one McNeil core sample was collected in reaches 2, 3, 6, and 7 due to an overall lack of appropriate spawning habitat. A McNeil core value of 19.2% <6.3 mm in reach 7 was meeting the water quality target of ≤28%. All riffle stability index values in these reaches were zero due to a lack of bars, which falls below the water quality goal of >45 and suggests scour conditions and high sediment transport capacities characterized these reaches (Kappesser 2002). Width/depth ratios exceeded the supplemental indicator criteria of ≤30 for in 6 out of 12 cross-sections. With a value of 7.6% in reach 3 and 8.6% in reach 6, the percent of sediment <2mm in riffles was meeting the water quality target of <20%. A grid-toss percent surface fines <6mm of 6.8 accompanying the reach 7 McNeil core samples was also meeting the target criteria of ≤8 in pool tail-outs.

Pool frequencies ranged from 0 to 126 pools per mile, generally falling below target values, which vary by stream width (**Section 4**). Similar to pool frequency, there was relatively little large woody debris in these reaches, with values of 4, 0, and 18 pieces per mile in reaches 3, 6, and 7 respectively. These values fall below the supplemental indicator. Large woody debris was not tallied in reach 2, though it was noted that a recent "blow-down" has knocked over numerous trees along the river left bank. These trees were found with their tops floating in the river and their roots still attached to the bank during the assessment, and will likely increase large woody debris inputs over time. The high stream energy in these segments transports wood to downstream bars in aggrading segments along with larger sized cobbles.

Sinuosity in reaches 2, 3, 6, and 7 ranged from 1.01 to 1.3 and was below the supplemental indicator of ≥1.2 in reaches 2, 6, and 7. Riparian assessments found "non-functioning" conditions in reaches 2 and 7, while reach 3 and 6 were "functioning-at-risk."

Reaches 8, 9 and 10

Reaches 8, 9, and 10 extended upstream from Taft into the headwaters of the St. Regis River. Reach 8 contained a C channel in a moderately confined valley, while reach 9 contained a Cb channel in a glacial formed valley (Rosgen 1996). Reach 10 was located upstream of roaded development. Reach 8 was unconfined by the interstate along much of its length, though the section between the rest area and Taft was highly channelized. McNeil core samples collected at two sites in reach 8 exceeded the water quality target of ≤28% <6.3 mm at both sites with values of 28.1 and 37.3%. Grid-toss percent surface fines values of 10.5 and 17.9 accompanying the McNeil core samples also exceeded the target criteria of ≤8 in pool tail-outs. Percent surface fines <2mm ranged from 3 to 6, meeting the target at all locations. Riffle stability index values from reach 8 ranged from 64 to 75, equaling the upper water quality target of <75 at one site. Width/depth ratios in reach 8 exceeded the supplemental indicator value of ≤20 at all three locations.

The majority of reach 9 represented "least-impacted" conditions. However, the downstream end of reach 9 was channelized to accommodate Interstate 90 in which a high amount of traction sand delivery was estimated (see **Section 6.1**). The McNeil core sample collected upstream of this section slightly exceeded the water quality target of ≤28% <6.3 mm, while downstream of the channelized reach, a McNeil core value of 56.9% <6.3 mm greatly exceeded the water quality target. Similarly with the grid-toss percent surface fines values, with a value of 15.3 upstream of the channelized section and a value of 45.9 downstream of the channelized section. The percent surface fines <2mm exceeded the target of <20 at site C with a value of 26, but met the target at the other two sites where it was measured. A riffle stability index value of 46 from reach 9 was meeting the water quality target of >45 and <75. Width/depth ratios in reach 9, which was a Rosgen C3b stream type, exceeded the supplemental indicator value of ≤20 at two of three sites.

Pool frequency ranged from 23 to 114 pools per mile in reach 8, which were meeting the water quality target of at least 16 pools per mile for Rosgen C stream types A total of 254 pools per mile were found in one measurement from reach 9, while a second value of "at least" 29 pools per mile was reported. A water quality goal of at least 16 pools per mile in this Rosgen C type stream reach appears to be met. A large woody debris measurement of 66 pieces per mile in reach 8 fell below the supplement indicator of at least 104 pieces per mile, while a large woody debris measurement of 15 pieces per mile in reach 9 fell below the supplemental indicator of at least 112 pieces per mile.

Both reaches 8 and 9 were rated as in "proper functioning condition." A sinuosity of 1.05 in reach 8 was below the supplemental indicator criteria of ≥1.2, while a sinuosity of 1.2 in reach 9 was meeting the criteria (**Table 5-8**).

Table 5-8. St. Regis River Physical Assessment Data

Reach	Survey Reach	Cross-Section	Bankfull Width	Width / Depth Ratio	Stream Type	Sinuosity	Grid-toss PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	RSI	McNeil Core % Surface Fines <6.3mm	Pools / Mile	LWD/ Mile	PFC Assessment
1	LNF Hydro 7	A	210.6	57.2	C3	1.14		0.0			40		
1	LNF Hydro 7	B	143.0	29.3	C4	1.14		5.0	90				
1	LWC 1	reach-walk									11	73	FAR
2	LNF Hydro 6	A	83.0	27.3	F3	1.11		4.0	0		126		
2	LNF Hydro 6	B	76.3	21.9	F3	1.11		7.0					
2	LNF Hydro 6	C	71.8	19.8	F4	1.11		2.0					
2	LWC 2	reach-walk									3	blow down	FAR
3	LWC 3	A	85.9	40.9	F3	1.3							
3	LWC 3	B	79.1	39.6	F3	1.3		7.6	0		8	4	NF
3	LWC 3	C	91.7	48.3	F3	1.3							
4	LNF Hydro 4	A	83.5	36.2	C3	1.08		10.0			63		
4	LNF Hydro 4	B	106.0	57.2	C3	1.08		16.0	87				
4	LNF Hydro 4	C	91.8	43.5	C3	1.08		3.0					
4	LWC 4	reach-walk					4.6			20.5	21	230	PFC
5	LWC 5	A	114.2	67.2	C4	1.2			93				
5	LWC 5	B	100.5	55.8	C3	1.2		2.6	93		9	71	NF
5	LWC 5	C	133.0	63.3	C4	1.2			81				
6	LWC 6	A	56.0	31.1	F3	1.1							
6	LWC 6	B	62.1	38.8	F3	1.1		8.6	0		0	0	FAR
6	LWC 6	C	62.3	38.9	F4	1.1							
7	LNF Hydro 11	A	30.8	14.4	B3c	1.01		6.0	0		102		

Table 5-8. St. Regis River Physical Assessment Data

Reach	Survey Reach	Cross-Section	Bankfull Width	Width / Depth Ratio	Stream Type	Sinuosity	Grid-toss PSF Lateral Scour Pools (mean)	Pebble Count % Surface Fines <2mm in Riffles	RSI	McNeil Core % Surface Fines <6.3mm	Pools / Mile	LWD/ Mile	PFC Assessment
7	LNF Hydro 11	B	29.7	13.3	B3c	1.01		6.0					
7	LNF Hydro 11	C	30.2	16.4	B3c	1.01		3.0					
7	LWC 7	reach-walk					6.8			19.2	18	18	NF
8	LNF Hydro 1	A	48.8	36.0	C4	1.05	3.1	27.0	64		114		
8	LNF Hydro 1	B	35.7	25.1	C4	1.05	17.9	15.0	71	37.3			
8	LNF Hydro 1	C	44.6	31.6	C4	1.05		26.0	75				
8	LWC 8	reach-walk					10.5			28.1	23	66	PFC
9	LNF Hydro 9	A	24.9	16.1	C3b	1.20		6.0			254		
9	LNF Hydro 9	B	27.3	20.1	C3b	1.20	45.9	23.0	46	56.9			
9	LNF Hydro 9	C	29.1	23.3	C3b	1.20		16.0					
9	LWC 9	reach-walk					15.3			31.8	29	15	PFC

5.8.2 Macroinvertebrates

Macroinvertebrate data were collected at four sites in the St. Regis River in 2001. At site C04STRGR01 the Mountain MMI was 78.8, meeting the supplemental indicator value of >63 for impairment, and the RIVPACS O/E score of 0.91 also met the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04STRGR02 the Mountain MMI was 63.9, just meeting the supplemental indicator value of >63, while the RIVPACS O/E score was 0.65, failing to meet the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04STRGR03 Mountain MMI was 63.2, just meeting the supplemental indicator value of >63, while the RIVPACS O/E score was 0.63, failing to meet the supplemental indicator value of 1.2>RIVPACS>0.8. At site C04STRGR04 Mountain MMI was 55.1, failing to meet the supplemental indicator value of >63, while the RIVPACS O/E score was 1.18, meeting the supplemental indicator value of 1.2>RIVPACS>0.8.

5.8.3 Periphyton

The 2001 DEQ periphyton bioassessment showed good biological integrity at each of four sites. However, siltation index values increased in a downstream direction, indicating increased sedimentation at the lower sample sites (Bahls 2002).

5.8.4 Fish Populations

Fisheries assessments contained in the Montana Interagency Stream Fishery database rated the St. Regis River as either “poor” or “below average” relative to its suitability for trout residence, spawning, and rearing. Problems were caused by a lack of spawning areas, low pool frequencies, siltation, and a lack of riparian vegetation. Problem sources included road construction, bank encroachment, channel alterations, and timber harvest practices. The trend for aquatic habitat quality was rated as “deteriorating” and aesthetics were rated as “below average” (MFWP 1985, 1999). Fisheries have been assessed recently in the upper reaches where brook trout and cutthroat trout are the predominant game fish species (per. com. Knotek).

An assessment of bull trout habitat issues was prepared by Lolo National Forest fisheries biologists to satisfy consultation requirements of the federal Endangered Species Act. The report rated the St. Regis River as among the most important spawning tributaries for bull trout in the middle Clark Fork River basin, and indicated that it also supported resident bull trout populations of moderate to low densities. Bull trout were also reported to be present in the North Fork, South Fork, and mainstem Little Joe Creek, as well as Ward, Timber, and Big Creeks. Although recent fisheries data indicate that the only remaining bull trout populations in the watershed are likely in the Little Joe drainage (per. com. Knotek). Further, the St. Regis River was classified as bull trout “core area.” A core area is defined as drainages that currently contain the strongest remaining populations of bull trout, usually have relatively undisturbed characteristics, and warrant the most stringent levels of protection because of their value as sources of stock for re-colonization. At the time of the report, both bull trout and westslope cutthroat trout populations were described as “depressed” in the St. Regis River (Hendrickson and Cikanek 2000).

Risks to bull trout in the middle Clark Fork planning unit, of which the St. Regis River is a sub-watershed, include dams on the Clark Fork River that limit bull trout migrations, water quality degradation related to agricultural practices and timber harvest, illegal fish species introductions, fish management, mining, transportation systems, illegal harvest, and population trends. The report also provided analyses of watershed characteristics and land uses in the St. Regis Watershed that directly or indirectly related to the above described risk factors. These included road densities and locations, past timber harvest, fish barriers, active and inactive mines, recreational uses, habitat indicators, and fish population status (Hendrickson and Cikanek 2000).

5.8.5 Temperature

The Lolo National Forest in cooperation with DEQ deployed two thermographs on the St. Regis River in 2001 from the middle of July to the middle of October near the mouth. The upper site was located upstream of Saltese and lower site was located at the USGS gaging station near the mouth. At the upper site, the 2001 temperature data documented a maximum temperature of 67.3°F on August 7. This value exceeded temperature limits for bull trout migration and rearing. There were a total of 41 days in which temperatures exceeded 59°F. The highest weekly maximum temperature (7DADMT) was 65.9°F. At the lower site, the 2001 temperature data documented a maximum temperature of 69.8°F on August 7. There were a total of 58 days in which temperatures exceeded 59°F at this site. The 7DADMT was 68.5°F. In 2002 and 2003, the temperature monitoring network was expanded. The maximum seven day average temperatures ranged from a low of 61.6°F at the USGS gage in 2002, to a high of 70.4°F at a site near Haugen in 2003 (**Appendix D**). At all monitoring locations in all years (2001-2003), the 7DADMT temperatures exceeded the temperature indicator.

Temperature conditions in the St. Regis River are much higher than temperatures expected. It is unclear if temperature conditions in the St. Regis River could meet bull trout rearing temperatures in the upper reaches or migration temperatures in the lower reaches in a naturally occurring condition where all reasonable land, soil, and water conservation practices are implemented, but the following paragraphs support the conclusion that temperatures could be reduced significantly from existing conditions with reasonable efforts.

Factors influencing stream temperature include solar radiation, the density of riparian vegetation, channel morphology, discharge, and stream aspect. Shade provided by riparian vegetation decreases the amount of solar radiation reaching the channel. A decrease in the canopy density along the stream channel can increase the amount of solar radiation reaching the stream channel, which leads to increased water temperatures (Hostetler 1991). Based on an analysis conducted in support of TMDL development (**Appendix F**), mean canopy density for the St. Regis River averages 30% along the river left bank and 50% along the river right bank. Thus, the overall mean canopy density along the St. Regis River is 40%, well below the 60% target value.

The riparian corridor along the St. Regis River competes with the transportation corridor for space upon the floodplain. Interstate 90 is primarily situated above the left bank along the north side of the river. Interstate 90 and the old railroad grade, which is located primarily along the right bank on the south side of the river, have effectively reduced the width of the riparian corridor, so that currently 50% of the river is bordered by a riparian corridor of less than 100 feet.

An extensive amount of stream bank alterations, stream channel alterations, and channel encroachment were documented along the St. Regis River. The vast majority of stream bank alterations were associated with the placement of rock riprap, which can negatively affect how the channel transports sediment and decrease the amount of shading riparian vegetation. Approximately 15.2 miles of riprap were measured along the St. Regis River. The left bank (facing downstream) contained approximately 10.5 miles of riprap, while the right bank had approximately 4.7 miles of riprap. A total of 7.4 miles of the documented riprap was associated with Interstate placement of riprap along the stream bank during the construction of Interstate 90 resulted in approximately 2.8 miles of direct channel alterations at seven different sites (**Appendix G**). Riprap placed during the construction and maintenance of Highway 10 and the two railroads has affected 7.8 miles of the St. Regis River. Overall, stream bank alterations brought about through the development of the transportation corridor have led to channel encroachment problems along 12.4 miles of the river.

Although no direct linkage between these impacts and potential in-stream temperature increases has been established for the St. Regis River, analysis conducted for Twelvemile and Big Creeks (**Appendix C**) determined that riparian corridor impacts of lower magnitude than those found on St. Regis River have resulted in increases in stream temperature of more than 1°F, which violates state water quality standards. In light of the extensive alterations of the St. Regis River and high summer in-stream temperatures, there is little doubt that the river is impaired by temperature and thus a temperature TMDL will be developed.

5.8.6 St. Regis River Water Quality Status Summary

The St. Regis River is listed as impaired due to sedimentation/siltation, water temperature, and other habitat related listings. The existing data support the conclusion that sediment impairments exist within the St. Regis River. Upper sections have high fine sediment deposition. Other sections are over-widened and pool habitat has been filled from upstream sediment sources. Filling of pool habitats reduces fish rearing. Specific reaches are aggrading coarse sediment and other areas are degrading or transporting too much coarse sediment because of channel length losses and associated steepened gradients. It is estimated that since the freeway was built, some sections of the St. Regis River have degraded 6 feet or more. Channelization from transportation corridors has caused increased stream power to transport larger sized sediments than previously in many sections of the river. Significant human caused sediment sources are present in the watershed from forest roads, eroding banks, and traction sanding. Sediment delivery, transport, and deposition and in-stream sediment sorting have been impacted by human caused activity. Sediment conditions are likely impacting the fishery and aquatic insects. A sediment TMDL and habitat restoration plan will therefore be developed for the St. Regis River.

Data collected in 2001, 2002, and 2003 in support of TMDL-related temperature assessment of the St. Regis River found that at all sites in all years for which data are available, the 7DADMT exceeded the indicator values and summer temperatures routinely exceed bull trout migration tolerances. Furthermore, the extensive alteration of the river corridor and its riparian areas provides ample evidence that human activities have contributed to the elevation of temperature in the St. Regis River. A temperature TMDL will thus be developed for the St. Regis River.

SECTION 6.0
SEDIMENT

The St. Regis TPA sediment pollutant assessment focused on evaluating actual and potential sediment inputs from all identified sources, including an extensive forest road network, erosion from highway cutslopes, and the application of winter traction sand along Interstate 90. Additional sediment sources included eroding stream banks, storm water runoff from impervious surfaces, a variety of private and permitted public land use activities, the potential for catastrophic culvert failures, and natural sources. The sediment assessment also considered impacts associated with landscape scale and stream reach scale influences on stream energy, which affect sediment transport. Lastly, the potential for changes in basin water yield from silviculture or other activities was evaluated because it could impact stream channel morphology, stream bank stability, and sediment transport capacity of the mainstem St. Regis River and affected tributaries. Delivery of sediment from the above described potential source categories was analyzed through a combination of approaches, including review and interpretation of aerial photographs, field measurement of cut and fill slopes and traction sand deposits, culvert surveys, computer modeling, review of agency records and data, and in-stream indicators.

6.1 Sediment Source Assessment

This section provides:

- A description of the methodologies used to assess sediment sources in the St. Regis River watershed
- A summary of the results of the sediment source assessment for all sediment-listed streams
- TMDLs for all of the sediment-listed streams in the St. Regis River watershed
- TMDL allocations and margin of safety for all of the sediment-listed streams in the St. Regis River watershed

The term sediment is used in this document to refer collectively to several closely-related pollutants, including siltation, suspended solids, and sediment sources such as streambank erosion and riparian degradation that appear on Montana's 303(d) Lists. The sediment TMDLs presented in this section are intended to address the sediment related 303(d) Listings.

6.1.1 Natural Background Sediment Load

The LoloSED computer model was used to analyze natural sediment production at the watershed scale including the HUC 6 tributary watersheds to the St. Regis River and the St. Regis HUC 5 **(Appendix H).** LoloSED is a sediment production model modified by the Lolo National Forest from the WATSED model, which was developed by the USDA Forest Service Region 1 and others (USDA 1991). Natural sediment production for the entire St. Regis 5th field hydrologic unit (HUC 5) was estimated at approximately 2,400 tons/year based on the LoloSED model runs, or about 6.6 tons of sediment per square mile of watershed area per year **(Table 6-1)**. Background natural sediment production was estimated at 7.4 tons per square mile per year for the Little Joe Creek watershed, while rates for Ward, Twelvemile, Deer, and Big Creeks and the upper St. Regis mainstem were estimated at 6.6, 5.2, 6.4, 7.2, and 7.5 tons per year respectively. Future upland sediment modeling efforts should use other models for determining natural background erosion rates. LoloSED likely over predicts sediment loads. WEPP or RUSLE based models should be used for future upland based erosion assessments. No reductions in natural background sediment loading are called for in the sediment reduction allocations.

Table 6-1. Lolosed Modeled Natural Sediment Production in the St. Regis Watershed

Watershed (5th & 6th code HUC #)	Natural Sediment Production (tons/year)	Area (sq mi)	Natural Sediment Production Normalized by area (tons/mi2/year)
St. Regis	2399	363	6.6
Big Cr (804)	273	38	7.2
Little Joe Cr (811)	319	43	7.4
Lower St. Regis_Mullan (812)	219	38	5.8
Twelvemile Cr (808)	310	60	5.2
Upper St. Regis (801)	306	41	7.5

6.1.2 Sediment Loading due to Timber Harvest

The LoloSED computer model was used to analyze sediment production due to timber harvest at the watershed scale, including the HUC 6 tributary watersheds to the St. Regis River and the St. Regis HUC 5 (**Appendix H**). Sediment production from timber harvest areas was determined using production coefficients for the timber harvest system used (tractor, skyline, or helicopter) and natural sediment production values. Loading estimates assumed timber harvest levels remain static in the future. Based on LoloSED model projections for the years 1990-2020, sediment increases due to timber harvest peaked in the early 1990s at approximately 2,525 tons/year, or about 125 tons above the expected natural background levels. In 2003, timber harvest contributed an estimated 35 tons of sediment above the expected natural background levels (**Appendix H**). Sediment production in future years, through 2020, is expected to show a static trend. However, currently unplanned future harvest and road construction activities could increase sediment production beyond the projected levels. Future upland sediment modeling efforts should use other models for determining natural background erosion rates. LoloSED likely over predicts sediment loads. WEPP or RUSLE based models should be used for future upland based erosion assessments.

At these levels, sediment loading from timber harvest is not considered a significant anthropogenic source of sediment and thus load reductions are not proposed in the TMDLs and allocations that follow. However, currently unplanned future harvest and road construction activities could increase sediment production beyond the projected levels, and thus the careful application of BMPs to all future harvest-related activities is critical. Future upland disturbance associated with timber harvest, excluding associated roads should be kept below 5% of the TMDL for the water body. Future harvest planning should consider this threshold. No new sediment production from road building associated with timber harvest is allowed unless mitigated 2 to1 until the road allocations are met. No new sediment production should occur from near stream (300 ft) timber harvest.

6.1.3 Sediment Loading due to Road Surface Erosion

The WEPP:Road model was used to estimate sediment loads from unpaved roads in the St. Regis TPA. The WEPP:Road model provides an estimate of sediment runoff from unpaved roads based on physical road characteristics, the soil type on which the road occurs and the climate. Physical road characteristics used in the model were measured in the field. Sediment loading from unpaved roads at the watershed scale for Big Creek, Little Joe Creek, Twelvemile Creek, and the St. Regis River was determined based on modeled sediment loads from both National Forest and non-federally managed lands. GIS analysis provided by the Lolo National Forest identified 621 unpaved road crossings on National Forest land in the St. Regis River watershed with 40 crossings in the Big Creek watershed, 83 crossings in the Little Joe Creek watershed, 30 crossings in the North Fork Little Joe Creek watershed, and 142 crossings in the Twelvemile Creek watershed. An additional two crossings were identified on non-federally managed lands in the Big Creek watershed, while six additional crossings were identified in the Twelvemile Creek watershed. In the St. Regis TPA, there are an estimated 52 crossings on non-federally managed lands. Total sediment loads from unpaved roads in the St. Regis TPA are estimated at 327.5 tons/year **(Table 6-2)**. Additional details on the road sediment assessment are presented in **Appendix I**.

To address this sediment source in the TMDLs and allocations that follow, the contributing segments of the roads were shortened to 200 feet in the model and used to estimate reasonable practices like diverting water from the road surface at points 100 feet from the stream crossing through vegetated buffers. The measurement of 200’ was selected as an example to illustrate the potential for sediment reduction by approximating BMP upgrades and is not a formal goal for all crossings. Although the modeled restoration analysis was used to estimate the potential for road sediment reduction, achieving this reduction in sediment loading from roads may be occur through a variety of methods such as diverting water from road surfaces, ditch BMPs and cut/fill slope BMPs.

While the TMDL was being prepared, the Lolo National Forest completed several large road decommissioning projects in the TPA, particularly in the Twelvemile and Big Creek watersheds, and thus the analysis presented in this document overestimate current sediment loading from unpaved roads. Additional details of the work completed by the Lolo National Forest are presented in Section 8.

Table 6-2. Sediment Loads from Unpaved Road Crossings in the St. Regis TPA

Watershed	**Estimated Number of Unpaved Road Crossings**	**Total Sediment Load (Tons/Year)**
Big Creek	42	21.1
Little Joe Creek	83	43.7
North Fork Little Joe Creek	30	15.8
Twelvemile Creek	148	74.9
St. Regis River	673	327.5

6.1.4 Potential Sediment Risk from Culvert Failures from Unpaved Roads

Culvert failure may result in the direct discharge of road fill material into the stream channel. Undersized culverts are susceptible to failure or blow-out due to the ponding of water at the culvert inlet. The ponding may produce mass failure of the road bed or by flow based erosion at the lowest point of the roadbed. Modeled discharge and the headwater depth (depth of water ponded at culvert inlet) to culvert depth ratio (Hw:D) was used by the Lolo National Forest to assess the risk of culvert failure (**Appendix J**). The magnitude of peak discharge (Q) for the 2, 5, 10, 25, 50, and 100-year stream flow recurrence intervals was modeled for each surveyed stream culvert crossing using regression equations developed by Omang (1992). Analysis of sediment risk from culvert failure was completed for 119 culverts. Surveyed culverts represented approximately 20% of the fish bearing stream crossings present in the St. Regis Watershed. Using the surveyed site results for certain sized flood events, the potential for existing loads from culvert failure was extrapolated to the watershed scale and normalized to an average yearly load over a century (**Table 6-3**). In the TMDLs and allocations that follow, sediment load reductions were estimated by modeling the effects of upgrading culverts to safely pass the 100 year flood upon their initial failure on all fish bearing stream crossings. Details about the culvert failure monitoring and modeling effort are provided in **Appendix J**.

Caution should be used when comparing the potential load from culvert failure to other sediment sources in the watershed. Culvert failure sediment load potential is based on the probability of culvert failure based on flood frequency analysis over a 100 year timeframe. Sediment loads from this source, like most other sediment sources are likely to occur in large pulses and annual sediment yields are a representation of average yearly conditions over a long timeframe.

Table 6-3. Estimated Culvert Failure Sediment Loading

	Existing Total Average Annual Sediment Yield Potential (t/Y)	**Total Average Annual Yield Potential (t/Y) for Q100 upgrade**	**% Reduction due to Q100 upgrades after initial failure**
Big Creek	10.8	6.8	37
Little Joe Creek	26.4	16.7	37
Twelvemile	36.6	23.2	37
St. Regis	186.0	117.8	37

6.1.5 Sediment Loading from In-stream Sources

6.1.5.1 Bank Erosion

Eroding banks were assessed along the mainstem of the St. Regis River and several tributaries in 1996 and 2002 by the Lolo National Forest using R1/R4 methodology. The assessment by the Lolo National Forest of three reaches along the St. Regis River in 1994 and 1995 using the R1/R4 methodology found the percent of eroding banks ranged from 0-0.1%, while the same reaches had 0-0.2% eroding banks in 2002. Lolo National Forest inventories in 2002 indicated 3.7% eroding banks on Little Joe Creek, 0-1.1% on North Fork Little Joe Creek, 2.9% on East Fork Big Creek, and 14.9% eroding banks on West Fork Big Creek.

Visually eroding banks were assessed along nine reaches of the St. Regis River during the physical habitat assessment conducted in 2003 by Land and Water Consulting. In addition, eroding banks in association with pools were assessed from the National Forest boundary to the St. Regis River confluence for Little Joe, Twelvemile, and Big Creeks in 2002. During the physical assessment in 2003, nine reaches covering 10% of the St. Regis River were looked at individually and only two or three reaches had any eroding banks. Eroding banks comprised minor portions of each of these reaches. However, there were several locations along the St. Regis River where large eroding banks were visible from the interstate, and some sediment loading undoubtedly occurs from these sites during high flow events.

Visually eroding banks were assessed in association with pools in the lower reaches of Little Joe, Twelvemile, and Big Creeks in 2002. There was 0% eroding banks in Little Joe Creek, an average of 2.2% eroding banks in Twelvemile Creek, and an average of 61.5% eroding banks associated with pools in Big Creek.

In 2006, an additional assessment was conducted to quantify sediment loading from visually eroding banks (**Appendix I**). Streambank erosion assessments were performed on a total of 39 eroding streambanks, including 25 streambanks on the St. Regis River, five streambanks along Big Creek, two streambanks along Little Joe Creek, and seven streambanks along Twelvemile Creek. Along the St. Regis River, stream bank erosion assessments were performed on eroding banks visible from Interstate 90 and the Frontage Road. Since Interstate 90 parallels the St. Regis River along the majority of its length, selection of sample sites through this technique was thought to capture all of the large eroding banks and the majority of smaller eroding banks. On tributary streams, eroding bank assessment sites were selected in the field based on observations made from the forest roads paralleling the stream channel, along with information from previous assessment work. Sections of Big Creek and Twelvemile Creek away from the road were walked, providing detailed coverage for these segments. Previous assessment work, along with local inquires, did not identify any other stream segments in the watershed in which streambank erosion was a significant source of sediment.

Streambank erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and estimating the Near Bank Stress (NBS) (Rosgen et al. 1996, Rosgen 2004). The BEHI score was determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. BEHI categories range from “very low” to “extreme.” At each eroding streambank, the NBS was visually estimated for a bankfull flow event. NBS categories range from “very low” to “extreme.” The length, height, and composition of each eroding streambank were noted, and the source of streambank instability was identified based on the following near-stream source categories:

- Transportation
- Riparian Grazing
- Cropland
- Mining
- Silviculture
- Irrigation-shifts in stream energy

- Natural Sources
- Other

The source of streambank erosion was evaluated based on observed anthropogenic disturbances and the surrounding land-use practices. For example, an eroding streambank in an area affected by timber harvest was assigned a source of "100% silviculture," while an eroding streambank due to road encroachment upstream was assigned a source of "100% transportation." If multiple sources were observed, then a percent was noted for each source, while naturally eroding streambanks were considered the result of "natural sources." The "other" category was chosen when streambank erosion resulted from a source not described in the list. In the St. Regis TPA, observed sources of streambank erosion included transportation, cropland, silviculture, and natural sources. Estimated stream bank sediment loading rates for watersheds in need of a Sediment TMDL are provided in **Table 6-4**.

Table 6-4. Sediment Loads due to Eroding Streambanks in the St. Regis TPA by Source

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources					Total Load
			Transportation	Cropland	Silviculture	Natural Sources	Other	
St. Regis River	38.6	**Tons/Year**	389.1	35.3	0.0	16.6	77.8	518.7
		Percent	75%	7%	0%	3%	15%	
Big Creek	3.4	**Tons/Year**	13.9	0.0	13.7	4.5	13.4	45.5
		Percent	30%	0%	30%	10%	30%	
Little Joe Creek	3.1	**Tons/Year**	0.0	0.0	36.4	0.0	0.0	36.4
		Percent	0%	0%	100%	0%	0%	
Twelvemile Creek	13.4	**Tons/Year**	42.2	0.0	2.3	3.3	0.0	47.8
		Percent	88%	0%	5%	7%	0%	

In the TMDLs and allocations that follow, a 90% reduction in the anthropogenic sediment load from bank erosion is proposed. This load reduction estimate is based on best professional judgment and use of the relationship between BEHI/near bank sheer stress and bank retreat rates on reference and nonreference banks. Reference conditions can be achieved in most locations via BMP application, restoration, and revegetation. In some cases however, the proximity of the existing road network, railroad, and other infrastructure may make achieving this reduction prohibitively expensive because the stream channel has been altered by bank armoring in the area, and the stream power is thus altered causing eroding banks nearby. An adaptive management approach should be used in these circumstances to determine if bank erosion sources due to transportation effects are economically feasible.

6.1.5.2 Historical Mass Wasting Sites

Sediment loading due to mass wasting was estimated for two large eroding hillslopes along the St. Regis River and two large eroding hillslopes along Twelvemile Creek using the Disturbed WEPP model. Input parameters for gradient, horizontal length, percent cover, and percent rock were derived through field data and a review of field photographs. In the TMDLs and allocations that follow, no reduction in the sediment loading from mass wasting is proposed due to the relatively low contribution from the source and the difficulty that would be associated with stabilizing the mass wasting locations. Some natural attenuation of sediment loading from these sites will likely occur over time but there will be zero allocation to future human caused mass wasting events.

Table 6-5. Hillslope Inputs along the St. Regis River

Field Data		WEPP Results	Sediment Erosion from Hillslope (Tons/Year)
Stream Segment	**Site**	**Average Sediment (Tons/Acre)**	
St. Regis River	Hillslope 1	11.05	6.24
St. Regis River	Hillslope 2	13.91	3.74
Twelvemile Creek	BEHI 11	7.50	2.20
Twelvemile Creek	BEHI 12	9.19	1.20

6.1.6 Sediment Loading due to Winter Application of Traction Sand along Interstate 90

The input, storage, and transport of traction sand were examined along the St. Regis River adjacent to Interstate 90 (**Appendix K**). The storage and transport of traction sand were assessed based on the proximity of Interstate 90 to the stream channel and the movement of traction sand on Interstate fill slopes. Based on this analysis, it is estimated that 464 tons of traction sand are delivered to the St. Regis River during an average winter, which amounts to roughly 2.1% of the annual application rate of 21,777 tons of traction sand (**Table 6-6**). Sections of Interstate 90 within 100 feet of the stream channel are estimated to contribute 258 tons annually, delivery of traction sand through culverts is estimated to contribute 118 tons annually, and traction sand runoff from bridge decks is estimated to contribute 88 tons annually.

Table 6-6. Mean Annual Input of Traction Sand into the St. Regis River from Interstate 90

Source	Tons	Percent of Mean Annual Application Rate
Interstate within 100 feet of the channel	258	1.2%
Contribution through culverts	118	0.5%
Contributions from bridges	88	0.4%
Total	464	2.1%

The majority of the traction sand entering the stream channel is derived from two stretches of Interstate 90. Traction sand inputs within 25 feet of the stream channel for 2,900 feet (approximately 0.5 miles) from mile marker 2.0 to 2.6 (with mile marker 0 at the top of Lookout Pass) along the westbound lane accounts for approximately 158 tons, which is approximately 34% of the mean annual delivery rate (**Table 6-7).** A 10,200-foot (1.9 mile) stretch of road just upstream of Saltese, in which the interstate is within 50 feet of the stream channel from mile marker 8.0 to mile marker 10.0, contributes approximately 81 tons, which accounts for approximately 17% of the mean annual delivery rate. Thus, direct runoff from Interstate 90 along these two stretches of highway accounts for almost 50% of the total contribution of traction sand, while the other stretches of Intestate 90 within 100 feet of the stream channel account for approximately 29 tons, which is approximately 6% of the mean annual delivery rate. The remaining traction sand is contributed through culverts (25%) and from bridges decks (19%).

Table 6-7. Percent Contribution of Traction Sand to the St. Regis River from Interstate 90

Source	Tons	Percent
Mile markers 2.0-2.6 and 8.0-10.0	229	49%
Other portions of I-90 within 100 feet of the channel	29	6%
Contribution through culverts	118	25%
Contribution from bridges	88	19%

Severe winter weather and mountainous roads in the St. Regis TPA will require the continued use of relatively large quantities of traction sand, and the close proximity of the St. Regis River to the road network will make significant reductions in loading difficult. The proposed 10% reduction in traction sand for the allocations that follow is based on ongoing efforts by the Montana Department of Transportation to incorporate BMPs into their winter sanding activities. These efforts may include improved maintenance of catchments basins, more effort in road sand recovery, and the increased use of chemical deicers as long as doing so does not create a safety hazard or undue degradation to water quality. Additional BMPs may include improved vegetation buffers, routing flows away from streams, and the creation of sediment catching structures.

Potential sediment inputs from cutslope erosion were considered during the traction sand assessment (**Appendix K**). Forty-seven cutslopes were identified along Interstate 90 between St. Regis and Lookout Pass covering a linear roadside distance of 9.7 miles and an estimated area of 180.0 acres. The majority of cutslopes were located along reaches 2, 3, 6, and 7. Out of 38 culverts identified in the field, 21 of the culverts were associated with cutslopes and provided pathways to the stream channel. A total of 66 tons was estimated to be delivered to the St. Regis River annually from cutslope erosion.

MDT will explore alternatives for stabilizing key cut/fill slopes and capturing sediment Additionally, BMPs may be utilized to prevent delivery of cutslope materials to the St. Regis River. As was the case with traction sand, these may include vegetation buffers, routing flows away from streams, and the creation of sediment catching structures. The loading from cut/fill slopes will be considered together with road sand inputs and allocations for these sources will be combined. This will provide MDT the freedom to explore alternatives to meet an overall 10% reduction of road sand and cut/fill slope sediment sources.

6.1.8 Minor Sediment Sources

6.1.8.1 Changes in Water Yield

Increases in water yield as a result of land management activities and natural events has the potential to increase peak flows, which can alter stream channel morphology and increase stream bank erosion. Equivalent clear-cut area analysis was used to model residual water yield increases in the St. Regis Watershed (**Appendix L**). Methods used for determining the effects of vegetation removal on water yield were developed specifically for the Lolo National Forest (Pfankuch 1973) and refined for U.S. Forest Service Region 1 (USDA 1976). Timber harvest activity on Lolo National Forest lands resulted in a projected 2.8% increase in water yield in the

St. Regis River in 2003 as compared to natural background levels (**Table 6-8**). In addition, water yield increases in 2003 for the St. Regis River watershed are estimated at 0.8% due to the clear-cut corridor associated with forest roads. The overall water yield increase due to land management in the St. Regis River watershed is estimated at 3.6% for 2003.

Acceptable water yield increases, where adverse hydrologic and water quality effects would not be expected, are lower for highly erosive drainages and streams in poor condition than for drainages with stable soils and well functioning streams (Pfankuch 1973). These values range from about 8% for the former to 10-15% for the latter category. Increases in water yield due to timber harvest and road building currently exceed the 8% level in Twelvemile Creek and the Lower St. Regis River watershed.

Table 6-8. Percent Water Yield Increase in 2003 due to Land Management Activities

Watershed	Timber Harvest	Forest Roads	Overall
Big Creek	3.1	0.7	3.8
Little Joe Creek	4.2	0.9	5.1
Twelvemile Creek	6.2	1.9	8.1
St. Regis HUC5	2.8	0.8	3.6

The impacts of vegetation loss on water yield due to the 1910 fires in many of the tributary drainages to the St. Regis River had the potential for tremendous geomorphic effects. Predicted water yield increases resulting from the major wildfires of 1910 vary depending on the projected condition of the streams at that time. Water yield in the St. Regis Watershed was projected to have increased by about 18.5% immediately after the fires, assuming that the river and its tributaries were not in excellent condition. According to the modeling results, it was not until the 1920s that water yield increases in the St. Regis Watershed due to the fires dropped to below 10% over natural background levels. As of 2003 most (97%) of the area burned by the 1910 fires has recovered. However, the effects of the 1910 and other fires on channel morphology may persist today, in part due to activities that have further reduced and in many cases continue to reduce the stability of vulnerable stream channels attempting to recover from fire-induced water yield impacts. These activities include road encroachment, alteration by development of transportation corridors, and other activities such as timber harvest, particularly timber harvest or other clearing within riparian areas.

The combined effects of documented timber harvest and the 1910 fires have lead to greater than 8-10% water yield increases in four areas of the St. Regis Watershed. These include the St. Regis headwaters area, Packer Creek, Twelvemile Creek, and the lower St. Regis River mainstem (**Appendix L**). Big Creek and Little Joe Creek were projected to have sustained roughly 5% increases in annual water yield during the 1970s and 1980s respectively. Water yield increases due to the combined effects of timber harvest and fire likely remained below 5% for all other tributaries and for the St. Regis Watershed as a whole. The baseline water yield comparison is to a fully forested condition that does not consider effects of natural fire or bug kill over time.

6.1.8.2 Storm Water Runoff from Impervious Surfaces

The Silver Dollar Bar parking lot in Haugen was examined relative to storm water runoff from impervious surfaces since it is one of the only large impervious surfaces in the watershed. The Silver Dollar Bar parking lot in Haugen was sloped inward and drained into a central collection area that did not appear to be connected to a stream channel. Thus, storm water runoff from the Silver Dollar Parking lot was determined not to be a significant source of sediment to the St. Regis River.

The amount of impervious surface due to Interstate 90 in the St. Regis Watershed was calculated. Storm water runoff from Interstate 90 has the ability to transport significant quantities of sediment, as was previously discussed in the traction sand assessment. Interstate 90 and the associated drainage network of culverts likely increase the flashiness of storm water runoff, which may influence the size and timing of peak flows in the St. Regis River. Interstate 90 covered an estimated 363 acres of the St. Regis River watershed between Lookout Pass and St. Regis. This was a conservative estimate of impervious surface based on four 12-foot wide lanes and four 10-foot wide shoulders along 34 miles and did not account for unvegetated cut and fill slopes along the interstate. This was equivalent to 0.16% of the watershed.

6.2 Potential Sediment and Fisheries Habitat Influences

6.2.1 Channel Alterations, Streambank Alterations and Channel Encroachment

Stream bank alterations, stream channel alterations, and channel encroachment associated with the construction and maintenance of two highways and two railroads are suspected to have influenced the hydrology, sediment transport capacity, water quality, and aquatic habitat features of the St. Regis River. Channel impacts associated with Interstate 90 were compared to preexisting impacts associated with the two railroads and Montana Highway 10 by examining aerial photographs from 1963-64, 1993, 1996, and 2000 along ten distinct reaches of the St. Regis River (**Appendix G**). Stream bank alterations, stream channel alterations, and road encroachment were also assessed along St. Regis River tributaries (**Appendix M**). The type of impact was categorized using the following criteria:

- **Stream bank alterations:** Structural practices such as riprap, jetties, and dikes used in an attempt to stabilize stream banks.
- **Stream channel alterations:** The straightening of meanders or cutting through of meander curves with a new channel of less distance than the original.
- **Channel encroachment:** An unnatural confinement or constriction of the stream channel and an accompanying loss of the stream's access to its natural floodplain and the extent of anthropogenic disturbances along the stream channel. Road density within 6th code HUC watersheds was used as one indicator of channel encroachment.

An extensive amount of stream bank alterations, stream channel alterations, and channel encroachment were documented along the St. Regis River. The vast majority of stream bank alterations were associated with the placement of rock riprap, which can negatively affect how the channel transports sediment on a site-specific and river-wide basis. Approximately 15.2 miles of riprap were measured along the St. Regis River (**Appendix G**). The left bank (facing downstream) contained approximately 10.5 miles of riprap, while the right bank had approximately 4.7 miles of riprap. A total of 7.4 miles of the documented riprap was associated with Interstate 90 (**Appendix G**). Placement of riprap along the stream bank during the construction of Interstate 90 resulted in approximately 2.8 miles of direct channel alterations at seven different sites (**Appendix G**). Riprap placed during the construction and maintenance of Highway 10 and the two railroads has affected 7.8 miles of the St. Regis River. Overall, stream bank alterations brought about through the development of the transportation corridor have led to channel encroachment problems along 12.4 miles of the river.

High road densities and road encroachment of stream channels within the St. Regis River watershed has led to stream bank alterations and channel encroachment on many of the tributary streams. Road densities between 1.7 and 4.7 miles of road per square mile are considered high by the U.S. Forest Service (USDA 1996). The overall road density is 2.8 in the St. Regis Watershed, with road densities of 2.5 in the Little Joe and Big Creek watersheds and a road density of 3.4 in the Twelvemile Creek watershed (**Table 6-9**). There were 0.04 miles of riprap along Little Joe Creek, 0.03 miles of riprap along in the North Fork Little Joe Creek, and 0.25 miles along the South Fork Little Joe Creek (**Appendix M**). There were 0.78 miles of riprap along Twelvemile Creek and 0.44 miles of riprap along Big Creek. Most of the observed sections of riprap were associated with roads encroaching upon the stream channels. These sources affect fisheries habitat along with sediment production. Sediment production from these sources is assessed via the unpaved roads assessment, road sanding assessment, and bank erosion assessments mentioned above. Additionally the impacts caused by these human influences may affect sediment transport and sorting within the stream channels. The sediment targets and TMDLs combined effectively deal with sediment transport and deposition.

Table 6-9. Road-Stream and Road-Watershed Relationships Characterized in Bull Trout Baseline Section 7 Consultation Study

HUC 6 No.	HUC Name	Road Density (miles/ mile^2)	% Stream with Road w/in 300' of Stream	% Stream with Road w/in 125' of Stream	*Stream density
12	Lower St. Regis_Mullan +	3.6	37.3	19.8	2.6
8	Twelvemile Cr +	3.4	34.0	15.6	2.6
7	Twin Cr_St Regis	2.9	26.9	13.5	2.3
1	Upper St. Regis +	2.8	37.8	20.6	2.0
11	Little Joe Cr +	2.5	36.8	18.9	2.4
4	Big Cr +	2.5	36.6	12.8	1.6
	St. Regis 5th Code HUC	2.8	265.4	122.1	Not included

* Not part of Hendrickson and Cikanek 2000 analysis. (Hendrickson and Cikanek, 2000)

6.2.2 Noxious Weeds

The distribution of weeds was not determined during this assessment, though qualitative observations were made during field work. In general, invasive weeds can have a negative impact on the development of functioning riparian vegetation and the ability of riparian vegetation to trap sediment transported from upland sources. Invasive weeds lack the deep binding root mass characteristic to most riparian vegetation and are thus ineffective at stabilizing stream banks. The establishment of invasive weeds in riparian zones may lead to bank destabilization, which increases sediment inputs due to stream bank erosion. In areas where weeds out-compete riparian vegetation, the ability to buffer sediment laden runoff from the uplands is reduced. Fill slopes and roadside ditches along Interstate 90 that are covered with traction sand are also colonized by weeds in many cases. Fill slopes colonized by weeds are less effective than fill slopes colonized with grasses at preventing Interstate 90 runoff from reaching the stream channel.

6.3 Point Sources

Two recreation suction dredge permits (Wesley Gillespie, MTG370275; J.R. Merchant, MTG370278) authorize minor amounts of dredging in Ward Creek. MPDES recreation suction dredge permit activities are transitory and intermittent. Recreational suction dredging does not introduce new sediment load to the stream network. Instead, it transports the sediments that are already on the stream bottom and re-deposits them. The MPDES permit process sets turbidity limits equal to Montana's water quality standards for turbidity. The MPDES permit process adequately considers water quality affects such as turbidity and sediment transport. Enforcing Montana's turbidity limits is protective of aquatic life and sediment transport capacity of the streams in the St. Regis Watershed. Therefore, no sediment load allocation is provided for this activity because there are no new sediments introduced into the stream network, in-stream sediment transport is not accelerated significantly, and the potential water quality impacts associated with increased turbidity are addressed through the permit. Additionally, it should be noted that recreation suction dredging activities in Montana not only need a MPDES permit, but must also acquire a 310 permit which involves a fish biologist and local conservation district review for stream bed and fishery related impacts. The 310 permit process considers the timing of the activity, the physical habitat alteration, and impacts to incubating fish embryos and fry.

6.4 Future Development

Future developments within the St. Regis River watershed may have a negative impact on beneficial use support of coldwater fisheries and aquatic life. Potential future development includes timber harvest, road construction and maintenance, mining, subdivision development, and increased recreational pressure. Future developments should consider the potential negative impacts on coldwater fisheries and aquatic life. Negative impacts to be avoided include road or home building encroachment and the addition of riprap along stream banks, placement of culverts that act as fish passage barriers, and the removal of large woody debris and riparian vegetation in the stream corridors that provides stream shade. Other negative impacts with the potential to increase sediment and thermal loads may arise on a site specific basis. Future developments should proceed only after potential negative impacts to water quality have been addressed and mitigation plans developed.

6.5 Uncertainty

A degree of uncertainty is inherent in any study of watershed processes related to sediment. The approach used in this study to characterize sediment sources involves several techniques, each associated with a degree of uncertainty. It should be noted that some sediment source inventories may under- or over-estimate natural inputs due to selection of sediment source inventory reaches and the extrapolation methods used to derive water body wide sediment loading. Thus, the source assessment should not be taken as an absolutely accurate account of sediment production within each watershed but should be considered as a tool to estimate and make general comparisons of sediment loads from various sources. This TMDL document will include a monitoring and adaptive management plan to account for uncertainties in the source assessment.

Sediment loading varies considerably with season and by sediment source. For example, delivery increases during spring months when snowmelt delivers sediment from upland sources and resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportions of deposited fines in critical areas for fish spawning and insect growth. Because both fall and spring spawning salmonids reside in the St. Regis River TPA, streambed conditions need to support spawning through all seasons. Therefore, sediment targets are not set for a particular season and source characterization is geared toward identifying average annual loads.

6.6 Total Maximum Daily Loads and Allocations

Based on the sediment source assessment, TMDLs and load allocations will be developed for each stream segment listed as impaired due to sediment in the St. Regis River TPA. A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. A TMDL is expressed by the following equation:

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

This definition of a TMDL reflects the initial emphasis on controlling point source pollution in the history of water quality planning under the Clean Water Act of 1972. It is relatively simple to identify point sources and allocate a waste load allocation among these discrete contributors. In contrast, identifying and allocating pollution among diffuse nonpoint sources across the landscape is problematic, making strict application of this equation difficult given spatial extent of contributing sources and budgetary constraints.

The sediment TMDL process presented in the main document for the St. Regis River TPA will adhere to this TMDL loading function, but use an average annual sediment yield source assessment, a percent reduction in loading allocated among sources, and an inherent margin of safety. A percent reduction approach is used because there is uncertainty associated with the loads derived from the source assessment, and using the estimated sediment loads creates a rigid perception that the loads are absolutely conclusive. The percent reduction TMDL approach constructs a plan that can be more easily understood for restoration planning. The total maximum daily loads for sediment are stated as an overall percent reduction of the sediment load that can be achieved by the sum of each individual allocation to a source. The sediment TMDLs use a percent reduction allocation strategy based on estimates of BMP performances in the watershed. Narrative performance based allocations may be used for smaller sources. An estimate of allowed daily sediment loads and daily allocations are provided in **Appendix N**.

The sediment load allocation strategy for the St. Regis River TPA depends upon estimating the performance of reasonable restoration practices to reduce sediment loads entering streams. Sediment yield from roads are the broadest based and significant sources in the St. Regis Watershed that are easily addressed through changes in current management. Performance based allocations will focus on the efficiency of BMPs to prevent sediment loading from specific source categories. BMPs for roads and other management practices are included in **Section 8**.

Some impacts are not as easily mitigated through changes in current management, can be very costly to restore and are sometimes irreversible. Therefore, these sources of sediment will be addressed at an individual watershed scale established by best professional judgment based cost/benefit consideration to determine if restoration is reasonable according to Montana law.

6.6.1 Big Creek

6.6.1.1 Big Creek Source Assessment

Natural background sediment was estimated to be 273 tons/year. Forest roads and eroding stream banks contribute an estimated 21.1 and 45.5 tons/year respectively. The estimated annual sediment load from culvert failure is 10.8 tons/year. Modeling indicated that water yields are 3.8% above natural; however, this value is below thresholds at which excess sediment loading is thought to occur. Sediment loading from timber harvest, mass wasting, and traction sanding are all insignificant in the Big Creek Watershed. Sediment loads from forest roads were calculated prior to recently completed road decommissioning and may thus be an overestimate of current loading.

6.6.1.2 Big Creek Sediment Allocations and Total Maximum Daily Load

The total maximum daily load (TMDL) for Big Creek is expressed as an overall 10% reduction in total sediment load. Sediment from natural background sources is beyond human control and is assumed to continue at rates estimated during the source assessment.

Of the 45.5 tons/year of sediment loading from eroding banks, 10% (4.5 tons/year) was determined to result from natural causes and is thus beyond human control **(Table 6-10).** For the remaining 41 tons/year, it is assumed that a 90% reduction in loading can be accomplished through a combination of BMP implementation and active restoration/stabilization. This provides an overall reduction of 80% from bank erosion. The allocation for reducing sediment from surface erosion on forest roads is a 48% reduction. Sediment loading from potential culvert failure can be reduced by an estimated 37% by upgrading all culverts to safely pass the 100 year flood after their first failure. Inevitably, some risk of failure will always remain, and this risk is reflected in the remaining 6.8 tons/year. There is no allocation to future human caused mass wasting although negligible loads from past events may persist. The sediment contribution from upland timber harvest disturbance is currently negligible but will be provided an allocation of approximately 5% of the overall TMDL. There are no point sources of sediment in the Big Creek Watershed; therefore, no waste load allocation is necessary.

Table 6-10. Sediment Allocations and TMDL for Big Creek

Sources		Current Estimated Load (Tons/Yr)	Performance Based Allocation (Estimated Sediment Reduction in Tons/Yr)	Estimated Sediment Load After Allocation Reductions (Tons/Yr)
Anthropogenic Nonpoint Sources	Forest Roads	21.1	- 48% (10.1)	11.0
	Eroding Banks	45.5	- 80% (36.4)	9.1
	Culvert Failure	10.8	- 37% (4)	6.8
	Upland Timber Harvest	Negligible	Up to 5% of TMDL	16
Natural Background		273	Not applicable	273
Total Load		350.4	- 10% (34.5)	315.9

6.6.2 Little Joe Creek

6.6.2.1 Little Joe Creek Source Assessment

Natural background sediment was estimated to be 319 tons/year. Forest roads and eroding stream banks contribute an estimated 43.7 and 36.4 tons/year respectively. The estimated annual sediment load from culvert failure is 26.4 tons/year. Modeling indicated that water yields are 5.1% above natural; however, this value is below thresholds at which excess sediment loading is thought to occur. Sediment loading from timber harvest, mass wasting, and traction sanding are all insignificant in the Little Joe Creek Watershed.

6.6.2.2 Little Joe Creek Sediment Allocations and Total Maximum Daily Load

The total maximum daily load (TMDL) for Little Joe Creek is expressed as an overall 10% reduction in total sediment load. Sediment from natural background sources is beyond human control and is assumed to continue at rates estimated during the source assessment. Almost all of the sediment from eroding streambanks was determined to be the result of human impacts. It is assumed that a 90% reduction in loading can be accomplished through a combination of BMP implementation and active restoration/stabilization.

The allocation for reducing sediment from surface erosion on forest roads is a 48% reduction. Sediment loading from potential culvert failure can be reduced by an estimated 37% via upgrading all culverts to safely pass the 100 year flood after their initial failure. Inevitably, some risk of failure will always remain, and this risk is reflected in the remaining 16 tons/year. There is no allocation to future human caused mass wasting although negligible loads from past events may persist. The sediment contribution from upland timber harvest disturbance is currently negligible, but will be provided an allocation of approximately 5% of the overall TMDL. There are no point sources of sediment in the Little Joe Creek Watershed; therefore, no waste load allocation is necessary.

Table 6-11. Sediment Allocations and TMDL for Little Joe Creek

Sources		Current Estimated Load (Tons/Yr)	Performance Based Allocation (Sediment Reduction in Tons/Yr)	Estimated Sediment Load After Allocation Reductions (Tons/Yr)
Anthropogenic Nonpoint Sources	Forest Roads	43.7	- 48% (21.0)	22.7
	Eroding Banks	36.4	- 90% (32.8)	3.6
	Culvert Failure	26.4	- 37% (9.7)	16.7
	Upland Timber Harvest	Negligible	Up to 5% of TMDL allowed	19
Natural Background		319	Not applicable	319
Total Load		445.5	- 10% (-40.5)	381

6.6.3 North Fork Little Joe Creek

6.6.3.1 North Fork Little Joe Creek Source Assessment

Natural background sediment was estimated to be 182 tons/year. Forest roads and eroding stream banks contribute an estimated 24.9 and 20.7 tons/year respectively. The estimated annual sediment load from culvert failure is 15 tons/year. Modeling indicated that water yields are 5.1% above natural; however, this value is below thresholds at which excess sediment loading is thought to occur. Sediment loading from timber harvest, mass wasting, and traction sanding are all insignificant in the North Fork Little Joe Creek Watershed.

6.6.3.2 NF Little Joe Creek Sediment Allocations and Total Maximum Daily Load

The total maximum daily load (TMDL) for Little Joe Creek is expressed as an overall 11% reduction in total sediment load. Sediment from natural background sources is beyond human control and is assumed to continue at rates estimated during the source assessment. Load calculations in North Fork Little Joe Creek were developed based on the watershed's proportion of the greater Little Joe Watershed; no separate analysis was conducted. This approach was selected due to the relatively small size of the North Fork Watershed and its similarity to the greater Little Joe Watershed.

Almost all of the sediment from eroding streambanks was determined to be the result of human impacts. It is assumed that a 90% reduction in loading can be accomplished through a combination of BMP implementation and active restoration/stabilization. Sediment loading from potential culvert failure can be reduced by an estimated 37% by upgrading all culverts to safely pass the 100 year flood after their initial failure. Inevitably, some risk of failure will always remain, and this risk is reflected in the remaining 9.4 tons/year. The allocation for reducing sediment from surface erosion on forest roads is a 48% reduction. There is no allocation to future human caused mass wasting, although negligible loads from past events may persist. The sediment contribution from upland timber harvest disturbance is currently negligible, but will be provided an allocation of approximately 5% of the overall TMDL. There are no point sources of sediment in the North Fork Little Joe Creek Watershed; therefore, no waste load allocation is necessary.

Table 6-12. Sediment Allocations and TMDL for North Fork Little Joe Creek

Sources		Current Estimated Load (Tons/Yr)	Performance Based Allocation (Sediment Reduction in Tons/Yr)	Estimated Sediment Load After Allocation Reductions (Tons/Yr)
Anthropogenic Nonpoint Sources	Forest Roads	24.9	- 48% (12.0)	12.9
	Eroding Banks	20.7	- 90% (18.6)	2.1
	Culvert Failure	15	- 37% (5.6)	9.4
	Upland Timber Harvest	Negligible	Up to 5% of TMDL allowed	11
Natural Background		182	Not applicable	182
Total Load		242.6	- 11% (25.2)	217.4

6.6.4 Twelvemile Creek

6.6.4.1 Twelvemile Creek Source Assessment

Natural background sediment was estimated to be 312 tons/year. Forest roads and eroding stream banks contribute an estimated 74.9 and 47.8 tons/year respectively. The estimated annual sediment load from culvert failure is 26.6 tons/year, and mass wasting was estimated to contribute an additional 3.4 tons/year.

Modeling indicated that water yields are 8.1% above natural. This value exceeds the 8% threshold at which increased water yields may begin to increase sediment loading. However the exceedence is so small that water yield will not be considered a separate source of sediment for purposes of the TMDL. The water yield analysis was completed in 2001 and little to no harvest has occurred since then, so the water yield is likely at or below the target. Any current increases in sediment loading that may have resulted from increased water yield (from increased stream power) should have been captured in the load estimate from eroding stream banks. Sediment loading from timber harvest and traction sanding are insignificant in the Twelvemile Creek Watershed. Sediment loads from forest roads were calculated prior to recently completed road decommissioning and may thus be an overestimate of current loading.

6.6.4.2 Twelvemile Creek Sediment Allocations and Total Maximum Daily Load

The total maximum daily load (TMDL) for Twelvemile Creek is expressed as an overall 16% reduction in total sediment load. Sediment from natural background sources is beyond human control and is assumed to continue at rates estimated during the source assessment. The 48% reduction in sediment loading from forest roads was modeled based on the application of Best Management Practices (BMPs) that could reduce contributing road lengths to a maximum of 200 feet at each crossing (100 feet from either side).

Of the 47.8 tons/year of sediment loading from eroding banks, it is assumed that a 90% reduction in loading can be accomplished through a combination of BMP implementation and active restoration/stabilization (**Table 6-13**). Sediment loading from potential culvert failure can be reduced by an estimated 37% by upgrading all culverts to safely pass the 100 year flood. Inevitably, some risk of failure will always remain, and this risk is reflected in the remaining 23.2 tons/year.

The allocation for reducing sediment from surface erosion on forest roads is a 48% reduction. No reduction in the sediment loading from mass wasting is proposed due to the relatively low contribution from the source and the difficulty that would be associated with stabilizing the mass wasting locations. Some natural attenuation of sediment loading from these sites will likely occur over time. There is no allocation to future human caused mass wasting although negligible loads from past events may persist. The sediment contribution from upland timber harvest disturbance is currently negligible, but will be provided an allocation of approximately 5% of the overall TMDL. There are no point sources of sediment in the Twelvemile Creek Watershed; therefore, no waste load allocation is necessary.

Table 6-13. Sediment Allocations and TMDL for Twelvemile Creek

Sources		Current Estimated Load (Tons/Yr)	Performance Based Allocation (Sediment Reduction in Tons/Yr)	Estimated Sediment Load After Allocation Reductions (Tons/Yr)
Anthropogenic Nonpoint Sources	Forest Roads	74.9	-48% (35.9)	39
	Eroding Banks	47.8	-90% (43.4)	4.4
	Culvert Failure	36.6	-37% (13.4)	23.2
	Human Caused Mass Wasting	3.4	0% (0)	3.4 decreasing to zero over time with no new sources
	Upland Timber Harvest	Negligible	Up to 5% of TMDL allowed	19
Natural Background		312	Not applicable	312
Total Load		474.7	- 16% (73.7)	401

6.6.5 St. Regis River

6.6.5.1 St. Regis River Source Assessment

Natural background sediment was estimated to be 2,399 tons/year. Sediment from timber harvest was estimated at 35 tons/year. Forest roads and eroding stream banks contribute an estimated 327.5 and 518.7 tons/year respectively. The estimated annual sediment load from culvert failure is 186 tons/year, and mass wasting was estimated to contribute an additional 9.98 tons/year. Traction sanding accounts for an estimated 467 tons/year, and eroding cutslopes along Interstate 90 contribute an additional 66 tons of sediment annually. Modeling indicated that water yields are 3.6% above natural; however, this value is below thresholds at which excess sediment loading is thought to occur. Sediment loads from forest roads were calculated prior to recently completed road decommissioning and may thus be an overestimate of current loading.

6.6.5.2 St. Regis River Sediment Allocations and Total Maximum Daily Load

The total maximum daily load (TMDL) for the St. Regis River is expressed as an overall 15% reduction in total sediment load. Sediment from natural background sources is beyond human control and is assumed to continue at rates estimated during the source assessment. The 48% reduction in sediment loading from forest roads was modeled based on the application of Best Management Practices (BMPs) that could reduce contributing road lengths to a maximum of 200 feet at each crossing (100 feet from either side). Of the 518.7 tons/year of sediment loading from eroding banks, it is assumed that a 90% reduction in loading can be accomplished through a combination of BMP implementation and active restoration/stabilization (**Table 6-14**). The allocation for reducing sediment from surface erosion on forest roads is a 48% reduction. Sediment loading from potential culvert failure can be reduced by an estimated 37% by upgrading all fish bearing stream, unpaved road culverts to safely pass the 100 year flood. Inevitably, some risk of failure will always remain, and this risk is reflected in the remaining 117.8 tons/year.

No reduction in the sediment loading from mass wasting is proposed due to the relatively low contribution from the source and the difficulty that would be associated with stabilizing the mass wasting locations. Some natural attenuation of sediment loading from these sites will likely occur over time. There is no allocation to future human caused mass wasting although negligible loads from past events may persist. The sediment contribution from upland timber harvest disturbance is currently very low, but will be provided an allocation of approximately 5% of the overall TMDL.

Severe winter weather and mountainous roads in the St. Regis TPA will require the continued use of relatively large quantities of traction sand, and the close proximity of the St. Regis River to the road network will make significant reductions in loading difficult. The proposed 10% reduction is based on ongoing efforts by the Montana Department of Transportation to incorporate BMPs into their winter sanding activities. These efforts may include improved maintenance and addition of sand capture basins, and road sand recovery, and the increased use of chemical deicers as long as doing so does not crate a safety hazard or undue degradation to water quality. Additional BMPs may include improved vegetation buffers, routing flows away from streams, and the creation of sediment catching structures.

MDT will explore alternatives for stabilizing key cut/fill slopes and capturing sediment. A variety of techniques are available to improve cutslope stability; however, long-term stability typically depends on the establishment of vegetation, which will be difficult given the steep cutslopes and semiarid climate. Additional BMPs may be utilized to prevent delivery of cutslope materials to the St. Regis River. As was the case with traction sand, these may include vegetation buffers, routing flows away from streams, and the creation of sediment catching structures.

There are no permanent point sources that introduce sediment to the stream network in the in the St. Regis Watershed; therefore, no waste load allocation is zero. Recreational suction dredge permitted activities will be managed so that no new sediment is introduced into the stream network.

Table 6-14. Sediment Allocations and TMDL for St. Regis River

Sources		Current Estimated Load (Tons/Yr)	Performance Based Allocation (Sediment Reduction in Tons/Yr)	Estimated Sediment Load After Allocation Reductions (Tons/Yr)
Anthropogenic Nonpoint Sources	Forest Roads	327.5	-48% (157.2)	170.3
	Eroding Banks	518.7	-90% (466.8)	51.9
	Upland Timber Harvest	35	Up to 5% of TMDL allowed	165
	Culvert Failure	186	-37% (68.2)	117.8
	Human Caused Mass Wasting	10	0% (0)	10 decreasing to zero load over time with no new sources
	Traction Sand I90 Cutslopes	530	10% (53)	477
Point Sources	Recreational Suction Dredge Permits	0	0% (0)	0
Natural Background		2,399	Not applicable	2,399
Total Load		4,006	15% (615)	3,391

6.7 Seasonality and Margin of Safety

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

6.7.1 Seasonality

Sediment loading varies considerably with season. For example, sediment delivery increases during spring months when snowmelt delivers sediment from upland sources and resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportions of deposited fines in critical areas for fish spawning and insect growth. Because both fall and spring spawning salmonids reside in the St. Regis River TPA, streambed conditions need to support spawning through all seasons. Therefore, sediment targets are not set for a particular season and source characterization is geared toward identifying average annual loads.

6.7.2 Margin of Safety

An implicit margin of safety (MOS) is provided by conservative assumptions for sediment loading, which are designed to ensure restoration goals will be sufficient to protect beneficial uses. The margin of safety is to ensure that target reductions and allocations are sufficient to sustain conditions that will support beneficial uses. An additional margin of safety is provided through an adaptive management approach that includes adjusting future targets and water quality goals based on monitoring outlined in **Section 9**. No explicit MOS is included in sediment TMDLs specified for each water body.

6.7.3 Future Growth and New Activities

There is potential for new sediment sources from future activities within the St. Regis Watershed. Future actions in the watershed that could produce increased sediment loads or further disturb stream channel sediment transport capacity should demonstrate that associated sediment loading and fishery habitat alterations will not further degrade fish spawning and rearing in any of the watersheds with TMDLs. If the activities will increase sediment yields, a mitigation program approved by DEQ may be considered.

6.8 Restoration Approach

Restoration recommendations focus primarily on addressing sediment inputs from roads, eroding banks, and potential culvert failure. The application of BMPs to unpaved roads, particularly at crossings and when the road parallels the stream channel, will provide a reduction in sediment loads once completed. Eroding streambanks can be addressed by best management practices and active restoration techniques that ultimately allow vegetation to recover. Load reductions derived from reduced streambank erosion may take a decade to fully respond. Reductions from potential culvert can be achieved by upgrading culverts to accommodate the expected 100 year flood. See **Section 8** of this document for a more detailed restoration approach.

6.9 Adaptive Management and Monitoring Recommendations

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. Any component can be changed to improve ways of achieving and measuring success. Furthermore, the use of multiple lines of evidence (biological and physical) allow for a more robust measure of stream conditions. Because of the wide range of conditions present on listed water bodies and uncertainty regarding the connections between sediment targets and beneficial use support, monitoring of in-stream sediment targets should be part of the adaptive management plan to meet water quality goals. Effectiveness monitoring will include restoration progress tracking and also measuring sediment parameters to determine the effectiveness of restoration activities.

SECTION 7.0
TEMPERATURE

Total maximum daily loads are based on the loading of a pollutant to a water body. In the case of temperature thermal heating or loading is assessed. Federal Codes indicate that for each thermally listed water body the total maximum daily thermal load cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters. Under the current regulatory framework for development of TMDLs, flexibility has been allowed for specifying allocations since *"TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure."* The main document of this TMDL does use other measures to fulfill requirements of Section 303(d) of the Clean Water Act. Although a loading capacity for heat is also estimated (e.g. kilocal/day, kilocal/second), it is of limited value in guiding management activities needed to solve the identified nonpoint source temperature problems in the St. Regis Watershed and is therefore included in **Appendix N**. Development of surrogate allocations and an implicit margin of safety following U.S. EPA guidance (EPA, 1999) is appropriate for the main document in this case because a loading based approach would not provide additional utility and the intent of the TMDL process is achieved by using other appropriate measures because there are no point sources that affect heat in the watershed.

Modeling results provided much of the technical framework for developing a surrogate-based temperature TMDL and allocation approach (**Appendix C**). Influences to instream temperatures are not always intuitive at a watershed scale and the modeling helped estimate the relative effects that stream shading, channel geometry, and stream flow have on temperature during the hottest time of year. Field assessment data and best professional judgment from a team of professionals are also incorporated into the temperature allocation process because there are inherent uncertainties and assumptions associated with modeling results.

The surrogate based temperature TMDLs will result in thermal loading reduction necessary to obtain compliance with Montana's temperature water quality standards. The applicable standard for the temperature limited streams in the St. Regis Watershed are a 1ºF increase above naturally occurring temperatures during timeframes that are naturally below 67ºF. Modeling indicated that naturally occurring temperatures are below 67ºF. The allocation for thermal load reduction will be expressed as a surrogate measurement in this section of the main document because restoration approaches tie into this strategy. TMDLs and Instantaneous Thermal Loads (ITLs) are provided numerically (kilocal/day, kilocal/sec) in **Appendix O**. The surrogate for thermal loading is:

- The percent change in effective shade that will achieve reference potential, applied to the sources that are currently limiting shade
- Reduction in bankfull width to depth ratio of St. Regis River's channel geometry

7.1 Big Creek Temperature Allocations and Total Maximum Daily Load

Shade assessments conducted in the Big Creek Watershed identified potential reference conditions in the upper Middle and East Forks of Big Creek and in the upper mainstem. Least impacted reaches of the tributaries averaged 71% daily shade as measure by a Solar Pathfinder, while in the upper mainstem daily shade averaged 52%. These values will serve as the basis of TMDL surrogate temperature allocations in the watershed, with the tributary values applied to steep forested reaches and the mainstem values applied to higher order and/or naturally shrub dominated reaches.

Development of a temperature TMDL and allocations for Big Creek identify human activities that influence the surrogate temperature factors. The allocations indicate the relative change needed for each temperature influencing factor that, in combination, will likely achieve Montana’s temperature standards (**Table 7-1**). This conclusion is supported by modeling results that demonstrate the connection between increased stream shading and decreased in-stream temperatures. This approach allows for prioritization of restoration activities for meeting water quality standards through an adaptive approach informed by long-term monitoring. Information presented in **Table 7-1** allows for a surrogate based allocation strategy. The allocations may be refined or modified with additional data collected through an adaptive management approach (**Section 9.0**). **Appendix O** contains a numeric temperature TMDL and allocation approach.

Table 7-1. Surrogate Temperature Allocations for Big Creek

Temperature Surrogates	Location	Reference % Shade	Current Average % Shade	Allocation	Human Influences
Effective Shade (Surrogate)	Tributaries with conifer canopy	71	?	Increase average daily shade	Road encroachment Historic timber harvest
	Upper Middle Fork[1] BG01	71	62	Increase average daily shade by 9%	Historic timber harvest
	Lower Middle Fork BG02	52	18	Increase average daily shade by 34%	Road encroachment Historic timber harvest
	Upper East Fork[1] BG03	71	63	Increase average daily shade by 9%	Historic timber harvest
	Lower East Fork BG04	71	36	Increase average daily shade by 35%	Road encroachment Historic timber harvest
	Upper West Fork BG05	71	21	Increase average daily shade by 50%	Historic timber harvest Localized channel widening
	Middle West Fork BG06	71	42	Increase average daily shade by 29%	Road encroachment
	Lower West Fork BG07	52	23	Increase average daily shade by 29%	Road encroachment Historic timber harvest Localized channel widening[2]
	Upper Mainstem BG08 (1&2)	52	52	Increase average daily shade by 0%	Road encroachment Localized channel widening
	Lower Mainstem BG08 (3)	52	24	Increase average daily shade by 28%	Channel widening and bank stability impacts

1. Reference data represents least impacted portions of these reaches.
2. No surrogate allocation is provided for channel widening because modeling indicated that channel dimensions are not impacting temperatures significantly.

7.2 Twelvemile Creek Temperature Allocations and Total Maximum Daily Load

Shade assessments conducted in the Twelvemile Creek Watershed identified potential reference conditions. Least impacted headwaters reaches averaged 89% daily shade as measure by a Solar Pathfinder, middle reaches in semi confined valleys averaged 65% and had some impact from the road which considers the road as a permanent impact during the allocation process, and lower reaches near the mouth averaged 52%. These values will serve as the basis of TMDL surrogate temperature allocations in the watershed.

Development of a temperature TMDL and allocations for Twelvemile Creek identify human activities that influence the surrogate temperature factors. The allocations indicate the relative change needed for each temperature influencing factor that, in combination, will likely achieve

Montana's temperature standards (**Table 7-2**). This conclusion is supported by modeling results that demonstrate the connection between increased stream shading and decreased in-stream temperatures. This approach allows for prioritization of restoration activities for meeting water quality standards through an adaptive approach informed by long-term monitoring. Information presented in **Table 7-2** allows for a surrogate based allocation strategy. The allocations may be refined or modified with additional data collected through an adaptive management approach (**Section 9.0**). **Appendix N** contains a numeric temperature TMDL and allocation approach.

Table 7-2. Temperature Allocations for Twelvemile Creek

Temperature Surrogates	Location	Reference % Shade	Current Average % Shade	Allocation	Human Influences
Effective Shade (Surrogate)	Tributaries with Tree dominated canopy	89%	?	Increase average daily shade	Timber harvest Road encroachment Power Lines
	Headwaters TM01	89[1]	89	Increase average daily shade by 0%	Minimal impacts
	Headwaters TM 02	89	59	Increase average daily shade by 30%	Timber harvest Road encroachment
	Middle TM 03	65[1]	65	Increase average daily shade by 0%	Minimal impacts w/ limited road encroachment
	Middle TM 04	65	58	Increase average daily shade by 8%	Channelization Power Lines Recreation
	Lower TM 05	52	24	Increase average daily shade by 28%	Road encroachment Timber Harvest Housing/Lawn/ Aesthetic Clearing
	Lower TM 06	52[1]	52	Increase average daily shade by 0%	Minimal impacts

[1] Reference data represents least impacted portions of these reaches.

7.3 St. Regis River Temperature Allocations and Total Maximum Daily Load

As discussed in **Section 4.0**, a canopy coverage supplemental indicator of $\geq$60% has been selected for the St. Regis River. A width to depth ratio supplemental indicator has also been set for the St. Regis at $\leq$22 for Rosen B channel reaches and $\leq$33 for Rosgen C channel reaches. These supplemental indicator values will serve as surrogates for temperature in the allocation and TMDL for the St. Regis River.

Development of a temperature TMDL and allocations for the St. Regis River identify human activities that influence the surrogate temperature factors. The allocations indicate the relative change needed for each temperature influencing factor that, in combination, will likely achieve Montana's temperature standards (**Table 7-3**). The surrogate shade allocation to tributaries uses the average reference condition from Big and Twelvemile Creeks. This approach allows for prioritization of restoration activities for meeting water quality standards through an adaptive approach informed by long-term monitoring. Information presented in **Table 7-3** allows for a surrogate based allocation strategy. The allocations may be refined or modified with additional data collected through an adaptive management approach **(Section 9.0)**.

Table 7-3. Temperature Allocations for the St. Regis River

Temperature Surrogates	Location	Goal	Current Average	Allocation	Human Influences
Percent Shade (Surrogate)	Tributary Reaches with Potential for Conifer Canopy	≥80%	?	Increase average canopy density	Road encroachment Historic Timber harvest Housing/Lawn/Aesthetic Clearing Power Lines
	Tributary Reaches with Potential for Shrub Canopy	≥58%	?	Increase average canopy density	Road encroachment Housing and Cabin Development
Canopy Cover (Surrogate)	Mouth to Twelvemile Creek	≥60%	32	Increase average canopy density by 28%	Road Encroachment Railroad Encroachment Riprap Channelization Land clearing Power Lines
	Twelvemile Creek to Saltese	≥60%	42	Increase average canopy density by 18%	
	Upstream of Saltese	≥60%	44	Increase average canopy density by 16%	
Width/Depth Ratio	St. Regis River Below Haugan	≤30	Range of 14.7-40.1	Decrease average W/D ratio on C and F channels by 10.1	

7.4. Additional Surrogate Allocation Components for the St. Regis Watershed

Any new areas of clearing stream shade influencing vegetation within any of the temperature limited watersheds is not consistent with the TMDL allocation until surrogate allocations are met or it can be determined that the numeric TMDLs in **Appendix O** are met. A thermal trading system is also not appropriate until surrogate allocations are met or it can be determined that the numeric TMDLs in **Appendix O** are met. If activities that reduce shade in a watershed with a temperature TMDL are absolutely necessary, DEQ suggests long term shade mitigation on a 2-to-1 basis be considered until the standard and TMDLs have been met for the watershed.

7.5 Seasonality and Margin of Safety

All TMDL/Water Quality Restoration Planning documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream, and load allocations. TMDL development must also incorporate a margin safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes in detail considerations of seasonality and a margin of safety in the temperature TMDL development process.

7.5.1 Seasonality

Seasonality addresses the need to ensure year round beneficial use support. The TMDL should include a discussion of how seasonality was considered for assessing loading conditions and for developing restoration targets, TMDLs and allocation schemes, and/or the pollutant controls. Seasonality is addressed in this TMDL document as follows:

- Temperature conditions were monitored by data logging devices during a range of seasons over a number of years.
- Temperature modeling simulated heat of the summer conditions when instream temperatures are most stressful to the fishery. The fishery is the most sensitive use in regard to thermal conditions.
- Temperature targets apply year round but are most applicable to summer conditions.
- Restoration approaches will help to stabilize stream temperatures year round.

7.5.2 Margin of Safety

The margin of safety may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA, 1999). The margin of safety is addressed in several ways as part of this document:

- Montana's water quality standards are applicable to any timeframe and any season. The temperature modeling analysis investigated temperature conditions during the heat of the summer during the most likely timeframe when the temperature standards are most likely exceeded.
- Targets provide guidance on both temperature conditions in relation to state temperature standards and to surrogate measures that will influence temperatures.
- Surrogate based TMDL allocation approaches are provided in the main document. Numeric heat load TMDLs and an Instantaneous Thermal Loads are provided in **Appendix O**.
- Montana has also built an inherent margin of safety into Montana's temperature standards. In effect, Montana's standard for B1 streams incorporates a combined load allocation and wasteload allocation equal to 0.5-1°F depending on naturally occurring temperature conditions at any time of the year. This small shift in allowed temperature increase will protect all beneficial uses in the St. Regis Watershed and should equate to cooler water in the St. Regis Watershed if the three load reduction approaches provided in this document are followed.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.

7.6 Restoration Schedule

Restoration recommendations focus on increasing riparian shade. Significant time is needed for riparian vegetation re-growth. Different riparian vegetation communities will take different amounts of time to grow after riparian BMPs or appropriate riparian management have emplaced. Load reductions derived from such an approach may take a decades to fully respond because of vegetation growth timeframes. See **Section 8.0** of this document for a more detailed temperature restoration approach.

7.6.1 Monitoring Recommendations and Adaptive Management Plan

Shade monitoring for further apportioning shade impacts to specific sources may be needed to refine restoration actions in specific areas. Future monitoring and modeling may be necessary to determine restoration goals and TMDL compliance.

SECTION 8.0
RESTORATION STRATEGY

8.1 Introduction

This section presents the overall strategy to achieve water quality restoration and meet water TMDL targets and load reductions. The restoration of water quality and habitat conditions in the St. Regis TPA could be achieved through a variety of management and restoration actions, and, in general, this document provides conceptual recommendations leaving the specific details to local stakeholders. A time element for restoration activities is not included in the document because most restoration projects rely upon public funding programs, local and private funding match, local efforts to apply for funds, and landowner participation. The following are the primary basin-wide objectives of this water quality restoration project. These goals would be achieved through implementation efforts outlined in this restoration strategy:

- Ensure full recovery of aquatic life beneficial uses to all impaired and threatened streams identified by the State of Montana within the St. Regis TPA.
- Avoid conditions where additional water bodies within the St. Regis TPA become impaired.
- Work with landowners and other stakeholders in a cooperative manner to ensure implementation of water quality protection activities.
- Continue to monitor conditions in the watershed to identify any additional impairment conditions, track progress toward protecting water bodies in the watershed, and provide early warning if water quality starts to deteriorate.

8.2 Agency and Stakeholder Coordination

Achieving the targets and allocations set forth in this plan will require a coordinated effort between land management agencies and other important stakeholders, including county governments, conservations districts, private landowners, state and federal agency representatives, and individuals from conservation, recreation, and community groups with water quality interests in the St Regis River Watershed. DEQ would support a stakeholder group that could foster water quality restoration efforts that generally follow restoration recommendations of this document.

8.3 General Management Recommendations

Forest roads, road sanding, potential culvert failure, eroding streambanks, and stream shade reduction via any human activities are currently the primary human caused sources of impairment to water quality in the St. Regis Watershed. Natural sources are also significant and surpass all other source categories combined. Past management influences such as large-scale riparian clearing, highway and rail line encroachment, riprap, and other channel alterations have had a large influence on the character of the listed water bodies, but these influences are not as easily mitigated through reasonable soil, land, and water conservation practices. Where feasible, these past impacts are also addressed in restoration priorities.

General management recommendations are outlined for major sources of pollutants in the St. Regis Watershed. Best Management Practices form the foundation of the management recommendations but are only part of the restoration strategy. Recommendations may also address evaluating current use and management practices. In some cases a larger effort than implementing new BMPs may be required to address sources of impairment. In these cases BMPs are usually identified as a first effort, and an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve all beneficial uses. Monitoring will also be an important part of the restoration process. Monitoring recommendations are outlined in **Section 9.0**.

8.4 Implementation Strategies and Recommendations by Source Type/Category

8.4.1 Forest Roads

The analysis conducted as part of TMDL development indicated there are approximately 673 unpaved road crossings in the St. Regis River watershed, with 42 crossings in the Big Creek watershed, 83 crossings in the Little Joe Creek watershed, 30 crossings in the North Fork Little Joe Creek watershed, and 148 crossings in the Twelvemile Creek watershed. Total sediment loads from unpaved roads in the St. Regis TPA are estimated at 327.5 tons/year (**Appendix I**). Through the application of BMPs, it is estimated that the sediment load could be reduced by 48%. This road sediment reduction represents the estimated sediment load that would remain once all contributing road treads, cut slopes, and fill slopes were reduced to the maximum of 200 feet. The measurement of 200’ was selected as an example to illustrate the potential for sediment reduction through BMP application and is not a formal goal. Achieving this reduction in sediment loading from road may be occurring through a variety of methods at the discretion of local land managers and restoration specialists:

- A localized implementation team should prioritize sediment contributing road sections and stream crossings for upgrading and sediment load mitigation, including potential road decommissioning. Specific locations and methods of sediment reduction will be left to the judgment of local land managers. This process should be pursued as a coordinated effort so that total road sediment reductions can be tracked in a consistent manner.
- Assessments should occur for roads within watersheds that experience timber harvest or other major land management operations. The information gathered during these assessments will allow for timely feedback to land managers about the impact their activities could have on water quality and achievement of TMDL targets and allocations. This feedback mechanism is intended to keep sediment load calculations current and avoid impacts that go undetected for an extended period of time.

8.4.2 Culvert Failure on Unpaved Road Network

Analysis of sediment risk from culvert failure was completed for 119 culverts (**Appendix J**). Surveyed culverts represented approximately 20% of the stream crossings present in the St. Regis Watershed. Using the surveyed site results for certain sized flood events, the potential for existing loads from culvert failure was extrapolated to the watershed scale and normalized to an average yearly load over a century. The estimated potential annual sediment load from culvert failure across the watershed was significant.

In the TMDLs and Allocations in **Section 6**, sediment load reductions were derived by modeling the effects of upgrading culverts to safely pass the 100 year flood. As part of this restoration plan, a local implementation team could prioritize culverts for restoration. This prioritization should begin by conducting an analysis of the remaining 80% of the culverts in the TPA. 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. Another consideration for culvert upgrades will be providing fish passage. Approximately 90% of the culverts assessed in the St. Regis did not allow for proper fish passage. Fishery biologists should be involved in culvert design to consider fish passage. If funding is available, culverts should be prioritized and replaced prior to failure.

8.4.3 Traction Sanding

Severe winter weather and mountainous roads in the St. Regis TPA will require the continued use of relatively large quantities of traction sand, and the close proximity of the St. Regis River to the road network will make significant reductions in loading difficult. Nevertheless, the Montana Department of Transportation (MDT) incorporates best management practices into their sanding efforts, and these may be applied to reduce loading to streams to the extent practicable. These BMPs may vary from area to area, but in the St. Regis TPA may include the following:

- Utilize a snow blower to directionally place snow and traction sand on cut/fill slopes away from sensitive environments.
- Increase the use of chemical deicers and decrease the use of road sand, as long as doing so does not create a safety hazard or cause undue degradation to vegetation and water quality.
- Improve maintenance records to better estimate the use of road sand and chemicals, as well as to estimate the amount of sand recovered in sensitive areas.
- Continue to fund and manage MDT research projects that will identify the best designs and procedures for minimizing road sand impacts to adjacent bodies of water and incorporate those findings into additional BMPs.
- Work with county road agents to share information and state-county road BMPs
- Identify areas with poor soil cover and explore options for revegetation to promote the growth of non-invasive species.

8.4.4 Interstate 90 Cutslopes

A variety of techniques are available to improve cutslope stability; however, long-term stability typically depends on the establishment of vegetation, which will be difficult given the steep cutslopes and arid climate. Additionally, BMPs may be utilized to prevent delivery of cutslope materials to the St. Regis River. As was the case with traction sand, these may include vegetation buffers, routing flows away from streams, and the creation of sediment catching structures.

8.4.5 Stream Corridor Restoration

The TMDL planning effort identified numerous conditions along stream corridors throughout the TPA that affect sediment loading, in-stream temperatures, riparian health and function, fish habitat, and geomorphic stability. These include conditions such as eroding banks, encroachment of structures, roads and rail lines on streams and their floodplains, riparian degradation, riprap, infestation of noxious weeds, and the presence of fish passage barriers. This section provides general prescriptions to address these conditions throughout the St. Regis TPA.

Channel straightening
Stream channels have been straightened in many areas of the St. Regis Watershed for several purposes related primarily to roads. Channel straightening should be avoided in future management. Restoration approaches that remediate straightened channels, which are sediment sources, are considered on a stream-by-stream basis, but associated costs and benefits should be weighed. Any future projects that require stream channel construction or channel realignment should consider natural channel designs.

Revegetation
The revegetation of eroding streambanks, and cleared or impacted riparian and floodplain areas with native vegetation will reinforce and anchor stream banks and over bank surfaces. In general, woody riparian understory species are most effective at generating root masses that effectively resist erosion, while large trees are most desirable for large woody debris and shade. Vegetated riparian banks also act to filter and hold fine sediment during periods of high flows.

Riparian Buffers
The implementation of a riparian buffer zone to limit stream encroachment from vegetation clearing and development can facilitate the management of the stream system as a channel/floodplain corridor rather than simply as a channel environment. Riparian buffers can also facilitate the growth of overstory trees, which function as a source of large woody debris and provide shade to the channel. A local implementation team is encouraged to work with county government to develop and implement consistent policies on appropriate setbacks from streams including:

- Establishing a minimum riparian buffer from the floodplain for all habitable structures to allow for natural channel migration and avoid the need for shoreline armoring to protect structures built too close to the migrating channel.
- Providing technical assistance to county commissions and conservation districts in developing maps that delineate the riparian buffer and creating a process for landowner setback exceptions.
- Encouraging riparian BMPs for vegetation management within the riparian buffer to promote long-term riparian health and avoid erosion and sedimentation.

Riparian Grazing BMPs
This watershed currently does not have high grazing pressure, but limited grazing occurs. Streamside areas provide high quality forage for livestock, and these areas often sustain impacts in the absence of effecting management. This plan calls for implementation of grazing best management practices to restore the structure and function of riparian communities. The

implementation/restoration team or NRCS can serve as a clearing house for technical assistance and educational support to landowners wanting to avoid degradation and bank trampling. Specific BMPs may include:

- Temporary exclusions where impacts are sever enough that several years of rest is required.
- Placement of riparian areas in conservation easements for extended periods.
- Rotational grazing or cross fencing.

Non-Structural Erosion Control
Montana regulates streambed and bank disturbance with two permitting processes. One is the Natural Streambed and Land Preservation Act (310 Permit), which is required of private entities that want to undertake work that would modify the bed or immediate banks of perennial streams, and is administered by local conservation districts. The second is the Stream Protection Act (124 Permit), which applies to state and federal agencies and county and city governments and is administered by the Montana Department of Fish, Wildlife, and Parks.

In addition, federal 404 permits administered by the U.S. Army Corps of Engineers, are required for activities along navigable waters. The U.S. Fish and Wildlife Service and the Environmental Protection Agency are also involved in this process. The goal of these permit programs is to minimize adverse effects on shoreline and in-stream resources from human activities.

Installation of hardened erosion control structures can negatively affect long-term river function. Complete arrest of bank erosion eliminates the rejuvenating processes of channel migration. Although streambank erosion control structures can reduce localized sediment sourcing through bank erosion, their long-term impacts on overall channel function makes them undesirable management options. Channel migration is necessary for large woody debris recruitment that provides critical components of channel complexity and associated habitat elements such as pools, resting areas, and cover. This restoration strategy focuses on management practices that facilitate natural reinforcement of channel banks by riparian vegetation. The restoration plan encourages CDs, counties, and local planning boards to promote:

- Non-structural erosion control except to protect existing road and bridge infrastructure at risk, and even then mitigating for down stream impacts.
- Riparian buffers and revegetation of degraded areas.
- Case-by-case review of bank erosion problems and landowner education regarding non-structural erosion control solutions.

8.4.6 Other Watershed Management Issues

This section includes a discussion of issues that are not currently primary limiting factors to water quality, but are a consideration for long-term watershed management and restoration. All of the previous and following management issues are interrelated; therefore, a long-term holistic approach to watershed management will provide the most effective results.

Timber Harvest
SMZ’s generally apply to a minimum of a 50 foot corridor from each stream bank. SMZ’s include several types of restoration activities, such as road repair and culvert sizing for modest

flood flows. Forestry Best Management Practices are intended to maintain and/or slightly improve upland and streamside watershed conditions to achieve overall watershed health. Montana Forestry BMPs proscribes stream crossing culverts that meet 25 year flood flows, while Forestry BMPs are being developed for fish passage suitability for new culverts. RHCAs include 300 foot riparian buffer zones that provide shade and sediment filtering, exclude road building in riparian zones as much as possible, and routing water off of existing sediment contributing roads. Watershed RCHA practices and reasonable water quality BMPs also include appropriate culvert sizing (50 or 100 year flood flows), fish passage suitable culverts in fish bearing streams, and instream physical habitat characteristics (bank stability, instream fine sediment percentage, pool frequency, pool width/depth ratio, and large woody debris).
Montana's SMZ law and or/ RHCA and INFISH standards are not synonymous with a term used in Montana's water quality rules, "all reasonable land, soil and water conservation practices".

Beyond associated forest roads and culverts, which are addressed in sections above, timber harvest can contribute sediment and thermal heating. Currently, timber harvest is not significantly affecting sediment production in the St. Regis TPA. Future tree harvest activities must follow the State of Montana's SMZ law to assist in meeting sediment TMDLs. Tree harvest within a watershed should adhere to the sediment load allocations, staying below 5% of the TMDL. Also, increased water yield thresholds at a watershed scale have to be considered.

Historic and recent riparian tree harvest does affect stream temperature in the St. Regis Watershed. Temperature allocations should be considered during any riparian tree harvest activities. The temperature allocations usually will equate to applying a restoration or planning approach to timber harvest that does not reduce long term human caused stream shade if feasible.

Invasive Weeds
Invasive weeds are a growing concern in the St. Regis TPA and most areas of Montana. Developing an integrated weed management plan is recommended to address noxious weeds across land ownership boundaries. This can be accomplished through the establishment of a Weed Management Area (distinguishable areas based on similar geography, weed problems, climate, and human use patterns), which can provide a channel of communication among landowners and a conduit for funding sources (Duncan, 2001). NRCS and County Weed Management Specialists can provide information about weed management BMPs.

Fish Passage
Twelve culverts were assessed for their ability to allow fish passage under the interstate. Best professional judgment was used to determine if a culvert was a potential barrier to fish passage. This was based on the length and slope of the culvert and whether there was a drop at the outlet. Nine culverts were assessed on tributaries and three on the mainstem of the St. Regis River. Culverts running under Interstate 90 were assessed on Twelvemile, Twin, Savenac, and Randolph Creeks along with the St. Regis River. Frontage Road crossings over Twin Creek and Savenac Creek were also assessed, along with several other tributary crossings.

The majority of culverts associated with Interstate 90 and Frontage Road were large diameter, with low gradients and deep water in the bottom that did not appear to present any fish passage problems at low flows. Most of the surveyed culverts were corrugated metal pipes (CMP), though two concrete box culverts and a concrete arch culvert were assessed. Culverts under Interstate 90 ranged from approximately 125 to 300 feet long. These culverts may present problems at high flows due to their substantial lengths. The culvert on the St. Regis River mainstem at river station 185,000 was a fish barrier. This culvert, which was on Forest Service land, was an aging concrete arch with a three foot drop at the outlet. The culverts under Interstate 90 at river stations 178,500 and 187,000 may present fish passage barriers, especially at higher flows. The culvert transporting Randolph Creek under Interstate 90 may also be a fish passage barrier. The culvert on Silver Creek was not assessed, though it has been affirmed to be a fish passage barrier. The USFS has also assessed fish passage for many of their culvert crossings and has an inventory of culverts that are likely barriers to fish. 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.

Fish passage barrier restoration strategies include:

- Locate and perform fish passage assessments on additional road crossings over stream segments where maintaining fish passage if a priority.
- Develop a priority list of barrier culverts for replacement.
- Conduct culvert replacement in consultation with LNF and FWP biologist to ensure protection of native trout genetics.

8.5 Other Restoration Considerations

- MDT should partner in restoration projects within the watershed to mitigate for irretrievable transportation impacts on the St. Regis River.
- The fishery in lower 12 mile creek could benefit if the stream was restored back into its old channel in a portion of the stream that was moved due to road installation. Sediment sources would be mitigated along with fishery habitat because most of the identified eroding banks and mass wasting sources in the Twelvemile Creek Watershed are in the section of the stream that was historically moved.
- The Little Joe road upgrade, if it occurs, should not further impact Little Joe Creek's channel constriction. Appropriate BMPs including catchments basins and other sediment trapping BMPs for road sanding should be considered during design and use if the Little Joe road is paved. An existing/future sediment yield analysis should occur prior to construction to determine if paving the road will increase sediment yields. If the sediment yield is increased a DEQ approved watershed mitigation strategy (ie. addressing other current sediment sources for reduction) should be included in the construction plan.
- Legacy management practices have contributed to temperature impairments along the St. Regis River. One of the primary components of this impairment is loss of effective shade. In order to achieve success in the watershed, careful considerations in regard to future management are needed. Therefore, this document recommends consultation with DEQ when SMZ waivers decisions are being addressed to ensure beneficial uses are not adversely affected and the overall goals of this TMDL are met.
- Future home/cabin site development should consider building locations that will not confine stream channel movement, consider leaving shade producing vegetation along stream corridors, and if stream crossings are needed – design culverts/bridges to handle

flows consistent with the culvert failure allocations. A county planning or zoning and a local landowner outreach program could be an effective tool to address private land sediment and temperature impacts.

8.6 Lolo National Forest Restoration Projects

The Lolo National Forest has completed numerous restoration projects in the St. Regis River Watershed during the course of TMDL development in the area. The projects have included both fisheries enhancement and sediment load reductions, particularly through road decommissioning and culvert removal. Among the 303d-listed streams in the watershed, Twelvemile and Big Creeks in particular have been the subject of several large scale road decommissioning projects. Road sediment loading calculation made in this TMDL document do not reflect the improvements made by the Lolo National Forest, and thus sediment loading estimates probably overestimate the actual current loading from forest roads, and much of the restoration required to meet TMDL loading goals and water quality targets may have already been accomplished. A summary of restoration projects that have been completed recently by the Lolo National Forest is presented in Table 8-1.

Table 8-1. Recent Restoration efforts by Lolo National Forest in the St. Regis Watershed

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Sunset Mine Reclamation Project	In 1991, a bond was obtained to reclaim the Sunset Placer Mine in Sunset Creek, a tributary to South Fork Little Joe Creek. This reclamation would reinforce a weak bank, recontouring of settling ponds, shape and stabilize steep banks, plant alder cuttings, etc. to promote stabilization and growth in the area.	1991	Sunset Creek (South Fork Little Joe Creek)	500 feet streambank stabilization 2 acres placer mine reclamation
Hendrickson Timber Sale	In 1997, the Superior Ranger District awarded the Hendrickson Timber Sale. The objective of this project was to harvest timber in the Little Joe Creek watershed. As part of the contract, roads #18557 and #4206 would receive level 2 decommissioning.	1997	Little Joe Creek	5.08 miles level 2 decommissioning

Table 8-1. Recent Restoration efforts by Lolo National Forest in the St. Regis Watershed

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Reset Timber Sale	In September of 1997, the Superior Ranger District awarded the Reset Timber Sale. This timber sale would harvest timber in the Two Mile and Little Joe Creek watershed. Five roads under the timber sale contract received scarification and erosion control seeding, which constitutes level 2 closures.	1997	Little Joe Creek Two Mile Creek	2.31 miles level 2 decommissioning
Hiawatha Trail Stabilization	Approximately 5 rock weirs and rootwads will be used to stabilize a 200 foot long, 100 foot high eroding slope that is actively being cut by the St. Regis River into the Hiawatha Trail. Willows will also be planted to aid in bank stabilization. The slope will also be hydro-seeded to ensure revegetation.	1998	St. Regis River	50 feet streambank stabilization 100 feet rootwad, log or boulder placement 5 weirs
Savenac Creek Stream Restoration Project	The objective of this project was to complete a full stream re-creation around an old mining dam in Savenac Creek. Approximately 550 feet of stream was rerouted and habitat structures were placed in-stream.	1998	Savenac Creek	550 feet stream channel relocation 550 feet rootwad, log or boulder placement
Tujo II Helo Timber Sale	In 1998, the Lolo National Forest, Superior Ranger District awarded the Tujo II Helo Timber Sale. This sale would salvage timber within the Little Joe Creek watershed. As part of the contract, road #16436 would receive level 2 decommissioning.	1998	Two Mile Creek Little Joe Creek	2.57 miles level 2 decommissioning
Ward Creek Flume Removal Project	A watershed monitoring flume was placed in Ward Creek in the early 1960's and is no longer in use. This project proposes to remove the flume from the stream. The removal of this flume allowed for fluvial fish passage approximately 3.0 miles upstream, which has been inaccessible since installation.	1998	Ward Creek	1 fish passage barrier removal 100 feet rootwad, log or boulder placement

Table 8-1. Recent Restoration efforts by Lolo National Forest in the St. Regis Watershed

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
2 Joe Road Obliteration Project	One of the objectives of the 2 Joe Road Obliteration Project was to conduct level 3 and 4 road decommissioning on approximately 3 miles of road in the Little Joe and Twomile Creek drainages.	1999	Twomile Creek Little Joe Creek	1.21 miles level 3 decommissioning 1.89 miles level 4 decommissioning 1 culvert removal (0.0 miles accessed)
Tarbox Mine Reclamation Project	The objective of the Tarbox Mine Reclamation Project was to reclaim a large area disturbed from past mining by removing much of the waste rock from the area and replacing with topsoil to promote vegetation growth in the area. There were also two stream restoration points associated with this project that will be tracked in this project.	2002	Packer Creek	748 feet stream channel stabilization 2000 feet mine tailing stabilization
Powerswitch Salvage Timber Sale	The objective of this project was to harvest dead and dying timber from a result of mountain pine beetle epidemic in the area. This sale also incorporated the replacement of several fish passage culverts within the project area. One road also received level 3 decommissioning.	2003	Rock Creek	3 culvert replacements (9.62 miles of upstream usable habitat accessed)
Knox Brooks Stewardship Project	This timber stewardship project will harvest up to 2500 acres to remediate the pressures of mountain pine beetle in the area, reconstruct approximately 40 miles of road and decommissioning of approximately 50 miles of road (along with the successive removal of culverts on these roads). Resources enhancement projects designed to enhance riparian and stream channel conditions will also take place.	2004-2005	Twelvemile Creek Rock Creek	39 culvert removals (11.55 miles upstream habitat opened) 7 culvert replacements (29.99 miles upstream habitat opened) 9.67 miles level 3 decommissioning 39.67 miles level 4 decommissioning 0.296 miles level 5 decommissioning

Table 8-1. Recent Restoration efforts by Lolo National Forest in the St. Regis Watershed

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Middle Fork Big Creek Culvert Removal	The objective of this project was to remove and undersized culvert on the Middle Fork Big Creek on a previously closed road.	2004	Middle Fork Big Creek	1 culvert removal (4.55 miles upstream habitat opened)
West Fork Packer Timber Sale	The objective of this project was to salvage dead and dying trees in the Packer Creek watershed. As part of this project, two roads in the area received level 3 decommissioning, including culvert removals.	2005-2006	Packer Creek	1.66 miles level 3 decommissioning 1 culvert removal (0.77 miles upstream habitat opened)
Big Creek Stream Restoration Project	The objective of this project was to remove several fish passage barriers along Trail 706, along with other culverts that were not fish passage barriers, but were undersized, complete necessary stream restoration work at these sites and at other sites where erosion was occuring, decommission road #18642, change the travel plan designation on Trail 706 from motorized to non-motorized, and exchange easements with Stimson Timber Company.	2005	West Fork Big Creek	8 culvert removals (7.0 miles of upstream habitat opened) 6 streambank stabilization sites 2.38 miles of level 3 decommissioning
Rainy Creek Culvert Replacement	The objective of this project was to replace an undersized culvert that was a fish passage barrier with a culvert that would accomodate passage and high flows. The Idaho Panhandle NF completed this project to haul timber on this road.	2005	Rainy Creek	1 culvert replacement (1.14 miles upstream habitat accessed)

SECTION 9.0
MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

9.1 Introduction

This section provides a monitoring strategy to strengthen the TMDLs presented in this report and to help meet the following objectives:

- Document progress of future implementation and restoration efforts.
- Monitor progress toward meeting water quality targets and supplemental indicators.
- Improve our understanding of appropriate reference conditions for the St. Regis TPA.
- Conduct an adaptive management strategy to fulfill requirements of the TMDLs.

This monitoring plan will evaluate the progress toward meeting or protecting water quality standards and associated beneficial uses (Montana State Law (75-5-703(7) and (9)). The monitoring will also address the tracking of specific implementation efforts. Funding for future monitoring is uncertain and variable due to economic and political change. Prioritization of monitoring activities depends on stakeholder priorities for restoration activities, future land use activities, and funding opportunities.

9.2 Implementation and Restoration monitoring

As defined by Montana State Law (75-5-703(9)), DEQ is required to evaluate progress toward meeting TMDL goals and satisfying water quality standards associated beneficial use support. If this evaluation demonstrates that water quality standards and beneficial use support have not been achieved, then DEQ is required to conduct a formal evaluation of progress in restoring water quality and the status of reasonable land, soil, and water conservations practice implementation to determine if:

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

Although DEQ is responsible for TMDL-related monitoring, it is envisioned that much of it could occur under coordination with land managers and local interests. Implementation and restoration monitoring may include summaries of such items as the length of road upgraded to BMP standards, length of decommissioned roads, fish passage barriers corrected, or tracking riparian shade disturbances, as well as the estimated impact of these actions in terms of decreased pollutant loading or improved habitat. Specific details of the implementation and restoration monitoring will be coordinated with local stakeholders and DEQ before future restoration activities occur. To ensure that TMDL implementation is effective in achieving full support of beneficial uses, this monitoring should be closely tied to target and indicator trend monitoring which is discussed in more detail below.

9.3 Monitoring Progress Towards Meeting Targets and Supplemental Indicators

Implementation of the restoration strategy and the continued and refined application of reasonable land, soil, and water conservation practices are expected to decrease pollutant loading to streams in the St. Regis TPA. Implementation ensures that TMDL targets and Montana water quality standards are met over time, eventually resulting in full support of beneficial uses. The monitoring described in this section is intended to track progress in meeting those goals, thus it is closely linked to the implementation and restoration monitoring described previously.

Fine sediment and RSI Targets
Annual monitoring of trends in surface fines and riffle stability indices should occur after significant restoration efforts are implemented throughout the listed watersheds. Information generated from this monitoring will be used in future evaluation of TMDL target attainment. Particle size distributions will be assessed using McNeil core samples, spawning area grid tosses, and Wolman pebble counts. DEQ will work with all stakeholders on monitoring methods and protocols as necessary. Information generated from this monitoring will be used in future evaluation of TMDL target attainment.

Pools/mile, LWD/mile, Sinuosity, PFC, and Width/Depth Ratios
These target and supplemental indicators measures will be monitored at after significant restoration efforts are implemented at established monitoring locations in each of the listed streams.

Macroinvertebrate and Other Biological Data
Macroinvertebrate samples will be collected after significant restoration efforts are implemented as a measure of aquatic life beneficial use support. As funding permits, periphyton samples will also be collected as an additional measure of biological use support. DEQ will also coordinate with FWP and the Lolo National Forest to continue long-term fish population monitoring, to document trends in juvenile bull trout and westslope cutthroat trout populations as well as numbers of spawning redds.

Anthropogenic Sediment Sources
The reduction of all preventable and significant anthropogenic sediment sources is a primary goal of this document. Accordingly, the TMDL implementation team will conduct 5-year inventories of these sources and will track progress towards meeting this goal.

Temperature
Continuously recording temperature monitoring devises provide and simple and cost effective way to gather a large quantity of temperature data, and they have already been used by DEQ, LNF, and other organizations to established a significant temperature monitoring network in the St. Regis TPA. A limited temperature monitoring network should be maintained annually. After significant changes in stream canopy via restorative management, a more robust network should assess conditions over a one year timeframe.

9.4 Reference Monitoring

Continued monitoring of the target/indicator parameters in reference streams is needed to help increase confidence that the TMDL targets and supplemental indicator values best represent the narrative water quality standards.

DEQ uses the reference condition for parameters that have a continuously progressing negative impact to uses to determine if narrative water quality standards are being achieved. 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.

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 and represent the potential conditions that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that pre-settlement water quality conditions usually are not attainable.

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

9.5 Adaptive Management Strategy

As monitoring data is obtained and evaluated, DEQ in partnership with the stakeholders will adjust load allocations as necessary to meet targets, especially those targets associated with in-stream conditions. Additionally, targets could also be adjusted. These adjustments would take into account new information as it arises.

The adaptive management strategy 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 condition 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.
- Impairment Status: As restoration activities are conducted in the St. Regis TPA and target and supplemental indicator variables move towards reference conditions, the impairment status of the listed waterbodies would be expected to change. An assessment of the impairment status will occur after significant restoration occurs in the watershed.

SECTION 10.0
PUBLIC PARTICIPATION AND INVOLVEMENT

Public and stakeholder involvement is a component of water quality restoration planning and TMDL development. This involvement is supported by U.S. EPA guidelines, the Federal Clean Water Act, and Montana State Law. Public and stakeholder involvement is desirable to ensure development of high quality, feasible plans and to increase public acceptance. Stakeholders including the Mineral County Conservation District; the Lolo National Forest; Montana Fish, Wildlife and Parks; Montana Department of Transportation; and Montana Department of Natural Resources and Conservation have been involved with technical support, interim product reviews, and public outreach components of the plan. Also, this group of stakeholders was given the opportunity to comment on portions of the draft document.

An important opportunity for public involvement was the 30-day public comment period. This public review period was initiated on October 1, 2007 and extended to November 5, 2007. A public meeting on October 16, 2007 in Superior, Montana, provided an overview of the TMDLs for the St. Regis River Watershed and an opportunity to solicit public input and comments on the plan. This meeting and the opportunity to provide public comment on the draft document were advertised via a press release by DEQ and was included in a number of local newspapers. Copies of the main document were available at the St. Regis and Superior City Libraries, the Montana State Library, and via the internet on DEQ's web page or via direct communication with the DEQ project manager.

Through the public comment process, significant comment was received by a number of different individuals, groups, agencies, or other entities. **Appendix P** includes a summary of the public comments received and DEQ's response to these comments. As noted in the introduction of **Appendix P**, many of the comments led to significant modifications captured within the final version of the this plan. The original comment letters are located in the project files at DEQ and may be reviewed upon request.

DEQ also provides an opportunity for public comment during the biennial review of the Montana's Integrated Water Quality Report that includes the 303(d) List. This includes public meetings and opportunities to submit comments either electronically or through traditional mail. DEQ announces the public comment opportunities through several media including press releases and the Internet.

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APPENDIX A
MCNEIL CORE ANALYSIS FOR THE ST. REGIS RIVER SEDIMENT TMDL

Prepared by Land and Water Consulting, Inc.

Introduction

Potential fine sediment impairment (siltation) within the St. Regis River mainstem and selected tributaries was evaluated by analyzing the distribution of streambed particle sizes. Streambed samples indicate the amount of fine sediment in the St. Regis River and several tributaries. This analysis attempts to evaluate potential impairment conditions by measuring both reference streams and streams that are potentially impaired. This analysis will provide baseline data for the development of a sediment TMDL for the St. Regis River while also providing a foundation for future monitoring.

Methods

In-stream Measurements using a McNeil Core Sampler
A McNeil core sampler was used to collect streambed samples and the percentage of fine sediment was determined. McNeil core samples were taken at six sites in the upper St. Regis River and at seven sites in tributaries (**Figure 2-17**). Tributaries sampled include the South Fork Little Joe Creek, North Fork Little Joe Creek, Ward Creek, Twelvemile Creek, Deer Creek, and Savenac Creek. In addition, a sample was collected on the West Fork Big Creek, though at the time of collection, the site was thought to be on Big Creek, which was the intended stream. Potential reference sites included Ward, Deer, and Savenac Creeks, which are described on the 2004 303(d) List as fully supporting their beneficial uses. A site on the South Fork Little Joe Creek was also chosen as a potential reference site due to observed bull trout redds by Lolo National Forest fisheries biologists. In addition, samples were collected from gravel bars at three sites in the middle and lower St. Regis River that are thought to be aggrading. Overall, 16 sites were sampled. The McNeil core sampler was used at 13 sites, and a small shovel was used at the three gravel bar sites. Four replicate samples were collected at each location for a total of 64 samples. All samples were collected in the early October 2003, and the sample sites were documented with GPS.

McNeil core samples were collected in pool tail-outs by embedding the 6-inch diameter base of the McNeil core sampler to a depth of 4 inches into the streambed. Material was then removed from the core until the jagged teeth at the base of the sampler were encountered (Shepard and Graham 1983). Particles larger than 64 mm along the intermediate axis were discarded so that the presence of a few large particles did not affect the percent fines (Church et al. 1987). Suspended sediment inside the corer was sampled with an Imhoff cone and allowed to settle for 20 minutes (Bunte and Abt 2001). Grid tosses were also performed at each of the McNeil core sample sites. A grid with 49 intersections was used for the grid toss and all particles smaller than the 6 mm intersections were counted.

A small shovel was used to sample the dry bed on gravel bars at sites that were thought to be aggrading. The same volume was collected in bar samples as in core samples. Samples were conducted by tossing a 6-inch metal hoop onto the gravel bar and excavating material to a depth of 4 inches. Gravel bar samples were conducted near the downstream end of the bar half way between the bankfull stage and the thalweg (Rosgen 1996).

Samples were dried and sieved in the laboratory using 50, 25, 12.5, 9.5, 6.3, 4.75, 2.36, 0.85, and 0.075 mm sieves. However, nothing was retained in the 9.5 mm portion of any sample and thus this category was removed from the final results. Material was dried in the laboratory and sieved for 20 minutes. Material from each sieve (including the pan) was weighed individually, and the percent of the total sample was determined. Imhoff cone measurements were added to the pan weight. Samples were assessed for the percent of fine sediment, which is computed as the cumulative percent finer than a specified particle size (Bunte and Abt 2001). For this analysis, the percent of material finer than 6.3 mm, 2.36 mm, and 0.85 mm was calculated.

Results and Discussion

St. Regis Mainstem McNeil Core Samples

Mainstem McNeil core samples were collected in a variety of channel conditions ranging from highly channelized to completely unconfined. McNeil core samples were collected in Reaches 4, 7, 8, and 9 of the St. Regis River (**Table A-1**). Two samples were collected in Reaches 8 and 9 since these reaches are most likely to provide suitable spawning habitat. The Reach 9 sample was collected upstream of Interstate 90 and represents least impacted conditions along the mainstem of the St. Regis River. McNeil core samples averaged 6.6 pounds for each individual core and 26.39 pounds per sample site. The percent retained in each of the four core samples was averaged for each site and are presented as an overall site value in **Figure A-1**, while individual results for each core are presented at the end of this report. The GPS and river station location for sample sites are also listed at the end of this report.

Table A-1. Location, Rational, and Description of St. Regis River Mainstem McNeil Core Sample Sites

Sample Site	Location	Rational	Description
9	Just downstream of the upstream-most St. Regis River crossing	Potential indicator of least impacted conditions	Small channel with small woody debris
9B	Downstream of I-90 mile marker 2.5	Potentially loaded by traction sand due to I-90 proximity	Excessive fine sediment deposited in all slow flow areas
8	Just downstream of Hanakar Creek confluence	Potential spawning area	Active large woody debris forming pools
8B	Downstream of the Rest Area, along Hanakar Creek Rd	Potentially loaded by traction sand due to I-90 proximity	Boulder formed pools, partially associated with riprap
7	Upstream of Saltese Exit	Potentially loaded by traction sand due to I-90 proximity	Fine sediment almost totally absent, pools associated with riprap
4	A relatively undisturbed portion of river downstream of DeBorgia	Attempt to quantify accumulation of fine sediment in low gradient reaches	Large, meandering channel with wood aggregates

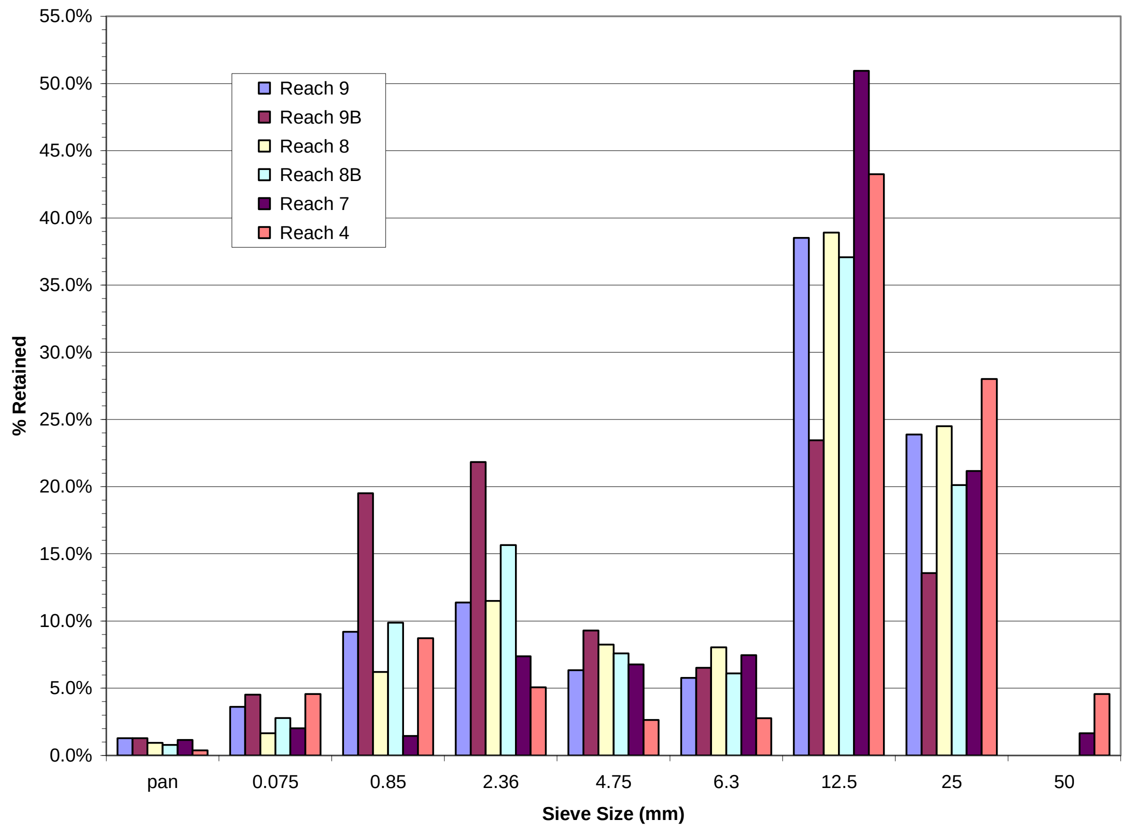

Figure A-1. Mean Percent Retained in Each Sieve Size for McNeil Core Samples along the Mainstem of the St. Regis River

McNeil core samples along the mainstem of the St. Regis River indicate areas of fine sediment accumulation. In reach 9B, 56.9% of the sample is finer than 6.3 mm as compared to 31.8% finer than 6.3 mm in the “least impacted” conditions in the Reach 9 core sample (**Table A-2**). The Reach 8 core sample, which is approximately 0.5 miles downstream of the Reach 9B core sample, has a much lower percent of fine sediment, with 28.1% finer than 6.3 mm. High percent fines are again apparent in the Reach 8B core sample, in which 37.3% of the sample is finer than 6.3 mm. The Reach 7 core samples taken in the channelized section of river upstream of Saltese have a low percent of fine sediment, with 19.2% finer than 6.3 mm. A low percent of surface fines in this reach is likely related to the highly confined channel. The percent of fine sediment in Reach 4 is also relatively low, with 20.5% finer than 6.3 mm. However, the Reach 4 sample was taken in braided channel conditions unlike any of the upstream samples. This site is more comparable to sites in which gravel bar samples were performed.

Table A-2. Mean Percent Finer than 6.3, 2.36, and 0.85 mm in Mainstem McNeil Core Samples

Sample Reach	% Finer than 6.3 mm	% Finer than 2.36 mm	% Finer than 0.85 mm
9	31.8%	14.0%	4.9%
9B	56.9%	26.8%	5.8%
8	28.1%	8.9%	2.4%
8B	37.3%	13.5%	3.7%
7	19.2%	4.9%	3.3%
4	20.5%	13.0%	4.7%

Results presented as the mean of 4 replicate samples.

St. Regis River Mainstem Gravel Bar Samples

Gravel bars were sampled at three sites along the St. Regis River that are thought to be aggrading (**Table A-3**). The gravel bar sample site in Reach 5 coincides with the Reach 5 physical survey site, which is located upstream of the Big Creek Road bridge outside of Haugan. Gravel bar samples in Reach 1 were conducted upstream of the Little Joe Creek bridge (Sample 1) and at the confluence with the Clark Fork River (Sample CF). Individual results for each gravel bar sample are presented at the end of this report.

Table A-3. Location, Rational, and Description of St. Regis River Mainstem Gravel Bar Sample Sites

Sample Site	Location	Rational	Description
5	Wide aggraded area upstream of the Big Creek Rd bridge	Attempt to quantify accumulation of fine sediment in low gradient reaches	Braided channel with extensive gravel bars
1	Upstream of Little Joe Creek	Attempt to quantify accumulation of fine sediment in low gradient reaches	Meandering channel with side channels containing fine sediment
CF	Just upstream of the confluence with the Clark Fork River	Attempt to quantify accumulation of fine sediment in low gradient reaches	Wide channel with mid-stream gravel deposits

The shovel method of collection employed on gravel bars varied from the technique used for McNeil core samples, though an attempt was made to collect the same size sample. Gravel bars samples averaged 4.9 pounds for each individual core and 19.43 pounds per sample site. The Reach 5 sample site has the greatest percent of fine sediment out of the three gravel bar sample sites, with 34.7% finer than 6.3 mm (**Table A-4**). This area may be one of the first places where fine sediment transported through channelized reaches upstream is deposited. All of the gravel bar samples contain a higher percentage of sediment finer than 0.85 mm when compared to any of the McNeil core samples, while the percent of sediment finer than 2.36 mm is also elevated compared to the mainstem core samples with similar percents finer that 6.3 mm.

Table A-4. Mean Percent Finer than 6.3, 2.36, and 0.85 mm in Mainstem Gravel Bar Samples

Sample Reach	% Finer than 6.3 mm	% Finer than 2.36 mm	% Finer than 0.85 mm
5	34.7%	21.2%	8.2%
1	18.2%	11.5%	6.1%
CF	27.2%	14.4%	7.4%

Results presented as the mean of 4 replicate samples.

St. Regis River McNeil Core Samples in Tributaries

McNeil core samples were collected in several tributaries of the St. Regis River that are either on the 303(d) List or are thought to be important salmonid spawning habitat (**Table A-5**). The listed tributaries for siltation (sediment) impairment in the St. Regis basin are Little Joe Creek, North Fork Little Joe Creek, Twelvemile Creek, and Big Creek. The South Fork Little Joe Creek, Ward Creek, Deer Creek, and Savenac Creek were sampled as potential reference conditions. The percent retained in the individual core samples was averaged for each site and is presented as an overall site value in **Figure A-2**, while individual results for each core are presented at the end of this report.

Table A-5. Location, Rational, and Description of Tributary Core Sample Sites

Sample Site	Location	Rational	Description
South Fork Little Joe Creek	8 miles upstream of the confluence with the NF of Little Joe Creek	Bull trout spawning redds documented	Pools formed by large woody debris, bull trout redds observed
North Fork Little Joe Creek	0.5 miles upstream of the confluence with the SF of Little Joe Creek	Bull trout spawning redds documented	Pools formed by large woody debris, bull trout redds observed
Ward Creek	Just upstream of the confluence with the St. Regis River	Stream gradient indicated a potential for spawning gravels	Pools formed by large woody debris and boulders
Twelvemile Creek	Just downstream of the old mill	Stream gradient indicated a potential for spawning gravels	Pools formed by small woody debris
Deer Creek	Approximately 1 mile upstream of the confluence with the St. Regis River	Stream gradient indicated a potential for spawning gravels	Pools formed by large woody debris and gravel bars
Savenac Creek	Approximately 2 miles upstream of the confluence with the St. Regis River	Stream gradient indicated a potential for spawning gravels	Generally lacked deposits of fine sediment, lateral scour pool sampled
West Fork Big Creek	Upstream of confluence with East Fork Big Creek, which marks the start of Big Creek	Stream gradient indicated a potential for spawning gravels	Pools associated with gravel bars

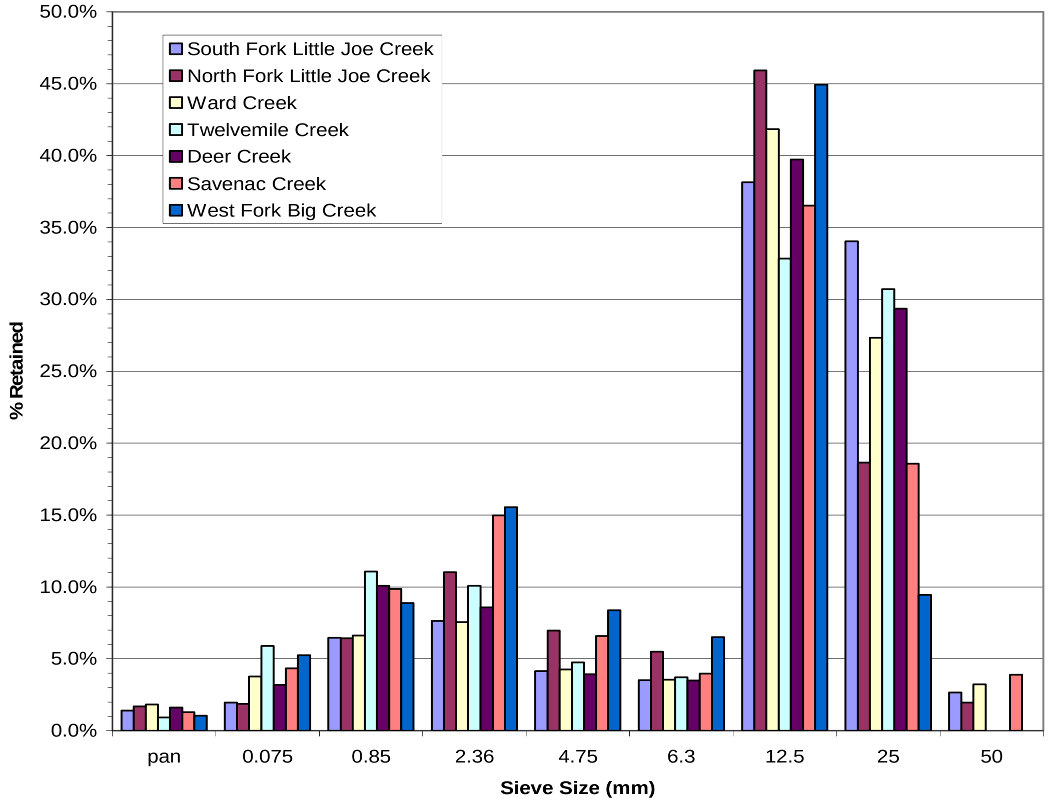

Figure A-2. Mean Percent Retained by Each Sieve Size for McNeil Core Samples Taken in Tributaries of the St. Regis River

McNeil core samples in the South Fork of Little Joe Creek and the North Fork of Little Joe Creek were collected in areas with observed bull trout spawning redds. McNeil core samples indicate that the South Fork of Little Joe Creek has the lowest percent of sediment finer than 6.3 mm (21.6%) and 2.36 mm (9.7%) of any St. Regis River tributary (**Table A-6**). The North Fork of Little Joe Creek has 27.6% finer than 6.3 mm and 9.5% finer than 2.36 mm. Ward Creek has 24.8% finer than 6.3 mm, Twelvemile Creek has 32.6% finer than 6.3 mm, Deer Creek has 27.8% finer than 6.3 mm, Savenac Creek has 36.8% finer than 6.3 mm, and West Fork Big Creek has 38.6% finer than 6.3 mm. Thus, Twelvemile Creek, Savenac Creek, and West Fork Big Creek have the highest percent of fine sediment. However, the Savenac Creek sample was performed in the only deposition of fine sediments identified in an extensive reach and these results may not apply to the creek as a whole.

Table A-6. Mean Percent Finer than 6.3, 2.36, and 0.85 mm in St. Regis River Tributary McNeil Core Samples

Tributary	% Finer than 6.3 mm	% Finer than 2.36 mm	% Finer than 0.85 mm
South Fork Little Joe Creek	21.6%	9.7%	3.4%
North Fork Little Joe Creek	27.6%	9.5%	3.4%
Ward Creek	24.8%	12.9%	6.0%
Twelvemile Creek	32.6%	20.3%	6.8%
Deer Creek	27.8%	15.0%	4.1%
Savenac Creek	36.8%	15.4%	5.6%
West Fork Big Creek	38.6%	14.7%	6.0%

Results presented as the mean of 4 replicate samples.

Relationship between McNeil Core Results and Grid-toss Results

The percent surface fines less than 6mm was assessed at each McNeil core sample site using a 49-point grid. In the St. Regis River, percent surface fines data collected using the grid-toss appear to be somewhat correlated with data collected using the McNeil core sampler, which assesses both surface and subsurface fines. Exceptions include Deer Creek, which had a fairly low McNeil core value, but the second highest grid-toss value, while Twelvemile Creek had one of the higher McNeil core values and a fairly low grid-toss value. Excluding these two sites, the other McNeil core samples sites with results <28% finer than 6.3mm are associated with grid-toss values of <8% finer than 6mm.

Table A-7. McNeil Core Results Presented from Lowest to Highest with Associated Grid-toss Result

Sample Reach/Tributary	McNeil Core % Finer than 6.3 mm	Grid-toss % Finer than 6mm
7	19.2%	6.8%
4	20.5%	4.6%
South Fork Little Joe Creek	21.6%	2.4%
Ward Creek	24.8%	3.6%
North Fork Little Joe Creek	27.6%	7.7%
Deer Creek	27.8%	22.4%
8	28.1%	10.5%
9	31.8%	15.3%
Twelvemile Creek	32.6%	7.8%
Savenac Creek	36.8%	13.6%
8B	37.3%	17.9%
West Fork Big Creek	38.6%	11.4%
9B	56.9%	45.9%

McNeil core results presented as the mean of 4 replicate samples. Grid-toss results presented as the mean of four grid-toss values collected in association with the four McNeil cores. Each grid-toss value was derived as the mean of three grid-tosses.

Conclusion

McNeil core samples in the mainstem of the St. Regis River and seven tributaries vary in the amount of fine sediment. McNeil core samples indicate excessive fine sediment accumulation downstream of the 0.6 mile stretch of river in which Interstate 90 is within 20 feet of the channel. The 2.0 mile stretch of river upstream of Saltese, in which the interstate is within 50 feet of the stream channel, has very little fine sediment accumulation due to a high transport capacity within this channelized reach. Overall, channelized reaches along the St. Regis River that have high transport capacities appear to easily transport the sediment load, which may then accumulate in unconfined reaches with lower gradients. Gravel bar samples suggest that the finer portion of the sediment load may accumulate in low gradient reaches. Thus, the road proximity and the degree of channel confinement appear to have a significant impact on sediment input and sediment transport in the St. Regis River.

Tributary samples collected in observed bull trout spawning gravels in the South and North Forks of Little Joe Creek average 21.6% and 27.6% finer that 6.3 mm, respectively. These values provide a basis for setting water quality targets in the development of a TMDL for the St. Regis watershed.

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ATTACHMENT 1 FOR APPENDIX A: RAW MCNEAL CORE DATA

Table A1-1. Percent Retained in Each Sieve Size for McNeil Core Samples and Gravel Bar Samples in the St. Regis Watershed

	R9-1	R9-2	R9-3	R9-4	R9B-1	R9B-2	R9B-3	R9B-4	R8-1	R8-2	R8-3	R8-4
Pan	2.2%	0.8%	1.2%	0.8%	1.3%	1.7%	0.6%	1.4%	1.6%	0.9%	0.3%	0.8%
0.074	4.1%	8.1%	2.4%	0.1%	2.3%	2.5%	6.1%	7.2%	2.8%	2.1%	0.5%	0.8%
0.85	12.8%	13.9%	7.2%	2.5%	23.7%	19.5%	19.8%	16.3%	7.0%	12.2%	2.6%	1.6%
2.38	10.2%	8.9%	12.6%	13.9%	30.1%	22.8%	18.8%	17.3%	14.6%	12.8%	11.9%	6.7%
4.76	4.7%	4.1%	7.2%	9.6%	7.1%	10.0%	7.8%	11.3%	10.8%	4.7%	8.7%	9.0%
6.3	4.9%	3.6%	7.2%	7.2%	4.7%	5.7%	4.9%	10.1%	9.6%	3.0%	9.9%	10.5%
12.7	31.1%	29.3%	46.7%	45.8%	24.0%	15.5%	23.4%	32.5%	40.3%	16.9%	43.7%	57.2%
25.4	30.1%	31.4%	15.6%	20.2%	6.9%	22.3%	18.5%	4.0%	13.4%	47.3%	22.5%	13.5%
50.8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	R8B-1	R8B-2	R8B-3	R8B-4	R7-1	R7-2	R7-3	R7-4	R4-1	R4-2	R4-3	R4-4
Pan	0.6%	0.5%	0.8%	1.3%	1.2%	0.6%	1.1%	1.9%	0.5%	0.4%	0.2%	0.3%
0.074	0.2%	2.8%	2.8%	5.5%	7.5%	0.2%	0.5%	0.2%	10.4%	5.9%	0.0%	0.9%
0.85	3.9%	14.7%	9.7%	11.0%	5.2%	0.2%	0.3%	0.4%	16.1%	13.7%	0.0%	3.4%
2.38	16.2%	14.1%	12.1%	21.5%	15.7%	3.7%	5.2%	5.7%	7.7%	7.2%	0.0%	4.9%
4.76	9.0%	5.1%	6.2%	10.8%	8.4%	4.4%	8.3%	6.3%	4.0%	3.3%	0.0%	3.0%
6.3	8.0%	4.1%	5.2%	7.7%	7.4%	5.7%	9.9%	6.9%	4.6%	3.0%	0.2%	3.1%
12.7	34.3%	29.3%	44.3%	40.0%	34.9%	53.2%	56.2%	59.1%	39.9%	31.5%	54.8%	48.4%
25.4	27.8%	29.4%	18.8%	2.2%	12.8%	32.1%	18.6%	19.5%	7.3%	27.5%	44.6%	36.0%
50.8	0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	0.0%	0.0%	9.6%	7.5%	0.0%	0.0%

	R5-1	R5-2	R5-3	R5-4	R1-1	R1-2	R1-3	R1-4	CF-1	CF-2	CF-3	CF-4
Pan	1.1%	0.7%	0.3%	0.5%	0.4%	0.2%	0.5%	0.4%	0.3%	0.1%	0.2%	0.3%
0.074	11.8%	6.0%	6.5%	6.1%	7.8%	0.8%	7.0%	7.0%	3.4%	1.6%	13.4%	10.2%
0.85	17.7%	11.8%	11.3%	10.9%	8.3%	1.6%	6.7%	5.0%	5.8%	2.9%	9.4%	10.0%
2.38	14.7%	8.6%	6.1%	9.2%	4.7%	2.3%	5.4%	4.0%	10.9%	5.7%	5.8%	7.4%
4.76	6.0%	3.1%	2.6%	3.8%	3.1%	1.5%	3.0%	2.8%	8.8%	5.4%	2.7%	4.4%
6.3	4.5%	2.1%	2.4%	2.7%	3.1%	1.2%	2.9%	2.6%	8.2%	7.8%	2.3%	3.8%
12.7	25.4%	30.4%	32.5%	24.9%	29.4%	36.3%	40.8%	27.9%	55.7%	61.3%	28.5%	38.6%
25.4	18.7%	37.4%	38.2%	42.0%	20.2%	56.0%	33.6%	42.1%	7.0%	15.1%	37.7%	25.3%
50.8	0.0%	0.0%	0.0%	0.0%	23.0%	0.0%	0.0%	8.1%	0.0%	0.0%	0.0%	0.0%
76.2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

CF = Sample taken just upstream of the confluence with the Clark Fork River

	SFLJ-1	SFLJ-2	SFLJ-3	SFLJ-4	NFLJ-1	NFLJ-2	NFLJ-3	NFLJ-4	W-1	W-2	W-3	W-4
Pan	1.0%	2.6%	0.5%	1.4%	2.1%	2.1%	1.9%	0.6%	3.3%	1.2%	2.4%	0.7%
0.074	0.4%	2.5%	2.1%	2.9%	2.4%	0.6%	3.3%	0.7%	10.4%	2.6%	3.1%	0.3%
0.85	3.8%	8.8%	7.8%	5.0%	7.8%	3.4%	10.6%	2.6%	10.4%	7.7%	8.5%	0.9%
2.38	9.8%	7.1%	6.9%	6.9%	9.3%	10.6%	11.0%	13.2%	8.6%	8.6%	9.9%	3.5%
4.76	6.0%	3.5%	3.7%	3.4%	4.9%	6.9%	6.0%	10.2%	4.3%	4.1%	4.8%	3.9%
6.3	5.4%	2.8%	2.7%	3.3%	3.2%	5.4%	4.6%	9.0%	2.9%	2.5%	3.5%	5.0%
12.7	44.0%	31.9%	31.9%	46.5%	35.6%	51.7%	42.1%	56.6%	43.1%	36.8%	39.1%	47.9%
25.4	29.5%	30.6%	44.3%	30.6%	27.1%	19.2%	20.4%	7.1%	16.9%	36.5%	28.8%	26.1%
50.8	0.0%	10.2%	0.0%	0.0%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.7%
76.2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

SFLJ = South Fork Little Joe Creek, NFLJ = North Fork Little Joe Creek, W = Ward Creek

	TM-1	TM-2	TM-3	TM-4	D-1	D-2	D-3	D-4	SAV-1	SAV-2	SAV-3	SAV-4
Pan	0.6%	1.0%	0.7%	1.5%	1.6%	1.4%	1.0%	2.3%	1.3%	1.3%	1.1%	1.5%
0.074	3.2%	4.1%	12.8%	3.5%	3.9%	2.3%	2.5%	4.2%	6.0%	3.1%	3.6%	4.5%
0.85	7.8%	13.4%	13.5%	9.4%	7.7%	7.8%	13.3%	11.7%	10.2%	9.2%	8.9%	11.1%
2.38	8.8%	12.0%	9.3%	10.1%	7.6%	3.9%	14.0%	9.6%	20.1%	12.5%	12.4%	14.4%
4.76	4.6%	5.1%	4.2%	5.1%	4.6%	1.3%	6.1%	4.3%	9.6%	5.2%	5.3%	5.8%
6.3	4.2%	3.6%	3.1%	3.9%	4.8%	1.3%	4.8%	3.7%	6.1%	3.1%	3.0%	3.4%
12.7	39.2%	25.2%	32.2%	35.2%	39.4%	43.1%	42.6%	33.7%	37.4%	35.1%	35.8%	37.8%
25.4	31.7%	35.6%	24.3%	31.2%	30.3%	38.9%	15.6%	30.5%	9.2%	22.7%	22.0%	21.4%
50.8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	8.0%	0.0%

TM = Twelvemile Creek, D = Deer Creek, SAV = Savenac Creek

	B-1	B-2	B-3	B-4
Pan	0.5%	1.0%	1.7%	1.0%
0.074	1.7%	11.9%	3.5%	2.8%
0.85	6.7%	13.0%	6.2%	8.9%
2.38	15.4%	16.9%	14.8%	14.8%
4.76	7.6%	9.0%	8.6%	8.2%
6.3	5.8%	6.6%	7.0%	6.5%
12.7	48.9%	41.6%	38.1%	51.4%
25.4	13.4%	0.0%	20.1%	6.4%
50.8	0.0%	0.0%	0.0%	0.0%

B = West Fork Big Creek

Table A1-2. River Stationing and GPS Location for McNeil Core Samples and Gravel Bar Samples within the St. Regis Watershed

Reach	River Station	Latitude	Longitude	Sample	Sample	Sample	Sample
9	195,800	47.443785	-115.704562	1	2	3	
9B	181,000	47.436809	-115.657176	2	3		
9B	181,000	47.436518	-115.657836	4			
8	178,000	47.432832	-115.654533	1	2		
8	178,000	47.432393	-115.653277	3	4		
8B	167,500	47.415734	-115.618529	1	2		
7	140,000	47.413768	-115.522239	1			
7	140,000	47.414076	-115.522380	2	4		
5	105,000	47.385487	-115.404201	1			
5	105,000	47.386065	-115.404949	2	4		
5	105,000	47.388491	-115.408164	3			
4	82,000	47.364370	-115.334218	1	2		
1	12,000	47.296622	-115.123602	1			
1	12,000	47.298289	-115.129649	2			
1	12,000	47.298565	-115.130890	3	4		
CF	500	47.297341	-115.090123	1	2		
CF	500	47.297178	-115.092122	3	4		
SFLJ	NA	47.188233	-115.224824	1			
SFLJ	NA	47.191749	-115.225556	4			
NFLJ	NA	47.264108	-115.162854	1			
NFLJ	NA	47.262046	-115.168064	3			
W	NA	47.311951	-115.234382	4			
TM	NA	47.356418	-115.287835	1			
D	NA	47.371216	-115.360597	2			
D	NA	47.372602	-115.360581	3			
SAV	NA	47.398399	-115.395667	1	2	3	4
B	NA	47.362692	-115.437141	1			
B	NA	47.362494	-115.436545	3	4		

APPENDIX B
PHYSICAL ASSESSMENT OF FOREST SERVICE REACHES

Prepared by Lolo National Forest

Physical Assessment – Channel Pattern

Sinuosity

Sinuosity is a dimensionless ratio of stream length over valley length, and provides a measure of a stream's degree of "meandering-ness." Sinuosity of our 2002 field sites was analyzed using a digital planimeter and 1:6000 aerial photos (1993) are included in the following table. Where a change in pattern (meander cutoffs) was detectable, sinuosity was calculated for the historic stream pattern as well **(Table B-1)**. In these instances, sinuosity of the St. Regis River mainstem reaches has decreased overtime.

Table B-1. Sinuosity of St. Regis River Mainstem Field Sites, Measured With a Digital Planimeter on 1:6000 Scale 1993 Aerial Photos

Reach No	Stream Length (ft)	Valley Length (ft)	Sinuosity	Change	Number of Cutoff Meanders	Road Encroachment or Other alteration*	Rosgen Stream Type	Target Sinuosity
9	1728	1446	1.20				C3b	> 1.2
1	1967	1879	1.05	- 0.01	1	yes	C3	> 1.2
	1988	1879	1.06					
11	2905	2879	1.01	- 0.24	3	yes	B3c	> 1.2
	3596	2879	1.25					
4	3367	3131	1.08			yes	C3/4	> 1.2
6	3750	3375	1.11	- 0.12	1	yes	B3c or F3	> 1.2
	4157	3375	1.23					
7	5043	4445	1.14			yes*	C3	> 1.2
7~	3145	2953	1.07				C3	> 1.2
7+	9376	7595	1.24				C3	> 1.2

*Other alteration: diking, berming, straightening
~ 2000, 1: 15840 photos; valley type 2
+ 2000, 1: 15840 photos; valley type 8

Physical Assessment – Channel Materials

Introduction and Methods

Riffle stability index (RSI) is a relative measure of bedload sediment supply to stream transport capacity. The RSI index value is easily derived. A Wolman pebble count in a riffle is conducted and the intermediate axis of the 30 largest mobile particles located on a nearby point bar is measured. The geometric mean of the largest bar particles is calculated, and a cumulative percent-finer distribution of the riffle particles is plotted. The RSI value is the cumulative percent finer than value that corresponds with geometric mean of the 30 largest mobile bar particles. Largest mobile bar particle measurements and riffle pebble counts were collect at 33 of the 46 stream sites (58 cross sections) surveyed during 2002 in the St. Regis watershed.

Results and Discussion

Kappeser (2002) demonstrated that RSI values differ for B stream types in managed versus unmanaged watersheds. RSI values for 2002 stream surveys in the St. Regis watershed, including B and C streams types, also differ from managed versus unmanaged watersheds. If roads existed in the watershed above a stream survey, the watershed was considered managed. The highest RSI values (>75) were found in managed watersheds. Intermediate RSI values (46-75) occurred in managed as well as managed watersheds. RSI values less than 46, and in all St. Regis cases values less than 46 were equal to 0 meaning no point bars were found in the reach. These divisions are similar to those found by Kappesser, although by including both B and C stream types, it is expected for the index values between groups to be lower because of the greater vulnerability of the C channels.

What the results suggest is that there is more mobile bedload in streams of managed (sic roaded) watersheds. There is a greater sediment supply in these streams than the stream is able to equilibrate with its flow regime, therefore bar deposits are found on which particles are larger than the particles found in the riffles. If the stream is moving these larger particles, then the stream is also moving the smaller particles that comprise the riffle, thereby making the riffles less stable. Streams with small index values (<45, and in this case 0) are either supply limited and/or have a flow regime with increased energy that prevents particles from being deposited. These reaches tend to be those confined between a hillslope and a road or between two roads, and those that have been shortened by meander-cutoff.

For the St. Regis mainstem, the managed depositional reaches we surveyed come in with high RSIs (Reach 7 near Little Joe confluence, Reach 4 at DeBorgia near Deer Creek confluence, and Reach 1 above Taft near Rainy Creek confluence, although two other samples in Reach 1 have intermediate RSI), St. Regis Reach 9, closest to the headwaters and in reference condition comes in with intermediate/low RSI (46-48), and the totally entrenched reaches smashed between the RR and I-90 (Reaches 6&11) had no point bars so their RSI is 0 **(Table B-2)**.

Table B-2. Riffle Stability Index (RSI) Values

Huc6	Tributary	Reach	Cross Section	Rsi	Managed	Stream Type	Potential Reference Reach
Little Joe Creek	Little Joe Creek	1		92	yes	C	
St. Regis River	St. Regis River	7	B	90	yes	C	
Twelvemile Creek	Twelvemile Creek	1		88	yes	C	
St. Regis River	St. Regis River	4	B	87	yes	C	
Big Creek	West Fork Big Creek	1a		85	yes	C	
Big Creek	Big Creek	3		85	yes	C	
Big Creek	West Fork Big Creek	1		82	yes	Bc	
Savenac Creek	Savenac Creek	1	B	80	yes	C	
Twelvemile Creek	Mineral Mountain Creek	1		78	yes	E	
Little Joe Creek	North Fork Little Joe Creek	1		78	yes	C	
Twelvemile Creek	Flat Rock Creek	1		76	yes	C	yes
Twelvemile Creek	Rock Creek	1		76	yes	B	
Little Joe Creek	North Fork Little Joe Creek	4		75	yes	Cb	
St. Regis River	St. Regis River	1	C	75	yes	C	
Savenac Creek	Savenac Creek	5		73	no	Cb	yes
Big Creek	Gilt Edge Creek	4		72	no	Ba	
St. Regis River	St. Regis River	1	B	71	yes	C	
St. Regis River	St. Regis River	1	A	64	yes	C	
Savenac Creek	Savenac Creek	1	A	63	yes	C	
Savenac Creek	Savenac Creek	4		63	no	B	yes
Little Joe Creek	South Fork Little Joe Creek	1		62	yes	Bc	
Twelvemile Creek	West Fork Twelvemile Creek	1		58	yes	Ba	
Twelvemile Creek	Rock Creek	2		58	yes	Cb	
Twelvemile Creek	Twelvemile Creek	2		57	yes	C	
Twelvemile Creek	East Fork Twelvemile Creek	1		56	yes	Cb	
Little Joe Creek	North Fork Little Joe Creek	1a		55	yes	Cb	
St. Regis River	St. Regis River	9	B	46	no	Cb	yes
Little Joe Creek	North Fork Little Joe Creek	2		0	yes	Cb	yes
St. Regis River	St. Regis River	11	A	0	yes	Bc	
St. Regis River	St. Regis River	6	A	0	yes	F	
Twelvemile Creek	Trapper Cabin Creek	1		0	yes	Ca	
Twelvemile Creek	Upper Rock Creek	1		0	yes	Ba	
Twelvemile Creek	Upper Rock Creek	2		0	yes	Ba	

Physical Assessment – Percent Surface Fines

Riggers et al. (1998) described reference conditions for natural streams on the Lolo National Forest based on six years of data (1989-1995) collected on 69 streams (**Figure B-1**) using the 49-point grid-toss method. Percent surface fines <6.3 mm data collected in the St. Regis watershed included 17 lateral scour pools, 4 on B streams, and 13 on C streams, and 32 low gradient riffles, 8 on B streams and 24 on C streams. These data were compared to the reference conditions described by Riggers. Results and discussion follow.

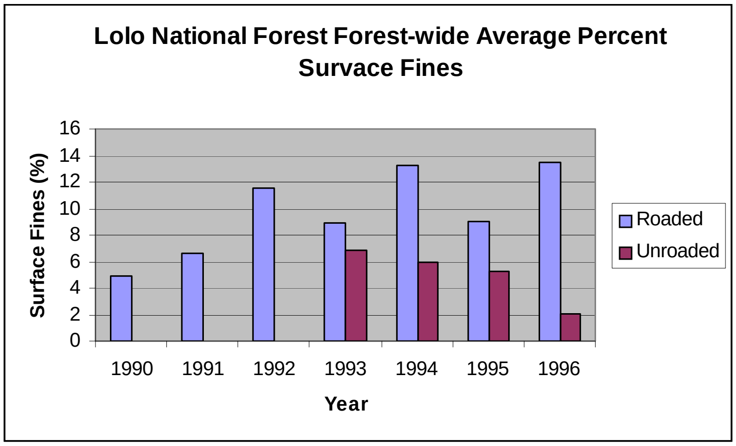

Figure B-1. Lolo National Forest Percent Surface Fines Data from 1994-1996 Monitoring Report

Lateral Scour Pools

The combined PSF values by stream type for lateral scour pools exceed the proposed reference conditions for various habitat types (**Figure B-2**). C channels appear to have a greater departure from reference conditions than B channels. When specifically compared to the mean value of about 5.3% PSF for all lateral scour pools, the departures from reference are even greater.

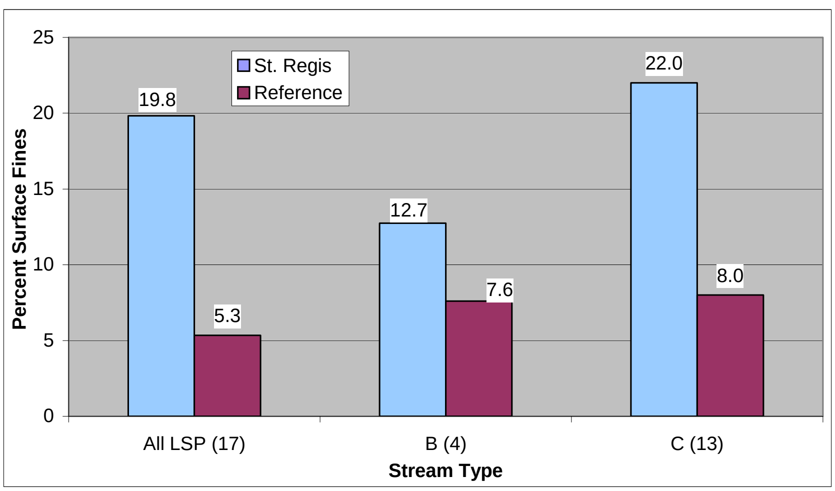

Figure B-2. Mean Percent Surface Fines in Lateral Scour Pools (LSP) By Stream Type

All B channel PSF values are within the range of 0-20.9% (based on one standard deviation or 68% of reference sites if one were to assume a normal distribution). For reference C channels, this range is 0-16.5% (68% of reference sites) and 0-25.9% (95% of reference sites).

PSF values **(Table B-3)** in North Fork of Little Joe 1, Rock Creek of Twelvemile 2, Flat Rock Creek of Twelvemile, and Savenac Creek 1A all have very high PSF values in comparison to the expected range for natural C stream conditions.

Table B-3. Percent Surface Fines for Lateral Scour Pools

Stream Name	Stream Type	Mean PSF	Compared to Reference
Big Creek 3	C	8.8	0.8
West Fork Big 1	Bc	8.2	0.6
West Fork Big 1A	C	0	-8
Gilt Edge	Ba	15	7.4
Little Joe Creek 1	C	4.1	-3.9
North Fork Little Joe 1	C	75.5	67.5
North Fork Little Joe 1A	Cb	14.3	6.3
North Fork Little Joe 2	Cb	4.1	-3.9
North Fork Little Joe 4	Cb	0	-8
Twelvemile Creek 1	C	4.1	-3.9
Rock 1	B	12.2	4.6
Rock 2	Cb	89.8	81.8
Flat Rock	C	26.5	18.5
Savenac Creek 4	B	15.6	8
Savenac 1A	C	43.5	35.5
Savenac 5	Cb	12.2	4.2
St. Regis River 1A	C	3.1	-4.9

Low Gradient Riffles

The combined PSF values by stream type for low gradient riffles exceed the proposed composite channel reference conditions. C and B channels appear to have approximately equal departures from reference conditions, B channels being slightly higher. When specifically compared to the mean value of about 0.8% PSF for all low gradient riffles, the departures from potential reference are even greater (**Figure B-3**).

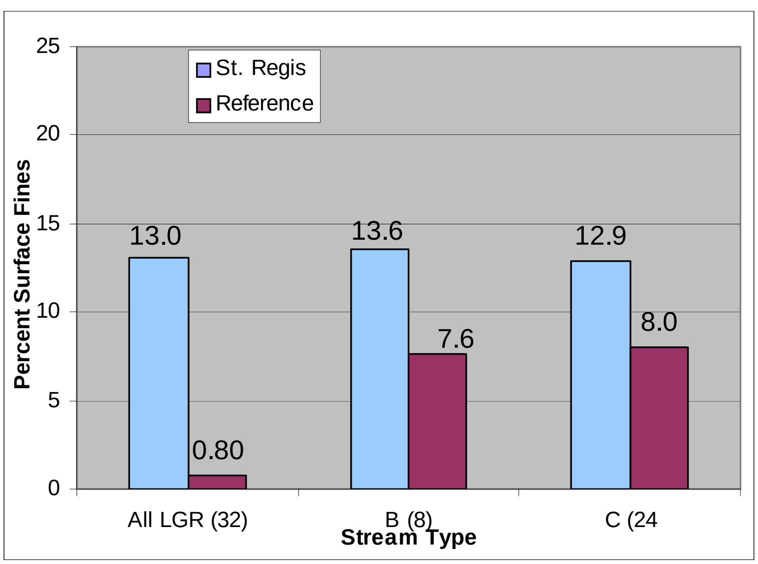

Figure B-3. Mean percent surface fines in low gradient riffles (LGR) by stream type

Savenac Creek 4 and Breen Creek 1 both exceed the 68% range-maximum for B channels. Savenac Creek 1B, Savenac Creek 1A, Flat Rock Creek 1, Savenac Creek 5, and Rock Creek 2 exceed the 68% range-maximum for C channels **(Table B-3)**. Surface fines in low gradient riffles were higher than reference at Savenac Creek 1 and 4, Breen Creek 1, South Fork Little Joe Creek 1, Big Creek 3, St. Regis 1, North Fork Little Joe Creek 1A, Flat Rock Creek 1, East Fork Twelvemile Creek 1, and Rock Creek 2 sites **(Table B-4)**.

Table B-4. Percent Surface Fines for Low Gradient Riffles

Stream Name	Stream Type	Mean PSF	Compared to Reference
Savenac Creek 4	B	38.1	30.5
Rock Creek 1	B	7.5	-0.1
Gilt Edge Creek 4	Ba	7.5	-0.1
Breen Creek 1	Ba	21.8	14.2
West Fork Twelvemile Creek 1	Ba	4.1	-3.5
West Fork Big Creek 1	Bc	9.5	1.9
South Fork Little Joe Creek 1	Bc	17.3	9.7
St. Regis River 11A	Bc	2.7	-4.9
Big Creek 3	C	10.2	2.2
West Fork Big Creek 1A	C	9.5	1.5
Little Joe Creek 1	C	2.7	-5.3
North Fork Little Joe Creek 1	C	5.1	-2.9
Savenac Creek 1B	C	59.9	51.9
Savenac Creek 1A	C	61.2	53.2
St. Regis River 1B	C	12.2	4.2
St. Regis River 4A	C	8.8	0.8
St. Regis River 4B	C	0.7	-7.3
St. Regis River 4C	C	2.0	-6.0
St. Regis River 7A	C	0.7	-7.3
St. Regis River 7B	C	2.0	-6.0
Flat Rock Creek 1	C	21.8	13.8
Twelvemile Creek 1	C	6.8	-1.2
Twelvemile Creek 2	C	6.8	-1.2
Trapper Cabin Creek 1	Ca	10.2	2.2
North Fork Little Joe Creek 1A	Cb	12.2	4.2
North Fork Little Joe Creek 2	Cb	2.6	-5.4
North Fork Little Joe Creek 4	Cb	2.0	-6.0
Savenac Creek 5	Cb	19.7	11.7
St. Regis River 9A	Cb	6.1	-1.9
St. Regis River 9B	Cb	10.9	2.9
East Fork Twelvemile Creek 1	Cb	14.3	6.3
Rock Creek 2	Cb	20.4	12.4

Literature Cited

Kappesser, Gary B. 2002. A Riffle Stability Index to Evaluate Sediment Loading to Streams. *Journal of the American Water Resources Association* 38(4): 1069-1081.

Riggers, B.W., A. Rosquist, R. Kramer, and M. Bills. 1998. An analysis of fish habitat and population conditions in developed and undeveloped watersheds on the Lolo National Forest.

APPENDIX C
STREAM TEMPERATURE, SHADE AND RIPARIAN VEGETATION ASSESSMENT FOR BIG CREEK AND TWELVEMILE CREEK

St. Regis TMDL Planning Area

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INTRODUCTION

Temperature impairments were assessed within Big Creek, Twelvemile Creek, and the St. Regis River using a combination of in-stream temperature measurements, riparian canopy density and shading assessments, mid-summer streamflow measurements, and modeling. This assessment was conducted to aid in the development of Total Maximum Daily Loads (TMDLs) in the St. Regis TMDL Planning Area (TPA). Data collected during this assessment was used in the QUAL2K model to assess the influence of shading on stream temperatures based on existing riparian shading conditions and potential riparian shading conditions along Big Creek and Twelvemile Creek. Along the St. Regis River, riparian canopy density data was collected to "ground-truth" the canopy density assessment performed in 2003. Methods employed in this assessment are described in *Field Monitoring and Temperature Modeling Sampling and Analysis Plan for the 2006 Field Season* (MDEQ 2006a). As outlined in the Sampling and Analysis Plan for this project, the objectives of this assessment are to:

- Evaluate stream water temperatures and riparian shading along Big Creek and Twelvemile Creek
- Evaluate canopy density along the St. Regis River

Additional information relevant to the riparian condition in the St. Regis TMDL Planning Area can be found in **Appendix B** (Item 11: Stream Channelization and Encroachment), **Appendix J** (Stream Temperature Data 2001-2003), and **Appendix K** (Canopy Density Assessment for the St. Regis River TMDL) in the *Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs* completed in June of 2006 (MDEQ 2006b).

Temperature Impairments

Water bodies in the St. Regis TPA listed as impaired due temperature on the 2004 303(d) List include the St. Regis River, Big Creek, and Twelvemile Creek. On the 1996 303(d) List, Big Creek, Deer Creek, Silver Creek, and Ward Creek were listed as impaired due to temperature. No additional assessments were performed on Deer Creek and Ward Creek, since temperature data collected in 2001 indicated the temperature never exceeded 59°F (12°C) (MDEQ 2006b), which is considered the upper limit for bull trout rearing (USFWS 1998). No additional assessments were performed on Silver Creek, since temperature data from 2001 suggested elevated stream temperatures were the result of natural conditions (MDEQ 2006b).

Montana Water Quality Standards

Montana's water quality standards for temperature were originally developed to address situations associated with point source discharges, making them somewhat awkward to apply when dealing with primarily nonpoint source issues. In practical terms, the temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable rate at which temperature changes (i.e., above or below naturally occurring) can occur to avoid fish and aquatic life temperature shock. The State of Montana considers the St. Regis River, Big Creek, and Twelvemile Creek B-1 waters. For waters classified B-1, the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 66º Fahrenheit) is 1°F and the rate of change cannot exceed 2°F per hour. If the naturally occurring temperature is greater than 67º F, the maximum allowable increase is 0.5º F [ARM 17.30.623(e)].

BIG CREEK AND TWELVEMILE CREEK TEMPERATURE ASSESSMENT

Temperature assessments along Big Creek and Twelvemile Creek were conducted to identify existing conditions and determine if anthropogenic disturbances have led to increased stream temperatures. This assessment utilized field data collection and computer modeling to assess stream temperatures relative to Montana's water quality standards.

Field Data Collection

Data collection on Big Creek and Twelvemile Creek in the 2006 field season included temperature measurements, streamflow measurements, and an assessment of riparian shading. Methods employed in this assessment are outlined in *Field Monitoring and Temperature Modeling Sampling and Analysis Plan for the 2006 Field Season* (MDEQ 2006a).

Temperature Measurements

Temperature monitoring occurred on Big Creek and Twelvemile Creek over a two-month timeframe in the summer of 2006. The study timeframe examines stream temperatures during the period when streamflow is lowest, temperatures are warmest, and negative affects to the cold water fishery and aquatic life beneficial uses are likely most pronounced. Temperature monitoring consisted of placing temperature data logging devices at 19 sites, with 10 sites in the Big Creek watershed and 9 sites in the Twelvemile Creek watershed. Temperature data logging devices were deployed on July 10th and 11th and retrieved on September 11th through 14th. Temperature monitoring sites were selected to bracket stream reaches with similar hydraulics, riparian vegetation type, valley type, stream aspect, and channel width, so that the temperature data collected during this assessment could be utilized in the QUAL2K model. A summary of temperature data is presented in **Attachment A**.

Streamflow Measurements

Streamflow was measured at the 19 sites where temperature data logging devices were placed on Big Creek and Twelvemile Creek. Streamflow was measured during mid-summer base flow conditions, with measurements performed on August 14th on Big Creek and August 17th on Twelvemile Creek. Streamflow data collected during this assessment was used in the QUAL2K model to help determine if in-stream temperatures exceed Montana standards. Streamflow data is presented in **Attachment B**.

Riparian Shading

Along Big Creek and Twelvemile Creek, riparian shading was assessed using a Solar Pathfinder, which measures the amount of shade at a site in 1-hour intervals. The Solar Pathfinder was used to assess riparian shading along 14 reaches, with 8 reaches in the Big Creek watershed and 6 reaches along Twelvemile Creek using the August template for the path of the sun. Reaches extended from one temperature monitoring site to the next site downstream, with an additional reach from the headwaters to the uppermost temperature monitoring site. Each reach was considered equivalent to a segment in the QUAL2K model and covered a segment of stream with a consistent riparian vegetation type, valley type, stream aspect, and channel width. In the QUAL2K model, additional reach breaks were placed where the existing riparian vegetation differed from the potential riparian vegetation condition due to anthropogenic disturbances. Within each reach, shade was measured at three sites distributed evenly along the reach. In addition to the Solar Pathfinder measurements, the following measurements were performed at each site in which riparian shading was assessed:

- Stream azimuth
- Stream aspect (0, 45, 90, -45)
- Bankfull width
- Wetted width
- Dominant tree species
- Dominant tree height
- Tree-to-channel distance at bankfull
- Percent overhang
- Shade controlling factor (topography, conifer, willow)
- Potential community type

Field notes were also recorded at each Solar Pathfinder measurement site, with discussions regarding the following categories:

- Description of human impacts and their severity
- Description of existing riparian vegetation and shading conditions
- Description of potential riparian vegetation and shading conditions
- Description of natural and anthropogenic factors affecting shading

This data was used to assess existing and potential riparian shading conditions relative to the level of anthropogenic disturbance at a site. Measurements obtained with the Solar Pathfinder were utilized in the QUAL2K model to help determine if in-stream temperatures exceed Montana standards. Solar Pathfinder data is presented in **Attachment C** and field notes collected at each Solar Pathfinder site are presented in **Attachment D**.

QUAL2K Model

The QUAL2K model was used to assess temperature impairments in Big Creek and Twelvemile Creek relative to Montana's temperature standards for B-1 waterbodies. The purpose of modeling stream temperature with QUAL2K is to help determine if anthropogenic disturbances in the watershed have lead to an increase in stream temperatures. The riparian shade and mid-summer streamflow data collected in 2006 were used directly in QUAL2K to simulate expected stream temperatures, while actual stream temperature data collected in 2006 were used to calibrate the model. The potential riparian shade condition was then used to model stream temperatures in the absence of anthropogenic disturbance. Potential riparian shading was determined based on reference reaches identified during field data collection and aerial imagery review. The relationship between anthropogenic disturbance and water quality impairments as described in ARM 17.30.623(e) was evaluated with the following definitions since almost all water temperature measurements were below 66°F and temperatures found above 66°F are not likely naturally occurring:

- If simulated stream temperatures derived from the model using the existing riparian shade data deviate by less than 1ºF from stream temperatures derived using the potential riparian shade, then anthropogenic sources are assumed to not be causing or contributing to violations of the relevant B-1 water temperature standards and the stream is not considered impaired due to anthropogenic (or anthropogenically induced) thermal modifications.
- If simulated stream temperatures derived from the model using the existing riparian shade data deviate by greater than 1ºF from stream temperatures derived using the potential riparian shade, then anthropogenic sources are assumed to be causing or contributing to violations of the relevant B-1 water temperature standards and the stream is considered impaired due to anthropogenic thermal modifications.

The QUAL2K model computes the amount of solar radiation entering the water at a particular latitude and longitude. The QUAL2K model tracks a column of water as it travels between two points which are defined by the user. In the QUAL2K model, "effective shade" was defined as the fraction of solar radiation blocked by vegetation and topography. Effective shade data collected in each reach using the Solar Pathfinder was used directly as the input variable in the "Shade" worksheet of the model, where effective shade is entered for the reach in one-hour intervals. Integrated hourly effective shade for each reach was entered as a percent for each hour (e.g. the value at 12:00 AM is applied from 12:00 to 1:00 AM). The QUAL2K model is available at http://www.epa.gov/ATHENS/wwqtsc/html/qual2k.html.

Data Sources and Model Assumptions

Data sources and model assumptions made during this assessment included:

- Shade values extrapolated from the individual Solar Pathfinder measurement sites to the reach scale were assumed to accurately reflect the overall reach condition. In instances where this did not appear to be the case, specific Solar Pathfinder measurement site data was used to represent localized conditions. This situation occurred in lower Twelvemile Creek where conditions varied based on the level of anthropogenic disturbance. In the Big Creek watershed, solar pathfinder measurements from reference sites in the upper portions of Middle Fork Big Creek and East Fork Big Creek were used to estimate potential riparian shading conditions in impacted reaches of the West Fork Big Creek.
- At the headwaters, the water temperature was assumed to be the same temperature as the groundwater, which was estimated to be 10.2ºF based on well data in the St. Regis area obtained from the Ground-Water Information Center (GWIC) database (http://mbmggwic.mtech.edu/).
- The Remote Automated Weather Station at Pardee (http://www.wrcc.dri.edu/), which is east of the St. Regis watershed at an elevation of 4,640 feet, was selected as the most representative site with data for air temperature, dew point, and wind speed.
- The U.S. Geological Survey's National Hydrography Dataset (NHD) stream layer was used to measure distance (http://nhd.usgs.gov). This layer is likely shorter than the actual stream distance resulting in less "residence" time for an individual water molecule in the QUAL2K model.

- Tributary streams were treated as discrete point-source inputs in the QUAL2K model for streamflow and temperature. Tributaries streamflows used in the model were based on field measurements, field estimates, and comparative watershed size.
- The QUAL2K model provides results in degree Celsius, while Montana's water quality standards are presented in degrees Fahrenheit. Conversions are provided in **Table C-1**.

Table C-1. Degrees Celsius Converted to Degrees Fahrenheit

Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F
0	32.0	**8**	46.4	**16**	60.8
1	33.8	**9**	48.2	**17**	62.6
2	35.6	**10**	50.0	**18**	64.4
3	37.4	**11**	51.8	**19**	66.2
4	39.2	**12**	53.6	**20**	68.0
5	41.0	**13**	55.4	**21**	69.8
6	42.8	**14**	57.2	**22**	71.6
7	44.6	**15**	59.0	**23**	73.4

Twelvemile Creek Modeled Temperatures

The following steps were taken to calibrate and run the various shading scenarios in the QUAL2K model for Twelvemile Creek:

1. Solar Pathfinder data was collected along six reaches in the field between each of the temperature data logger sites with one reach upstream of the uppermost data logger site. In the field, reaches were labeled TM01 through TM06 progressing in the downstream direction. Reach averages for the percent shade based on the Solar Pathfinder measurements were determined for each reach and are presented in **Attachment C**.
2. Reaches defined in the field for Solar Pathfinder measurements were further divided for input into the QUAL2K model. Reach labels in the model progress from TM1 to TM10 in the downstream direction. Reach breaks in the model were created based on a review of color and infrared aerial imagery from 2005 in GIS (**Figure C-1**). Reach breaks were made at all shade influencing clearcuts, which were primarily identified in the upper watershed and specifically along reach TM02 which was divided into reaches TM4A through TM4I for input into the model. In the lower watershed, reaches TM04 and TM05 were further divided based changes in riparian canopy density and channelization due to the road.

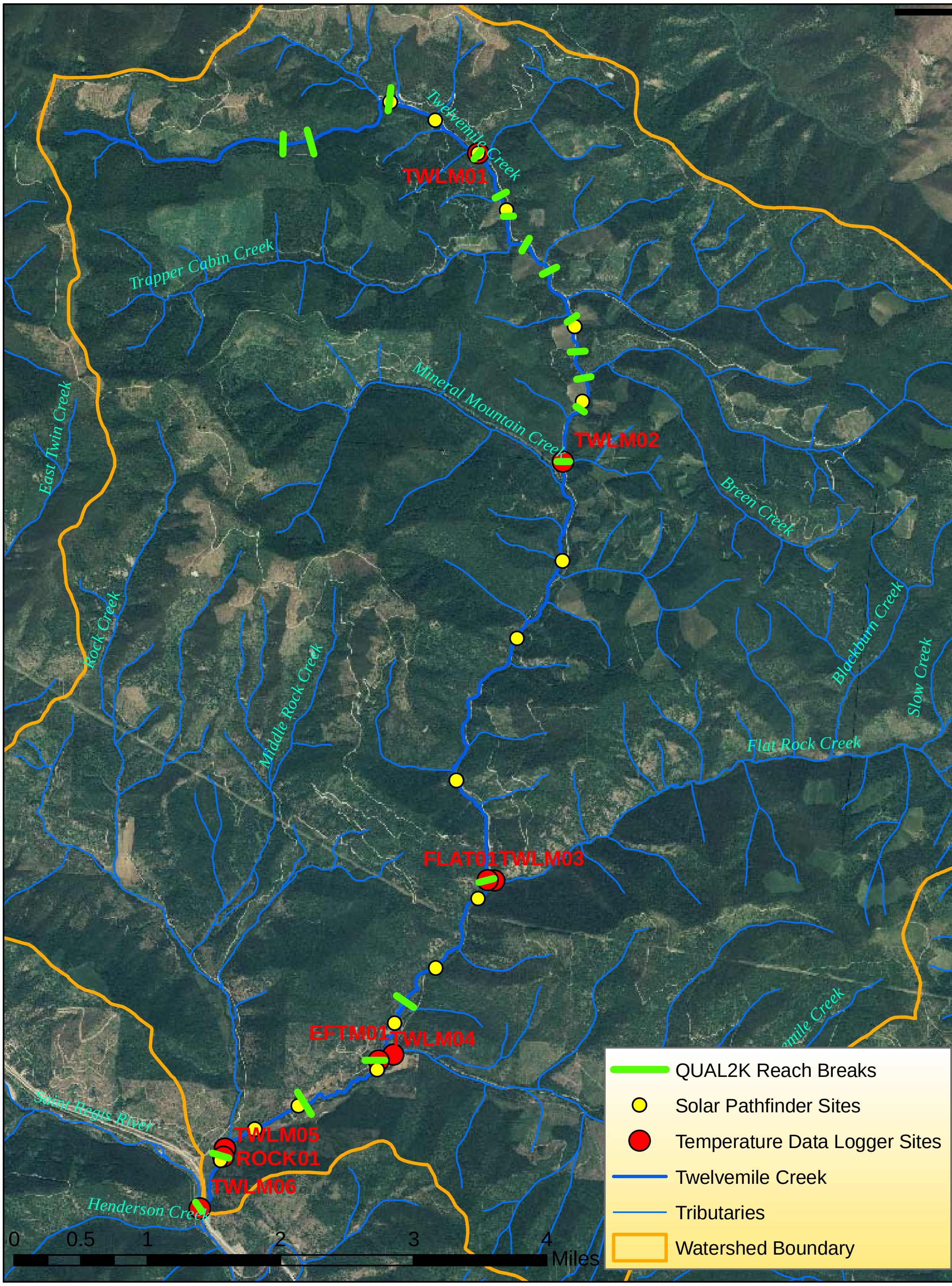

Figure C-1. Twelvemile Creek Reach Breaks and Data Collection Sites

3. Once the reach breaks were defined, the Solar Pathfinder data was reviewed to determine the appropriate measurements to apply to each reach for both existing and potential riparian shading conditions. Based on the shade data, a review of field notes, and aerial imagery, it was determined that TM01 represented reference conditions for small headwater streams within the Twelvemile Creek watershed. Thus, the average shade from this reach was assigned to other reaches which appeared to be free from timber harvest in the upper watershed. In reach TM02, all of the solar pathfinder measurements were performed at sites with clearcuts. Thus, the average results of the reach TM02 shade assessment were assigned to all of the upper reaches influenced by clearcuts. Reach TM03 was determined to represent reference conditions for mid-sized streams in semi-confined valleys with a mix of shrubs in the understory and conifers in the overstory. Shading in this reach was slightly impacted by the road, so conditions represent the potential with the continuing presence of the road. Shading from this reach was applied to impacted reaches in the lower watershed when modeling the potential to decrease stream temperatures by increasing shade. Reach TM04 was divided into two reaches based on changes in riparian vegetation density and canopy type, with the upper two Solar Pathfinder measurements representing essentially natural conditions, while there was a notable decrease in riparian vegetation density at the lower end of the reach. Reach TM05 was channelized by the road at the lower two Solar Pathfinder measurement sites, which were averaged to represent the influence of the channelization. Streamside shading along reach TM06 was determined to be in essentially natural conditions, excluding the influence of the I-90 crossing. **Table C-2** presents the reach average shade values for field defined reaches and a brief description of the reach conditions. This table also includes columns for "Existing Conditions" and "Increased Shading" that identify which shade values were assigned to the QUAL2K model reaches.

Table C-2. Twelvemile Creek Solar Pathfinder Reaches

Solar Pathfinder Reach	Reach Description	Average Daily Shade	QUAL2K Defined Reaches Assigned Shading Values based on Field Identified Reaches	
			Existing Conditions	Increased Shading
TM01	Potential reference conditions for small headwater streams	89%	TM1, TM3, TM4A, TM4C, TM4E, TMG, TM4I	TM1, TM2, TM3, TM4A-I
TM02	Clearcut conditions for small headwater streams	59%	TM2, TM4B, TM4D, TM4F, TM4H	
TM03	Potential reference conditions for mid-size streams in semi-confined valleys with some road influence, shrubs and conifers	56%	TM5	TM5
TM04 (1&2)	Potential reference conditions for mid-size streams in semi-confined valleys with shrubs and conifers	65%	TM6	TM6
TM04 (3)	Reach TM4 split to exclude lower pathfinder site where canopy density was reduced	44%	TM7	TM5
TM05 (1)	Un-channelized conditions along lower Twelvemile Creek with reduced canopy density	30%	TM8	TM5
TM05 (2&3)	Channelized conditions along lower Twelvemile Creek with reduced canopy density	22%	TM9	TM5
TM06	Typical conditions in shrub dominated valleys	52%	TM10	TM10

4. Once the existing shade was assigned to each reach in the model, additional calibration was required to account for tributary inputs and groundwater influences. Temperature data loggers on Flat Rock Creek, East Fork Twelvemile Creek, and Rock Creek were reviewed and it was determined that additional tributaries in the upper watershed would be modeled based on the temperature for Flat Rock Creek, since it was the farthest upstream tributary at which temperature data was available. Streamflow measurements and estimates were used to come up with a hydrologic balance for the model. During this process, it was observed that Twelvemile Creek is a "losing" stream from the confluence with Flat Rock Creek to the mouth (see **Attachment B**). Downstream of the East Fork Twelvemile Creek, the channel has been relocated which may be related to decreased streamflows observed during this assessment.

5. The QUAL2K model was run using the existing shade data, streamflow and stream temperature measurements at temperature data logger sites, and streamflow and temperature estimates at other identified tributaries. The model did not calibrate well with this information and under-predicted the average stream temperature at the mouth. The model was then re-calibrated by assigning the temperature data from Flat Rock Creek to the East Fork Twelvemile Creek and Rock Creek. Thus, all of the tributaries were modeled at the same temperature, which resulted in the model calibration depicted in **Figure C-2**.

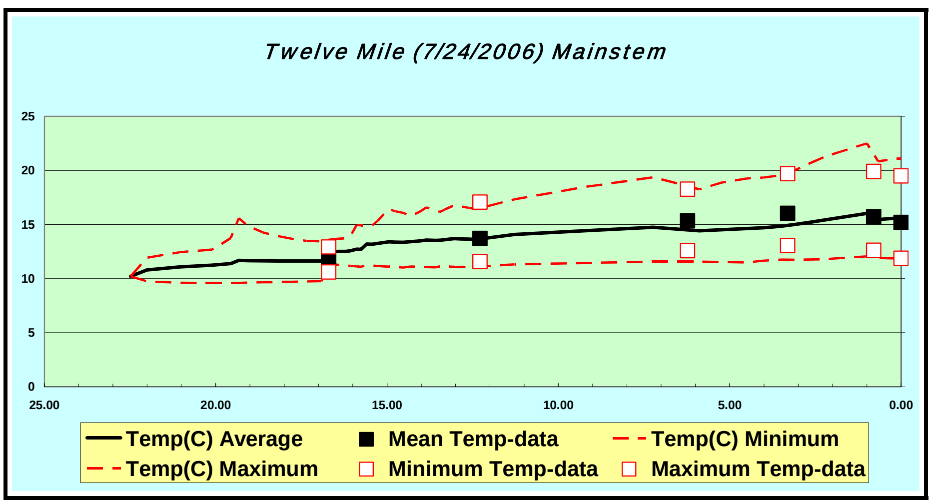

Figure C-2. QUAL2K Model Results for Twelvemile Creek with Existing Shade

6. Once stream temperatures based on existing shade was modeled, the potential to decrease stream temperatures by increasing the amount of shade was assessed. Shading values were adjusted for clearcut reaches in the upper watershed (TM2, TM4B, TM4D, TM4F, and TM4H) by assigning the average shade from TM01 (**Table C-1**). Shading values for impacted reaches in the lower watershed (TM7, TM8, and TM9) were assigned the average shade from TM03, which acknowledges the continuing presence of the road. With an increase in shade along the mainstem of Twelvemile Creek, the QUAL2K model predicted a slight reduction in stream temperatures (**Figure C-3**). Note that the spike in water temperature upstream of the first temperature data logger (**Figure C-1**), which represents a clear cut section, was removed by increasing the amount of shade in this

reach. The model also predicted that increasing the amount of shade will decrease temperatures between the first (TWLM01) and second (TWLM02) temperature data loggers, where there are several clearcuts, and between the forth (TWLM04) and fifth (TWLM05) temperature data loggers, which bracket the channelized section.

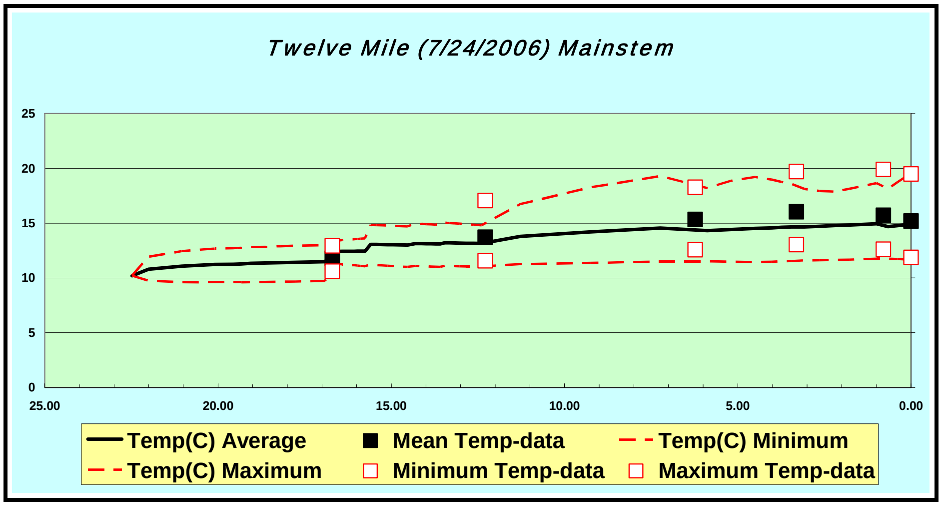

Figure C-3. QUAL2K Model Results for Twelvemile Creek with Increased Shade

7. The additional influence of timber harvest in tributary watersheds was then analyzed for the potential to affect water temperatures in Twelvemile Creek. The tributary to the north of Breen Creek was modeled using QUAL2K to determine the potential to decrease temperatures in tributary streams by increasing the amount of riparian shading. This uncalibrated model used aerial photo assessment techniques and a comparison to monitoring sites on the mainstem. The results of this exercise indicated that an approximately 5% reduction in temperature could likely be achieved in most of the headwater tributaries in the Twelvemile Creek watershed where historic clear cutting has affected streamside shading. This value, which equates to an approximately 1.8°F (1°C) reduction in tributary stream temperature, was then applied to all of the tributaries within the watershed, which resulted in a significant decease in stream temperatures along the mainstem of Twelvemile Creek (**Figure C-4**).

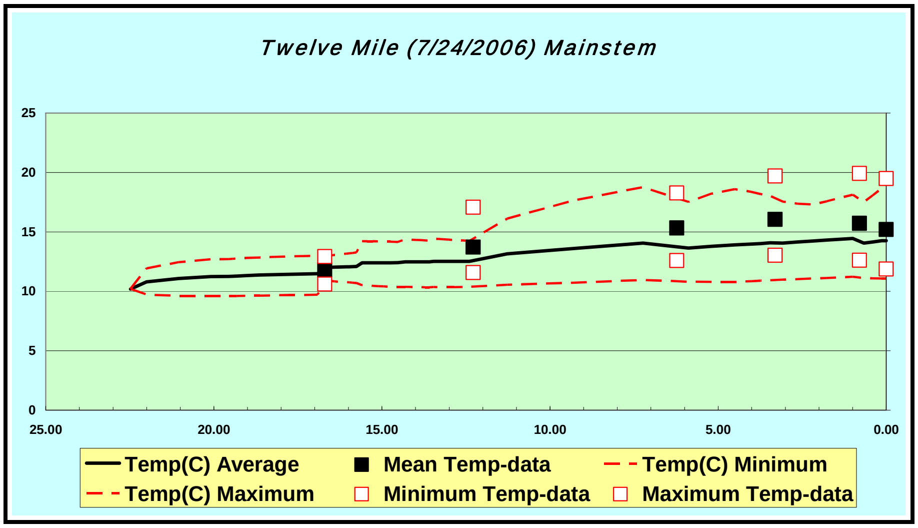

Figure C-4. QUAL2K Model Results for Twelvemile Creek with Increased Shade and Decreased Tributary Temperatures

Twelvemile Creek Modeled Temperatures Relative to Montana Standards

To evaluate the QUAL2K model results relative to Montana's water quality standards, the maximum temperatures predicted in the model scenario for increased shading and decreased tributary inputs were compared to the maximum temperatures predicted by the model for the existing shade conditions. The QUAL2K model results indicated that stream temperature could be decreased by greater than 1ºF by increasing shade (**Figure C-3**) along the mainstem of Twelvemile Creek (**Table C-3**). Additional stream temperature reductions could be achieved by decreasing temperatures on tributary streams (**Figure C-4**). This result suggests that Twelvemile Creek is exceeding Montana's water quality standard and that reduced shading resulting from anthropogenic disturbance is partially responsible for the increase in stream temperatures.

Table C-3. QUAL2K Model Results for Twelvemile Creek Relative to Montana Standards

Data Logger Site	Field Measured Data		QUAL2K Modeled "Existing Shade"		QUAL2K Modeled "Increased Shade"		QUAL2K Modeled "Increased & Decreased Tributary Temperature"	
	Distance (km)	Maximum Temper-ature (°F)	Estimated Maximum Temper-ature (°F)	Departure from Field Data (°F)	Estimated Maximum Temper-ature (°F)	Departure from "Existing Shade" Model (°F)	Estimated Maximum Temper-ature (°F)	Depart-ure from "Existing Shade" Model (°F)
TWLM01	16.70	55.3	56.2	0.91	55.4	-0.81	55.4	-0.81
TWLM02	12.29	62.7	61.6	-1.15	58.7	-2.92	57.6	-3.94
TWLM03	6.23	64.9	66.9	1.98	66.7	-0.13	65.8	-1.10
TWLM04	3.31	67.5	67.2	-0.21	65.4	-1.81	64.4	-2.83
TWLM05	0.80	67.8	72.5	4.65	65.6	-6.91	64.6	-7.87
TWLM06	0.00	67.1	69.9	2.86	66.7	-3.26	65.6	-4.37

Big Creek Modeled Temperatures

The following steps were taken to calibrate and run the various shading scenarios in the QUAL2K model for Big Creek:

1. Solar Pathfinder data was collected at 8 reaches in the field between each of the temperature data logger sites, with one reach upstream of the uppermost data logger on each of the three forks of Big Creek. The mainstem of Big Creek was divided into one reach, with temperature data loggers at the mouth and below the confluence of the West Fork and East Fork. The East Fork and Middle Fork were each divided into two reaches, while the West Fork was divided into three reaches. In the field, reaches were labeled BG01 through BG08 progressing in the downstream direction, with BG01 and BG02 on the Middle Fork, BG03 and BG04 on the East Fork, BG05 through BG07 on the West Fork, and BG08 on the mainstem of Big Creek. Reach averages for the percent shade based on the Solar Pathfinder measurements were determined for each reach and are presented in **Attachment C**.
2. Reaches defined in the field for Solar Pathfinder measurements were further divided for input into the QUAL2K model. Reach labels in the model progress from “Mainstem headwaters” to “Big8” in the downstream direction. For purposes of the model, the West Fork was considered the headwaters and the Middle and East forks where considered point source inputs. The mainstem of Big Creek begins at the confluence of the West and East forks. Reach breaks in the model were created based on a review of color and infrared aerial imagery from 2005 (**Figure C-5**). Reach breaks were made at all clearcuts and other observed changes in riparian canopy conditions. Additional reach breaks for the QUAL2K model include the West Fork headwaters, which was split into three reaches based on an observed timber harvest (Mainstem headwaters, Big2 and Big3). In addition, the West Fork between data logger WFBG03 and BIGC01 was identified as a short individual reach (Big6), while the mainstem of Big Creek (BG08) was divided into two reaches, since the upper half of the mainstem appeared to be in relatively natural conditions (Big7), while the lower half of the mainstem is wide and aggraded with extensive gravel bar complexes (Big 8).

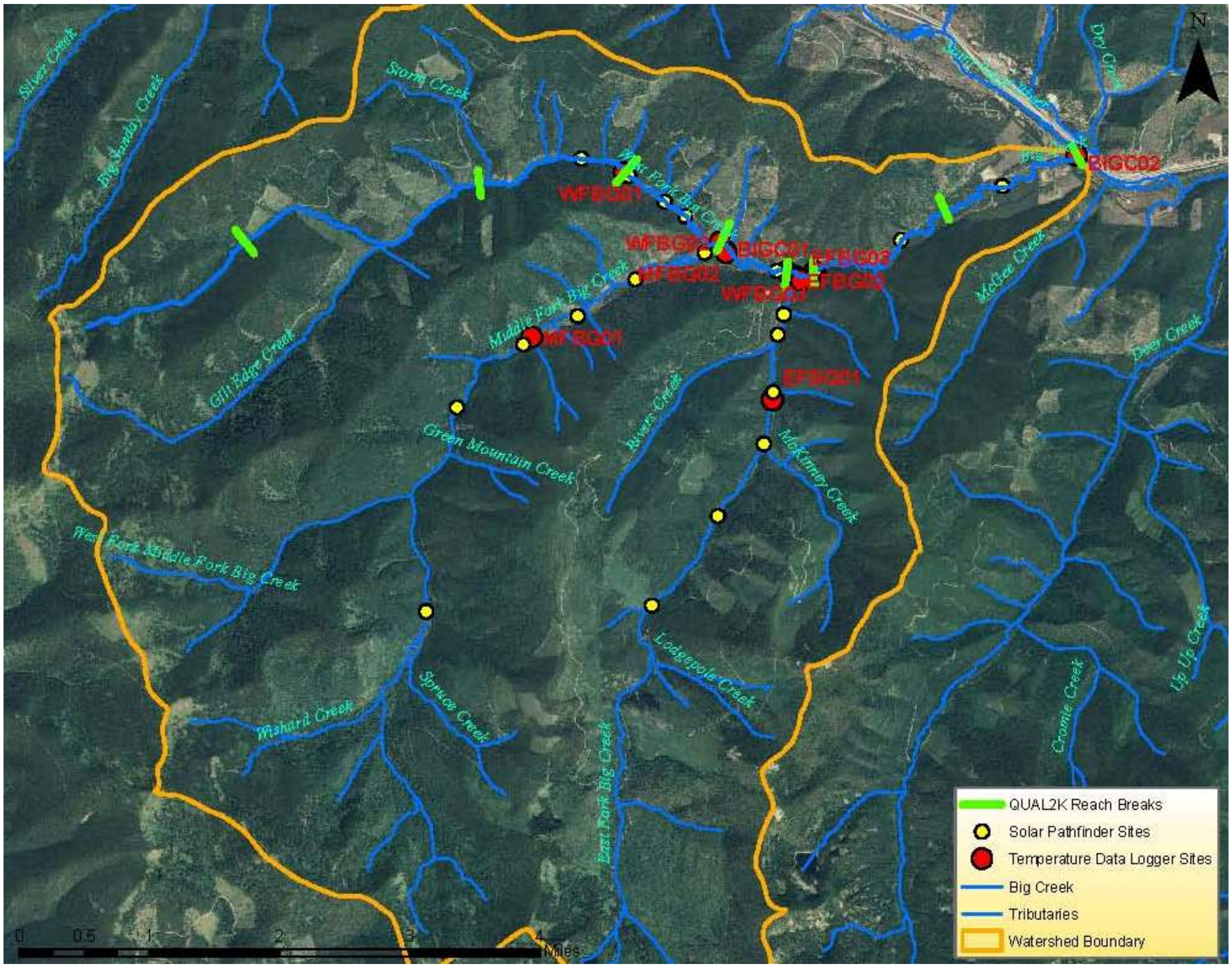

Figure C-5. Big Creek Reach Breaks and Data Collection Sites

3. Once the reach breaks were defined, Solar Pathfinder data was reviewed to determine which data should be applied to each reach for both existing and potential riparian shading conditions. Since no shade data was collected in the upper West Fork watershed, data from the upper Middle Fork (BG01) was assigned to reaches "Mainstem headwaters" and "Big2" based on a review of aerial imagery. Reference conditions for mid-sized streams in confined valleys with coniferous vegetation along the channel margin were most accurately represented by two solar pathfinder measurements in the upper East Fork (BG01) and two measurements in the upper Middle Fork (BG03). While selective timber harvest of large trees from these sites historically was observed at these sites, the overall amount of shading appeared to most closely represent reference conditions. The reference value derived from these four solar pathfinder measurements was assigned to the West Fork reaches upstream of the confluence with the Middle Fork (Mainstem headwaters, Big 2, Big3, and Big 4) when modeling the potential for increased shading. For the mainstem of Big Creek, reference conditions were developed based on the upper two solar pathfinder measurements on Big Creek. Shade from this reach was assigned to Big5, Big6, and Big8 when modeling potential shading. Existing conditions along Big7 were not altered, since the system appeared to be in a relatively

natural state. **Table C-4** presents the reach average shade, provides a brief description of reach conditions, and identifies which shade values were assigned in QUAL2K.

Table C-4. Big Creek Solar Pathfinder Reaches

Field Identified Reaches	Reach Description	Average Daily Shade	QUAL2K Defined Reaches Assigned Shading Values based on Field Identified Reaches	
			Existing Conditions	Increased Shading
BG01	Upper Middle Fork, confined, mid-size stream in conifers (big cedars) with some logging, road impacts at lowest site	62%	Mainstem headwaters, Big 2	
BG02	Lower Middle Fork, signs of historic removal of cedars from valley bottom, site of recent timber harvest, streambed was dry during site visits in August & September	18%	not included directly in the model*	
BG03	Upper East Fork, confined, mid-size stream in conifers (big cedars) with some logging	63%	not included directly in the model*	
BG04	Lower East Fork, likely historic harvest of valley bottoms	36%	not included directly in the model*	
BG05	Upper West Fork, shrub meadow with conifers on hillslopes, historic road, likely historic harvest	21%	Big 3	
BG06	West Fork above Middle Fork, shrubs and conifers, beaver impacts at lower end	42%	Big 4	
BG07	West Fork above East Fork, typical shrub meadow in area with beaver influence	23%	Big 5, 6	
BG08 (1&2)	Big Creek mainstem in area dominated by conifers, appears to be approaching natural conditions for the size of the stream	52%	Big 7	Big 5, 6,7, 8
BG08 (3)	Big Creek mainstem in area dominated by cottonwoods, with overwidened channel and exposed gravel bars	24%	Big 8	
BG01 (1&2) & BG03 (2&3)	Reference conditions for confined, mid-size streams in conifers (big cedars) with some logging, based on BG01-1,2 & BG03-2,3	71%		Mainstem headwaters, Big 2, 3, 4

* Riparian shade data for the East Fork and Middle Fork, which includes field defined reaches BG02, BG03 and BG04, was not included directly in the modeled since these tributaries were considered “point sources” (see bullet #7).

4. The model was first run with 0% shade between the hours of 6am and 5pm (**Figure C-6**). This was done to assess potential groundwater inputs at temperature data logger WFBG03. This area was of interest since there was a large beaver complex upstream of site WFBG02 that greatly reduced streamflow. In addition, the Middle Fork was dewatered between the upper (MFBG01) and lower (MFBG02) temperature data loggers and groundwater upwelling was observed at the lower data logger (WFBG03). When the hydrologic balance was performed (see **Attachment B**), it appeared that all the water “lost” from the West and Middle forks upstream of their confluences was “gained” by the West Fork at site WFBG03 just upstream of the confluence with the East Fork and the start of the Big Creek mainstem. This large upwelling of groundwater led to decreased stream temperatures at data loggers WFBG03 and BIGC01 (points 3 and 4 on **Figure C-6**). When the model was run with existing stream temperatures and no shade, the results supported the hypothesis that stream temperature at these two sites was primarily controlled by groundwater upwelling.

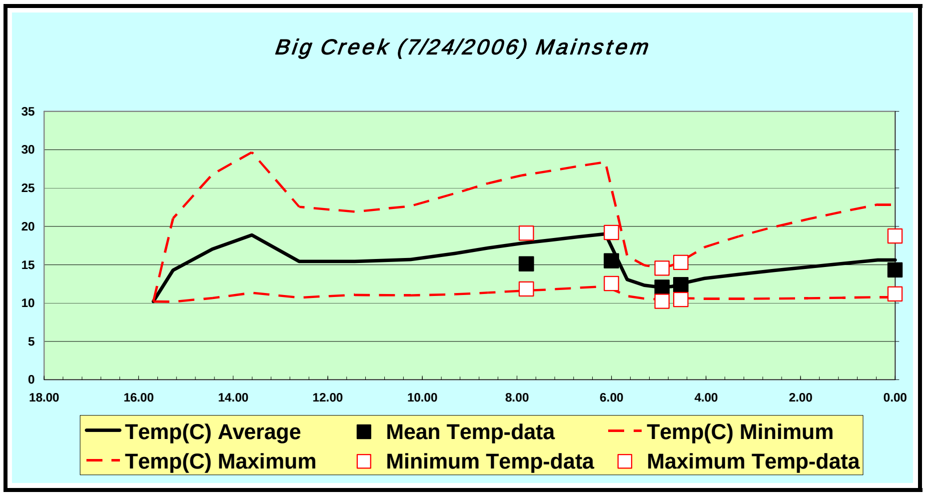

Figure C-6. QUAL2K Model Results for Big Creek with No Shade

5. When the QUAL2K model was run with the existing shade, the results provide further support for the hypothesis that stream temperature at data loggers WFBG03 and BIGC01 was primarily controlled by groundwater upwelling, while riparian shading plays an important role in stream temperatures in the West Fork Big Creek (**Figure C-7**). It is worth noting that the mean daily stream temperature increased 1.9°C (3.5°F) on July 24, 2006, between the headwaters of the Big Creek mainstem at the confluence with the West and East Forks and the mouth, which is a distance of approximately 4.5 miles. In addition, it was observed that Big Creek was a "losing" stream between the upper (BIGC01) and lower (BIGC02) data loggers and it was noted in the field that this appeared to occur in an over-widened area with aggraded gravel bar conditions along the lowermost 2 miles of Big Creek. It is unclear what process led to the existing aggraded conditions, though the 1910 fires, historic timber harvest, the presence of a large bridge, or a combination of all of these factors may have led to the aggradation.

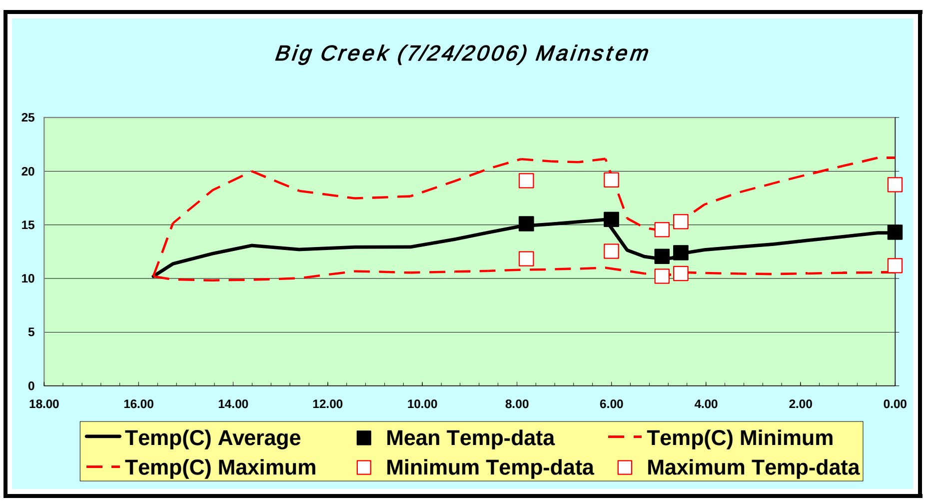

Figure C-7. QUAL2K Model Results for Big Creek with Existing Shade

6. The potential for increased shade was then modeled, with reaches "Mainstem headwaters," Big2, Big3, and Big4 modeled based on reference data from BG01 and

BG03, and shade along the lower West Fork (Big5 and Big6) and the mainstem of Big Creek (Big7 and Big8) modeled based on shade for Big7 (**Figure C-8**). The model predicated that temperatures on the West Fork could be lowered by increasing the amount of shading, and that this would lead to a slight decrease in stream temperatures along the mainstem of Big Creek. Increased shading on the Middle Fork is not likely to influence temperatures at this time since the stream becomes dewatered in mid-summer, though the anthropogenic role in this phenomenon is unknown. Temperatures in the East Fork influence the Big Creek mainstem, though the existing data and the model suggest that relatively cool water due to groundwater upwelling is the major influence on water temperature at the upper end of the mainstem of Big Creek. Temperatures then increase in the downstream direction, which is likely related to a loss of shade in the aggraded gravel-bar area, along with a loss of streamflow to groundwater infiltration.

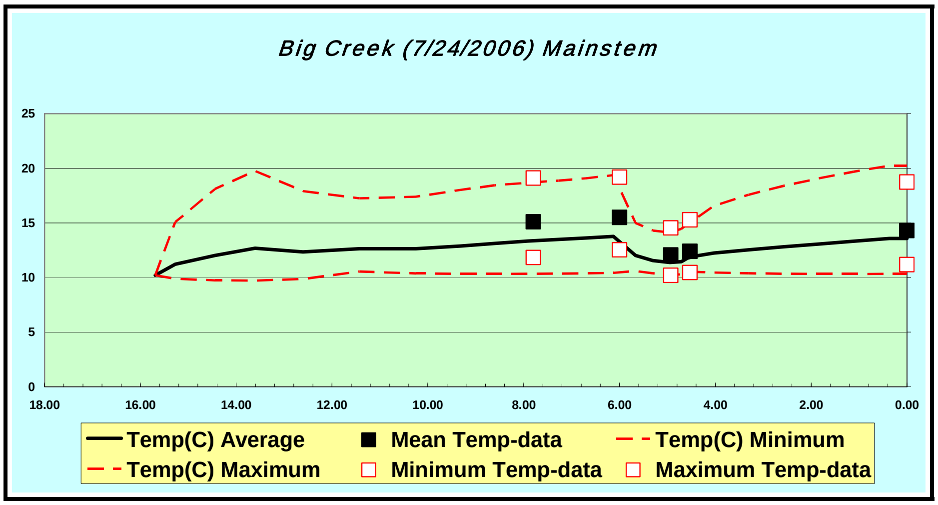

Figure C-8. QUAL2K Model Results for Big Creek with Increased Shade

7. The additional influence of timber harvest in tributary watersheds was then analyzed for the potential to affect water temperatures in Big Creek. As in Twelvemile Creek, it was estimated that an approximately 1.8°F (1°C) reduction in tributary stream temperature could be achieved through an increase in streamside shading. This value was applied to all of the modeled tributaries within the watershed, which include the Middle Fork Big Creek, East Fork Big Creek, and Gilt Edge Creek, which is a tributary of the West Fork Big Creek. This resulted in a slight decease in stream temperatures along the mainstem of Big Creek (**Figure C-9**).

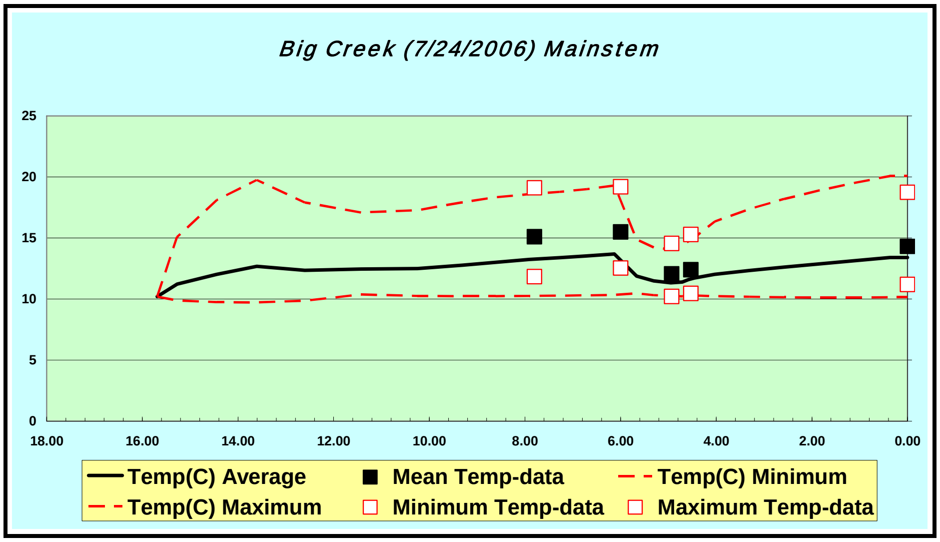

Figure C-9. QUAL2K Model Results for Big Creek with Increased Shade and Decreased Tributary Temperatures

Big Creek Modeled Temperatures Relative to Montana Standards

To evaluate the QUAL2K model results relative to Montana's water quality standards, the maximum temperatures predicted in the model scenario for increased shading and decreased tributary inputs were compared to the maximum temperatures predicted by the model for the existing shade conditions. The QUAL2K model results indicated that stream temperature along the mainstem of Big Creek could be decreased by greater than 1ºF by increasing the amount of shade (**Figure C-8** and **Table C-5**). A slight additional reduction in stream temperature could be achieved by decreasing temperatures on tributary streams (**Figure C-9**). This result suggests that Big Creek is exceeding Montana's water quality standard and that reduced shading resulting from anthropogenic disturbance is partially responsible for the increase in stream temperatures. Warm water inputs from the East Fork and West Fork are identified as sources of increased stream temperatures to Big Creek.

Table C-5. QUAL2K Model Results for Big Creek Relative to Montana Standards

Data Logger Site	Field Measured Data		QUAL2K Modeled "Existing Shade"		QUAL2K Modeled "Increased Shade"		QUAL2K Modeled "Increased & Decreased Tributary Temperature"	
	Distance (km)	Maximum Temperature (°F)	Estimated Maximum Temperature (°F)	Departure from Field Data (°F)	Estimated Maximum Temperature (°F)	Departure from "Existing Shade" Model (°F)	Estimated Maximum Temperature (°F)	Departure from "Existing Shade" Model (°F)
WFB01	7.8	66.4	70.0	3.64	65.6	-4.39	65.5	-4.57
WFB02	6.00	66.5	70.1	3.54	66.9	-3.20	66.7	-3.34
WFB03	4.93	58.2	58.1	-0.12	57.4	-0.63	57.3	-0.73
BIG01	4.53	59.5	59.4	-0.10	58.8	-0.60	58.5	-0.93
BIG02	0.00	65.7	70.2	4.51	68.4	-1.82	68.1	-2.12

ST. REGIS RIVER CANOPY DENSITY ASSESSMENT

The canopy density along the St. Regis River was initially assessed using 2000 vintage aerial photographs (1:15,840 scale) and a mirror stereoscope in 2003. This assessment is summarized in Section 7.1.2 of the *Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs* (MDEQ 2006b), with a more detailed discussion provided in **Appendix K**. During the aerial assessment, canopy density was determined at the reach scale. In addition to the reach scale measurements, canopy density of specific riparian stands was noted on hard copy aerial photos at twenty-five sites. Canopy cover was field verified in 2003 utilizing a spherical densiometer at seven of these sites in which aerial photo interpretation ranged from 35-75% canopy cover. The purpose of field verification was to assess the results of the aerial assessment within riparian stands for which the canopy density was specifically noted. Canopy cover measurements using a spherical densiometer averaged 11% higher than the aerial photo interpretation with the mirror stereoscope indicated. In 2006, canopy density was field verified at an additional twelve sites to provide further support for the aerial photograph assessment.

Densiometer Measurements

Canopy density was assessed with a spherical densiometer at twelve sites along the St. Regis River on August 15th and 16th, 2006. These sites were assessed to confirm the accuracy of the aerial photograph assessment for canopy density along the St. Regis River. Sites were selected from the twenty-five sites for which canopy density was specifically noted in 2003. Sites were selected to span a range of canopy densities (25%-85%), while also evaluating the canopy density of different types of riparian vegetation (cottonwood vs. conifer). Densiometer measurements ranged from 2% below the aerial assessment measurements to 14% above the aerial assessment measurements in the 2006 assessment (**Table C-6**). Densiometer measurements at these twelve sites indicated a greater percentage of canopy density than in the aerial assessment by an average of 4%. Based on the results of ground truthing performed in 2003 and 2006, it is estimated that actual canopy densities average between 4% and 11% greater than the aerial assessment indicates. Field data from the 2006 assessment is presented in **Attachment E**.

Table C-6. Canopy Density Comparison between Aerial Assessment and Densiometer Measurements

AERIAL ASSESSMENT		DENSIOMETER	
Reach	**Canopy Density (%)**	**Site ID**	**Canopy Density (%)**
1	75	**SR 1.0-1**	75
1.7	55	**SR 1.7-1**	62
1.9	55	**SR 1.9 -1**	63
4.1	45	**SR 4.1-1**	43
5	50	**SR 5.0-1**	57
5.3	45	**SR 5.3-1**	47
5.4	35	**SR 5.4-1**	34
5.5	35	**SR 5.5-1**	49
5.7	25	**SR 5.7-1**	28
7.5	75	**SR 7.5-1**	88
7.5	55	**SR 7.5-2**	53
7.7	85	**SR 7.7-1**	84

REFERENCES

MDEQ. 2006a. Field Monitoring and Temperature Modeling Sampling and Analysis Plan for the 2006 Field Season. Prepared by PBS&J, Helena, Montana: PBS&J.

MDEQ. 2006b. Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs. Prepared by PBS&J.

U.S. Fish and Wildlife Service. 1998. A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale.

ATTACHMENT A
2006 TEMPERATURE DATA SUMMARY

St. Regis TMDL Planning Area

Big Creek Watershed

Site ID	Site Name	Lat	Long	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max T		Seasonal Maximum 7-Day Averages			
						Date	Value	Date	Value	Date	Value	Date	Daily Maximum	Daily Minimum	T
WFBG01	530220- West fork Big Creek upper site	47.37182	115.4597	07/11/06	09/12/06	07/24/06	66.4	09/02/06	44.4	07/21/06	14.1	07/25/06	65.7	52.2	13.5
WFBG02	530250-West fork above Middle fork "notch"	47.36496	115.44315	07/11/06	09/12/06	07/23/06	66.8	09/02/06	45.1	09/11/06	14.2	07/25/06	66.0	53.6	12.5
WFBG03	584786-West fork at mouth, above east fork	47.36219	115.43198	07/11/06	09/11/06	07/24/06	58.2	09/11/06	45.9	07/14/06	10.3	07/23/06	57.7	49.6	8.1
MFBG01	530247-Middle Fork-upper site at upstream end of meadow	47.35277	115.47286	07/11/06	09/11/06	07/24/06	63.1	09/01/06	42.1	08/14/06	11.7	07/25/06	62.1	51.2	10.9
MFBG02	584807-Middle fork above West fork	47.36379	115.44207	07/11/06	09/12/06	07/24/06	65.2	09/11/06	46.9	07/19/06	13.8	07/24/06	64.5	52.6	11.9
EFBG01	530225-EF Big Creek	47.34785	115.43278	07/11/06	09/12/06	07/23/06	61.7	09/01/06	42.3	07/14/06	9.8	07/25/06	60.7	52.0	8.7
EFBG02	530206-East Fork above mouth	47.3617	115.43031	07/11/06	09/11/06	07/24/06	60.8	09/02/06	44.6	07/15/06	9.2	07/25/06	60.2	51.7	8.5
EFBG03	530219-EF Big Creek, lower most fork	47.36141	115.42957	07/11/06	09/11/06	07/24/06	62.3	09/02/06	45.5	07/21/06	10.1	07/25/06	61.5	51.9	9.6
BIGC01	530232-Big Creek below E and W forks	47.36247	115.42743	07/11/06	09/11/06	07/24/06	59.5	09/02/06	45.5	07/14/06	10.1	07/25/06	59.0	50.3	8.7
BIGC02	530209-Big Creek by railroad bridge	47.37752	115.38597	07/11/06	09/11/06	07/24/06	65.8	07/31/06	48.0	07/21/06	14.1	07/25/06	65.0	51.5	13.5

Big Creek Watershed

Site ID	Site Name	Days > 50 F	Days > 59 F	Days > 70 F	Hours > 50 F	Hours > 59 F	Hours > 70 F	Warmest day of 7-day max			Agency
								Date	Maximum	Minimum	
WFBG01	530220- West fork Big Creek upper site	64	34	0	1204.5	199.5	0.0	07/23/06	66.4	53.3	DEQ
WFBG02	530250-West fork above Middle fork "notch"	64	54	0	1346.0	329.5	0.0	07/23/06	66.8	54.6	DEQ
WFBG03	584786-West fork at mouth, above east fork	62	0	0	710.0	0.0	0.0	07/23/06	58.2	50.4	DEQ
MFBG01	530247-Middle Fork-upper site at upstream end of meadow	63	14	0	944.0	55.5	0.0	07/24/06	63.1	52.1	DEQ
MFBG02	584807-Middle fork above West fork	63	21	0	1171.0	137.5	0.0	07/23/06	65.2	53.6	DEQ
EFBG01	530225-EF Big Creek	64	9	0	1059.5	47.5	0.0	07/23/06	61.7	53.2	DEQ
EFBG02	530206-East Fork above mouth	63	7	0	972.5	28.0	0.0	07/24/06	60.8	52.7	DEQ
EFBG03	530219-EF Big Creek, lower most fork	63	11	0	1072.0	44.5	0.0	07/24/06	62.3	52.8	DEQ
BIGC01	530232-Big Creek below E and W forks	63	2	0	762.0	4.5	0.0	07/23/06	59.5	50.8	DEQ
BIGC02	530209-Big Creek by railroad bridge	63	46	0	1372.5	244.0	0.0	07/24/06	65.8	52.2	DEQ

Twelvemile Creek Watershed

Site ID	Site Name	Lat	Long	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max T		Seasonal Maximum 7-Day Averages			
						Date	Value	Date	Value	Date	Value	Date	Daily Maximum	Daily Minimum	T
TWLM01	530216-Twelvemile Cr. above Trapper Cabin @ mile marker 8	47.4664	115.25957	07/12/06	09/10/06	07/23/06	55.6	09/01/06	41.9	08/06/06	5.0	07/25/06	54.5	50.1	4.4
TWLM02	530238-Twelvemile Cr. above Mineral Mt. Cr.	47.43311	115.24282	07/12/06	09/10/06	07/24/06	62.7	09/01/06	41.4	08/06/06	10.9	07/25/06	61.8	51.9	9.9
TWLM03	530231-Twelvemile Cr. above Flatrock	47.38748	115.24949	07/12/06	09/10/06	07/23/06	65.5	09/01/06	42.9	07/21/06	11.6	07/25/06	64.2	53.5	10.8
TWLM04	584847-Twelvemile Creek above east fork	47.36701	115.26478	07/12/06	09/10/06	07/23/06	67.8	09/01/06	42.7	08/06/06	13.5	07/25/06	66.6	54.1	12.5
TWLM05	530228-Twelvemile Cr. Upstream of Rock Cr.	47.3853	115.2886	07/12/06	09/10/06	07/23/06	68.1	09/01/06	43.0	09/02/06	15.3	07/25/06	67.1	53.4	13.6
TWLM06	530237-Twelvemile at mouth	47.34949	115.29169	07/12/06	09/10/06	07/23/06	67.7	09/01/06	43.9	07/21/06	15.3	07/25/06	66.7	52.3	14.3
FLAT01	584732-Flat Rock Cr. Above bridge under moss covered log	47.3875	115.24843	07/12/06	09/10/06	07/24/06	61.6	09/01/06	42.6	07/17/06	9.8	07/25/06	60.8	51.8	9.0
EFTM01	530251-East fork Twelvemile	47.36773	115.26252	07/12/06	09/10/06	07/15/06	45.2	09/02/06	41.9	09/02/06	2.5	07/25/06	44.9	43.1	1.9
ROCK01	530236-Rock Creek mouth	47.35618	115.28838	07/12/06	09/10/06	07/15/06	55.4	08/03/06	44.0	08/14/06	10.6	07/25/06	54.9	44.9	10.0

Twelvemile Creek Watershed

Site ID	Site Name	Days > 50 F	Days > 59 F	Days > 70 F	Hours > 50 F	Hours > 59 F	Hours > 70 F	Warmest day of 7-day max			Agency
								Date	Maximum	Minimum	
TWLM01	530216-Twelvemile Cr. above Trapper Cabin @ mile marker 8	45	0	0	495.5	0.0	0.0	07/23/06	55.6	50.8	DEQ
TWLM02	530238-Twelvemile Cr. above Mineral Mt. Cr.	61	10	0	940.5	40.5	0.0	07/23/06	62.7	53.1	DEQ
TWLM03	530231-Twelvemile Cr. above Flatrock	61	24	0	1213.5	175.0	0.0	07/23/06	65.5	54.7	DEQ
TWLM04	584847-Twelvemile Creek above east fork	61	42	0	1240.0	293.0	0.0	07/23/06	67.8	55.2	DEQ
TWLM05	530228-Twelvemile Cr. Upstream of Rock Cr.	61	50	0	1214.5	316.0	0.0	07/23/06	68.1	54.7	DEQ
TWLM06	530237-Twelvemile at mouth	61	43	0	1227.0	292.0	0.0	07/23/06	67.7	53.7	DEQ
FLAT01	584732-Flat Rock Cr. Above bridge under moss covered log	61	8	0	1032.5	40.5	0.0	07/23/06	61.6	52.9	DEQ
EFTM01	530251-East fork Twelvemile	0	0	0	0.0	0.0	0.0	07/22/06	44.9	43.0	DEQ
ROCK01	530236-Rock Creek mouth	61	0	0	425.0	0.0	0.0	07/23/06	55.2	45.4	DEQ

ATTACHMENT B
STREAMFLOW DATA

St. Regis TMDL Planning Area

Stream Segment	Site	Site Name	Date	Flow (cfs)	Flow (cms)	Temperature (ºC)	Time
Twelvemile Creek	upstream of Trapper Cabin Cr	TWLM01	8/17/07	2.50	0.071	9.0	7:45
Twelvemile Creek	upstream of Mineral Mt Cr	TWLM02	8/17/07	7.84	0.222	9.9	9:15
Twelvemile Creek	upstream of Flat Rock Creek	TWLM03	8/17/07	8.08	0.229	11.3	11:15
Twelvemile Creek	upstream of East Fork Twelvemile Creek	TWLM04	8/17/07	13.00	0.368	12.4	12:00
Twelvemile Creek	upstream of Rock Creek	TWLM05	8/17/07	10.37	0.294	14.0	13:15
Twelvemile Creek	at mouth	TWLM06	8/17/07	10.27	0.291	12.8	13:45
Flat Rock Creek	at mouth	FLAT01	8/17/07	5.83	0.1651	10.2	10:45
East Fork Twelvemile Cr	at mouth	EFTM01	8/17/07	1.06	0.030	6.6	11:45
Rock Creek	at mouth	ROCK01	8/17/07	3.92	0.111	11.5	13:00
tributary		Trib 1	8/17/07	0.2*	0.01	9.3	8:15
tributary	Trapper Cabin Creek	Trib 2	8/17/07	4.0*	0.11	8.9	8:30
tributary	tributary north of Breen Creek	Trib 3	8/17/07	0.4*	0.01	9.7	8:45
tributary	Mineral Mountain Creek	Trib 4	8/17/07	2.0*	0.06	9.5	9:45
tributary		Trib 5	8/17/07	0.4*	0.01	8.3	10:15
tributary		Trib 6	8/17/07	0.8*	0.02	8.6	10:30

* Flow Visually Estimated

Stream Segment	Site	Site Name	Date	Flow (cfs)	Flow (cms)	Temperature (ºC)	Time
Big Creek	downstream of confluence of West & East fks	BIGC01	8/14/07	17.05	0.48	12.9	15:45
Big Creek	at mouth	BIGC02	8/14/07	8.40	0.24	15.8	18:45
East Fork Big Creek	upper	EFBG01	8/14/07	3.88	0.11	13.1	18:00
East Fork Big Creek	at mouth - upstream fork	EFBG02	8/14/07	2.29	0.06	12.3	14:30
East Fork Big Creek	at mouth - downstream fork	EFBG03	8/14/07	1.10	0.03	12.6	15:00
West Fork Big Creek	upper	WFBG01	8/14/07	4.20	0.12	10.6	11:15
West Fork Big Creek	upstream of Middle Fork confluence	WFBG02	8/14/07	1.70	0.05	12.9	12:45
West Fork Big Creek	at mouth	WFBG03	8/14/07	13.91	0.39	12.0	14:15
Middle Fork Big Creek	upper	MFBG01	8/14/07	3.14	0.09	14.5	17:00
Middle Fork Big Creek	at mouth	MFBG02	8/14/07	0.57	0.02	10.9	12:30

ATTACHMENT C
SOLAR PATHFINDER DATA

St. Regis TMDL Planning Area

Twelvemile Creek

Reach	Section	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	Site
	Potential	3	5	8	10	12	12	12	12	10	8	5	3	Average
TM01-1	Upstream	3	5	6	2	12	12	12	12	10	8	5	3	90
TM01-2	Middle	3	5	7	6	10	12	11	12	10	8	5	3	92
TM01-3	Downstream	3	5	7	9	9	9	9	10	9	8	5	3	86
TM01	**Average %**	**100%**	**100%**	**83%**	**57%**	**86%**	**92%**	**89%**	**94%**	**97%**	**100%**	**100%**	**100%**	**89%**
TM02-1	Upstream	3	5	7	9	1	6	2	0	7	7	5	3	55
TM02-2	Middle	3	5	4	10	12	9	1	6	7	8	5	3	73
TM02-3	Downstream	3	5	8	9	9	3	0	0	0	5	5	3	50
TM02	**Average %**	**100%**	**100%**	**79%**	**93%**	**61%**	**50%**	**8%**	**17%**	**47%**	**83%**	**100%**	**100%**	**59%**
TM03-1c	Upstream center	3	5	8	7	0	0	0	2	10	8	5	3	51
TM03-1l	Upstream left	3	5	8	5	0	0	0	0	8	8	5	3	45
TM03-1r	Upstream right	3	5	7	3	0	0	0	11	10	8	5	3	55
TM03-2c	Middle center	3	5	8	10	11	2	3	0	8	8	5	3	66
TM03-2l	Middle left	3	5	8	10	12	6	4	0	3	7	5	3	66
TM03-2r	Middle right	3	5	7	9	8	3	0	6	10	8	5	3	67
TM03-3c	Downstream center	3	5	5	3	0	0	0	9	9	8	5	3	50
TM03-3l	Downstream left	3	5	6	5	2	0	0	8	8	8	5	3	53
TM03-3r	Downstream right	3	5	4	0	0	0	3	11	9	8	5	3	51
TM03	**Average %**	**100%**	**100%**	**85%**	**58%**	**31%**	**10%**	**9%**	**44%**	**83%**	**99%**	**100%**	**100%**	**56%**
TM04-1c	Upstream center	3	5	8	9	9	6	7	0	0	3	4	3	57
TM04-1l	Upstream left	3	5	8	9	10	9	11	7	1	0	2	3	68
TM04-1r	Upstream right	3	5	7	7	8	5	5	0	0	3	5	3	51
TM04-2c	Middle center	3	5	8	9	8	8	4	2	8	8	4	3	70
TM04-2l	Middle left	3	5	8	9	6	8	4	8	9	8	4	3	75
TM04-2r	Middle right	3	5	8	9	9	9	6	0	3	7	4	3	66
TM04-3c	Downstream center	3	4	2	0	0	11	9	0	5	4	3	1	42
TM04-3l	Downstream left	3	4	6	2	3	7	11	2	3	4	4	1	50
TM04-3r	Downstream right	3	2	0	0	5	12	1	0	5	5	4	2	39
TM04	**Average %**	**100%**	**89%**	**76%**	**60%**	**54%**	**69%**	**54%**	**18%**	**38%**	**58%**	**76%**	**81%**	**58%**
TM05-1c	Upstream center	3	5	8	7	0	0	0	0	0	0	0	2	25
TM05-1l	Upstream left	3	5	7	9	11	8	1	0	0	0	0	1	45
TM05-1r	Upstream right	3	5	3	5	0	0	0	0	0	0	1	2	19
TM05-2c	Middle center	3	2	0	0	0	0	0	1	0	0	0	1	7
TM05-2l	Middle left	3	4	0	0	0	0	0	3	0	0	0	1	11
TM05-2r	Middle right	2	1	0	0	0	0	0	0	0	0	0	2	5
TM05-3c	Downstream center	2	5	8	9	0	5	0	0	0	0	2	2	33
TM05-3l	Downstream left	3	5	8	10	3	1	7	0	0	0	1	2	40
TM05-3r	Downstream right	3	4	6	9	1	5	0	0	0	0	2	3	33
TM05	**Average %**	**93%**	**80%**	**56%**	**54%**	**14%**	**18%**	**7%**	**4%**	**0%**	**0%**	**13%**	**59%**	**24%**
TM06-1c	Middle center	3	5	8	10	9	11	3	0	0	2	2	1	54
TM06-1l	Middle left	3	5	8	10	8	8	6	0	0	0	3	1	52
TM06-1r	Middle right	3	5	8	8	10	7	0	0	1	6	1	2	51
TM06	**Average %**	**100%**	**100%**	**100%**	**93%**	**75%**	**72%**	**25%**	**0%**	**3%**	**33%**	**40%**	**44%**	**52%**

Big Creek

Reach	Section	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	Site Average
	Potential	3	5	8	10	12	12	12	12	10	8	5	3	
BG01-1	Upstream	3	5	8	10	3	2	0	7	10	4	5	3	60
BG01-2c	Middle center	3	5	8	10	12	12	8	0	4	6	5	3	76
BG01-2l	Middle left	3	5	8	10	12	12	4	2	2	7	5	3	73
BG01-2r	Middle right	3	5	8	10	12	12	12	3	4	5	5	3	82
BG01-3	Downstream	3	1	0	0	0	1	4	3	0	0	4	3	19
BG01	**Average %**	**100%**	**84%**	**80%**	**80%**	**65%**	**65%**	**47%**	**25%**	**40%**	**55%**	**96%**	**100%**	**62%**
BG02-1c	Upstream center	3	2	0	0	0	0	0	0	0	0	0	2	7
BG02-2l	Upstream left	3	2	1	0	0	0	0	0	0	0	0	3	9
BG02-2r	Upstream right	3	2	1	1	0	0	0	0	0	0	0	2	9
BG02-2	Middle	3	5	4	5	0	4	0	0	0	0	0	2	23
BG02-3	Downstream	2	0	0	1	7	11	1	8	9	3	0	1	43
BG02	**Average %**	**93%**	**44%**	**15%**	**14%**	**12%**	**25%**	**2%**	**13%**	**18%**	**8%**	**0%**	**67%**	**18%**
BG03-1	Upstream	3	5	8	7	8	0	1	2	10	7	4	3	58
BG03-2	Middle	3	5	8	9	11	9	1	0	0	3	5	3	57
BG03-3	Downstream	3	5	7	10	12	10	0	9	3	8	5	3	75
BG03	**Average %**	**100%**	**100%**	**96%**	**87%**	**86%**	**53%**	**6%**	**31%**	**43%**	**75%**	**93%**	**100%**	**63%**
BG04-1	Upstream	3	5	8	9	3	2	0	0	0	6	5	3	44
BG04-2	Middle	3	5	3	9	11	0	0	7	0	0	3	3	44
BG04-3	Downstream	3	5	2	0	0	0	0	0	0	3	3	3	19
BG04	**Average %**	**100%**	**100%**	**54%**	**60%**	**39%**	**6%**	**0%**	**19%**	**0%**	**38%**	**73%**	**100%**	**36%**
BG05-1	Upstream	2	0	0	0	6	6	5	0	0	0	1	3	23
BG05-2	Middle	2	0	0	0	0	0	0	4	10	7	4	1	28
BG05-3	Downstream	2	0	0	5	0	0	0	0	0	0	1	3	11
BG05	**Average %**	**67%**	**0%**	**0%**	**17%**	**17%**	**17%**	**14%**	**11%**	**33%**	**29%**	**40%**	**78%**	**21%**
BG06-1	Upstream	3	4	4	0	0	8	9	11	9	8	5	3	64
BG06-2	Middle	3	4	7	2	0	0	0	1	9	8	5	3	42
BG06-3	Downstream	3	2	1	5	0	0	0	0	0	0	5	3	19
BG06	**Average %**	**100%**	**67%**	**50%**	**23%**	**0%**	**22%**	**25%**	**33%**	**60%**	**67%**	**100%**	**100%**	**42%**
BG07-1c	Upstream center	2	1	0	0	0	0	0	0	0	0	0	1	4
BG07-1l	Upstream left	1	0	0	0	0	0	0	0	0	0	0	2	3
BG07-1r	Upstream right	3	5	8	10	12	11	10	11	1	2	1	0	74
BG07-2c	Middle center	3	5	8	5	0	0	0	0	0	0	0	2	23
BG07-2l	Middle left	0	0	0	0	0	0	0	0	0	0	1	3	4
BG07-2r	Middle right	3	5	8	9	11	6	8	2	0	0	0	1	53
BG07-3c	Downstream center	3	5	5	0	0	0	0	0	0	0	0	1	14
BG07-3l	Downstream left	2	0	0	0	0	0	0	0	0	0	0	2	4
BG07-3r	Downstream right	3	5	8	9	3	2	0	0	0	0	0	2	32
BG07	**Average %**	**74%**	**58%**	**51%**	**37%**	**24%**	**18%**	**17%**	**12%**	**1%**	**3%**	**4%**	**52%**	**23%**
BG08-1c	Upstream center	3	5	8	10	12	8	1	0	0	0	3	3	53
BG08-1l	Upstream left	3	5	8	10	11	6	0	0	0	5	5	3	56
BG08-1r	Upstream right	3	5	8	10	12	8	11	1	0	0	1	2	61
BG08-2c	Middle center	3	5	7	9	8	7	0	0	0	3	5	3	50
BG08-2l	Middle left	3	5	7	7	2	2	0	0	0	4	4	3	37
BG08-2r	Middle right	3	5	7	9	11	10	2	0	0	1	4	3	55
BG08-3c	Downstream center	3	3	0	0	0	0	0	10	5	0	0	2	23
BG08-3l	Downstream left	3	5	3	0	0	0	0	9	5	0	0	3	28
BG08-3r	Downstream right	1	0	0	0	0	0	0	7	9	1	0	2	20
BG08	**Average %**	**93%**	**84%**	**67%**	**61%**	**52%**	**38%**	**13%**	**25%**	**21%**	**19%**	**49%**	**89%**	**43%**

ATTACHMENT D
FIELD NOTES

St. Regis TMDL Planning Area

Twelvemile Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
TM01-1	0	6.5	10.6	PIEN	72	conifers	alders, topography	Dense alder understory w/conifers in overstory, PIEN, PICO, PSME, ABGR	Road present on river left, some hillslope logging, but retained riparian corridor
TM01-2	0	10.1	13.2	ABLA	86	conifers	alders, topography	Small stream with subalpine fir overstory mixed with Doug Fir, young and old cedars, Engelmann spruce, lots of shade representing more natural/potential conditions	Road present about 100 ft from channel
TM01-3	0	8.3	11.4	ABLA	92	conifers	alders, topography	PIEN, THPL, ABLA, PSME, present	Road further confines channel in small valley bottom in areas
TM02-1	0	5.8	9.1	ABLA	39	conifers	alders, topography	ABLA, THPL, alder, red osier, PIEN, present: many trees are taller than the ones accounting for the shade at the site	Several clearcuts along right side of river w/minimal riparian buffer, stumps present along bank=riparian harvest
TM02-2	0	17.1	19.4	PIEN	111	conifers	alders, topography	Dense alders along channel	Clearcut/road on river left (just upstream) and clearcut along right, though there is a band of conifers along channel
TM02-3	0	18.8	23.9	ABLA	65	conifers	alders, topography	Road is along river right abutting channel in places with a narrow band of spruce and alder at bankfull	A road limits the riparian vegetation on river right and hillslope cut
TM03-1	0	18.0	25.1	PIEN	147	conifers	alders, topography	Medium size stream with Red osier, alder, Engelmann spruce, subalpine fir, larch, cedar trees present	Road present about 100 ft from channel, a few old cut stumps present in riparian zone
TM03-2	0	20.6	31.8	ABLA	103	conifers	alders, topography	Medium size stream with Red osier, alder, Engelmann spruce, subalpine fir, larch, cedar trees present	Road along river right with narrow band of conifers and alders
TM03-3	0	20.0	29.9	Alder	25	conifers	alders, topography	Medium size stream with Red osier, alder, Engelmann spruce, subalpine fir, larch, cedar trees present	Stream is primarily away from road
TM04-1	45	28.8	36.4	PICO	81	conifers	alders,	Alder and red osier, PIPO,	Road along river left, some

Twelvemile Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
TM01-1	0	6.5	10.6	PIEN	72	conifers	alders, topography	Dense alder understory w/conifers in overstory, PIEN, PICO, PSME, ABGR	Road present on river left, some hillslope logging, but retained riparian corridor
							topography	ABLA, PSME, THPL, Larch present	shrubs and sparse conifers on hillslope
TM04-2	0	24.3	30.6	LAOC	102	conifers	alders, topography	Valley is becoming more open with Sub Alpine fir, Engelmann spruce, larch, grand fir, cedar, lodgepole, ponderosa, Douglas fir, cottonwoods and alders	Road is present, but up higher on the hilslope
TM04-3	45	18.2	25.1	Cottonwoods	85	alders	alders, topography	Some cottonwoods, and conifers, alders, PICO encroaching on floodplain	Site is below Cabin City campground, it appears channelized or entrenched w/ loss of riparian forest, old channels present on floodplain suggesting channel relocation
TM05-1	0	27.4	32.1	PIEN	70	conifers	alders, topography	River left has mostly conifers, river right appears to be a former cottonwood gallery w/sparse shrubs and PICO, PIEN	Upstream channelization leading to overwidening and bank erosion limiting shrub development
TM05-2	45	20.7	28.4	PIEN	102	conifers	alders, topography	Limited shade, grassy, small alders present and sparse conifers	Roads and timber harvest led to loss of riparian and hillslope vegetation
TM05-3	0	19.5	26.7	ABLA	73	conifers	alders, topography	Mature cottonwoods present on river right, mostly conifers on river left	Logging and road building reduces shade
TM06-1	0	26.3	32.6	PSME	72	alders	topography	PSME and large PIPO along river right w/ABLA, Alder on river left w/some cottonwoods farther back	Road fill across Rock and Twelvemile creek, floodplain dynamic alteration

ABGR Grand fir

ABLA Subalpine fir

PICO Lodgepole pine

PIMO White pine

PIPO Ponderosa pine

Twelvemile Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
TM01-1	0	6.5	10.6	PIEN	72	conifers	alders, topography	Dense alder understory w/conifers in overstory, PIEN, PICO, PSME, ABGR	Road present on river left, some hillslope logging, but retained riparian corridor

PIEN Engelmann spruce

PSME Douglas fir

THPL Western red cedar

Big Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
BG1-1	0	15.6	19.5	ABLA	72	conifers	alders, topography	Dense conifer forest (ABLA, THPL, PIEN)	Road encroachment in places, upstream harvest?, stream becomes much smaller upstream of site, historic logging of THPL
BG1-2	45	21.8	30.8	ABGR	114	conifers	alders, topography	Dense THPL, near where confined canyon opens up, wide B3 channel, some red osier, mountain maple, willow along margin, also, ABGR, THPL with good overhang, 80% approx.	Historic THPL logging present in riparian
BG1-3	90	12.7	24.6	ABGR	31	conifers	alders, topography	ABGR, ABLA, Larch, PIEN and shrubs present	Road clearing at lower end of site
BG2-1	90	23.5	32.5	Willow	6	willow	conifers	Shrubs with some PSME, PICO, PIEN, ABGR, cottonwoods, with wide channel and some bank erosion	Riparian harvest present
BG2-2	90	dry	22.2	Willow	8	willow	conifers	Channel is dry! Larch, PICO, ABLA, PSME, ABGR, on river right, left side has willows, red osier, and some cottonwoods	Current harvest along river right above low bench, 47' from river right to top of bench, fully cleared at 90', SMZ flagging at 75'.
BG2-3	90	dry	22.4	Cottonwoods	33	willow	cottonwoods	Channel is dry! Cottonwoods w/shrubs present, willows are moving into the channel	Logging present, w/floodplain buffer

Big Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
BG3-1	0	15.3	24.1	ABGR	40	conifers	alders, topography	Conifers along channel, logging influences shade in the late afternoon, ABGR, PIEN, THPL, some cottonwoods, Mountain maple, Red osier, ABLA and PSME present	Clearcut along river right that reduces shade some, historic (stumps) along river left
BG3-2	45		22.9	PIEN	140	conifers	alders, topography	Dense cedars along river right (with historic logging), some PIEN and riparian shrubs present	Road and logging, both have forest buffer along stream
BG3-3	0	18.0	24.8	THPL	86	conifers	alders	Lots of cedar with PIEN, ABGR, this looks like PNC w dense cedar bottom, deadfall across channel.	Minimal, a few stumps from historic logging
BG4-1	0	12.1	17.2	THPL	107	conifers	alders, topography	THPL, ABLA, also some PSME, PIEN, ABGR and red osier	Some logging on river left, road fairly close to stream, but w/adequate buffer, stumps on river right too
BG4-2	45	10.9	18.4	ABLA	79	conifers	alders, topography	PIEN, ABLA, PICO and cottonwoods present	Doesn't appear disturbed, more open meadow character.
BG4-3	0	15.3	23.9	Cottonwoods	10	alder	cottonwoods	Narrow band of cottonwoods/alders/willows, then gravel and dry floodplain with cottonwoods and conifers	Appears to have been some sort of sediment pulse w/large bar deposits, dry/cobble floodplain w/many cedar stumps
BG5-1	90	17.4	21.7	PIEN	128	conifers	alders, topography	PIEN, ABLA, THPL, PICO, ABGR, with alder, red osier, willows along stream	Road along river right encroaches in places

Big Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
BG5-2	90	17.9	23.9	PIEN	128	conifers	alders, topography	PIEN, ABLA, THPL, PICO, ABGR, with alder, red osier, willows along stream	Road crossing obliterated and pools added, plus bank stabilization project upstream
BG5-3	90	17.0	19.5	PIEN	128	conifers	alders, topography	PIEN, ABLA, THPL, PICO, ABGR, with alder, red osier, willows along stream	Doesn't appear to have been harvested, except for road, which reduces shade on south side of the river
BG6-1	-45	12.2	23.1	PIEN	37	conifers	alders	Dense ABLA, Larch, THPL, PSME, PIEN on river right with PIEN, PICO cottonwood on river left, alders on both sides	Potential historic clearing along river left, river right is forested, road crossing upstream
BG6-2	0	14.8	19.2	Cottonwoods	85	alder	conifers	Larch, ABLA, THPL, ABGR on river right with cottonwoods, PICO, PIPO, THPL, PSME on river left	Appears that stream has shifted on floodplain, potential due to increase sediment/discharge from upper watershed due to logging/burns
BG6-3	-45	10.0	21.7	Cottonwoods	57	alder	conifers	Some conifers on floodplain w/scattered large cottonwoods	Some road encroachment and an altered floodplain?
BG7-1	90	17.6	42.5	Willow	12	willow	willow	Primarily willow corridor along channel with some alder and cottonwood (farther back on floodplain)	Road on both sides, upstream land mgmt alters sediment and flow regimes, road abuts channel along minor potions of reach

Big Creek

Solar Pathfinder Site	Stream Aspect	Wetted Width (Feet)	Bankfull Width (Feet)	Dominant Tree Species	Dominant Tree Height (Feet)	Primary Shade Controlling Factor	Secondary Shade Controlling Factor	Description	Visible Anthropogenic Impacts
BG7-2	45	16.8	40.4	Willow	12	willow	willow	Primarily willow corridor along channel with some alder and cottonwood (farther back on floodplain)	Road on both sides, upstream land mgmt alters sediment and flow regimes, road abuts channel along minor potions of reach
BG7-3	90	25.2	40.1	Willow	12	willow	willow	Primarily willow corridor along channel with some alder and cottonwood (farther back on floodplain)	Road on both sides, upstream land mgmt alters sediment and flow regimes, road abuts channel along minor potions of reach
BG8-1	90	33.4	56.3	ABLA	84	conifers	topography	River right: ABLA, THPL, larch, PIMO on left: PIMO, PICO, farther back w/alder, willow, some cottonwood and ABLA.	Minimal impacts
BG8-2	90	25.5	34.0	PIXX	49	conifers	topography	Aspect limits shade available by conifers	Minimal impacts
BG8-3	90	22.0	35.8	Cottonwoods	81	willow	cottonwoods	Sparse mature cottonwoods with conifers encroaching on floodplain	Fence along river right and PICOs suggest disturbance, bridge upstream appears to create a “flume” with fill across floodplain, wide open gravel area w/bank erosion, not much bank vegetation downstream

ATTACHMENT E
CANOPY DENSITY DATA

St. Regis TMDL Planning Area

AERIAL ASSESSMENT			DENSIOMETER							
Reach	**Canopy Density**	**Canopy Type**	**Site ID**	**Canopy Type**	**Reading 1** (# of dots covered by canopy)		**Reading 2** (# of dots covered by canopy)		**Latitude**	**Longitude**
1.0	75%	Cottonwoods	**SR 1.0-1**	mature cottonwoods with shrub understory	**N**	54	**N**	68	47.29661	-115.09355
					E	73	**E**	66		
					S	82	**S**	83		
					W	72	**W**	80		
1.7	55%	Cottonwoods	**SR 1.7-1**	cottonwood and conifer overstory with shrub understory	**N**	73	**N**	79	47.29050	-115.16186
					E	45	**E**	46		
					S	49	**S**	50		
					W	68	**W**	69		
1.9	55%	Cottonwoods	**SR 1.9 -1**	mature cottonwoods with alder, red osier understory, some larch/pine	**N**	52	**N**	49	47.29450	-115.16860
					E	40	**E**	37		
					S	70	**S**	72		
					W	81	**W**	81		
4.1	45%	Cottonwoods	**SR 4.1-1**	mature/decadent cottonwoods, alders, fir, spruce, pine	**N**	18	**N**	26	47.35431	-115.29517
					E	60	**E**	58		
					S	15	**S**	25		
					W	56	**W**	71		
5.0	50%	Cottonwoods	**SR 5.0-1**	decadent cottonwoods, sprouts, confiers	**N**	53	**N**	40	47.37762	-115.36024
					E	77	**E**	78		
					S	41	**S**	39		
					W	53	**W**	58		
5.4	35%	Cottonwoods	**SR 5.4-1**	cottonwood, spruce, pine, willows	**N**	50	**N**	48	47.38799	-115.40713
					E	52	**E**	51		
					S	5	**S**	7		
					W	23	**W**	24		
5.3	45%	Cottonwoods	**SR 5.3-1**	cottonwoods, pine, herbaceous understory	**N**	58	**N**	53	47.38610	-115.40384
					E	70	**E**	73		
					S	18	**S**	22		
					W	33	**W**	33		
5.5	35%	Cottonwoods	**SR 5.5-1**	mature cottonwoods, herbaceous understory, young pine	**N**	36	**N**	32	47.38900	-115.41354
					E	43	**E**	51		
					S	55	**S**	50		
					W	54	**W**	53		
5.7	25%	Cottonwoods	**SR 5.7-1**	pole cottonwoods, young pine	**N**	31	**N**	35	47.39281	-115.42304
					E	29	**E**	28		
					S	23	**S**	32		
					W	21	**W**	18		
7.5	75%	Conifers	**SR 7.5-1**	fir, spruce, larch, pine	**N**	78	**N**	76	47.41337	-115.58675
					E	80	**E**	88		
					S	92	**S**	91		
					W	88	**W**	80		
7.5	55%	Cottonwoods	**SR 7.5-2**	pine, fir, spruce	**N**	47	**N**	45	47.41418	-115.58592
					E	75	**E**	79		
					S	68	**S**	56		
					W	23	**W**	14		
7.7	85%	Conifers	**SR 7.7-1**	larch, fir, spruce, cedar	**N**	78	**N**	82	47.41725	-115.59615
					E	85	**E**	84		
					S	95	**S**	96		
					W	62	**W**	65		

APPENDIX D
STREAM TEMPERATURE DATA 2001-2003

Table D-1. 2003 Temperature Summary Data

Site Name	Latitude	Longitude	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
					Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	ΔT
233641-Flat Rock Creek At Mouth			06/26/03	10/06/03	10/06/03	82.4	10/04/03	40.0	10/06/03	40.4	07/20/03	61.1	50.8	10.3
233682-Ward Creek-Upper			06/27/03	10/06/03	10/06/03	82.9	10/04/03	43.8	10/06/03	37.7	07/25/03	56.3	52.4	3.9
233683-S. FK Little Joe Above Mouth			06/26/03	10/09/03	06/26/03	73.1	07/04/03	44.4	06/26/03	27.9	10/06/03	56.8	51.8	5.0
472546-ST Regis Above Ward Creek			06/27/03	07/20/03	07/20/03	70.4	07/04/03	48.5	07/20/03	18.6	07/17/03	67.0	52.2	14.8
480933-Savenac Cr. Above Nursery			06/26/03	07/17/03	07/17/03	64.4	07/04/03	46.7	07/15/03	12.6	07/14/03	62.4	51.2	11.2
530205-Big Sunday Creek			06/24/03	09/30/03	08/01/03	60.5	06/24/03	41.5	07/18/03	8.7	07/29/03	60.0	52.1	7.9
530206-Silver Creek at F.B.			06/24/03	09/30/03	08/01/03	64.6	09/30/03	41.2	07/18/03	12.7	07/29/03	63.7	52.4	11.4
530207-E FK Savenac Creek			06/25/03	10/01/03	08/01/03	53.0	06/25/03	43.2	07/18/03	3.1	07/29/03	52.6	50.0	2.6
530209-E. Fork Twin Creek			06/26/03	10/01/03	08/01/03	56.3	09/18/03	44.9	06/29/03	5.6	07/29/03	56.0	51.8	4.2
530210-Deer Cr Above DNRC			06/26/03	10/01/03	07/28/03	56.2	10/01/03	43.7	07/04/03	6.7	07/25/03	56.1	52.1	4.1
530211-Deer Creek			06/26/03	10/01/03	07/28/03	57.8	09/30/03	44.7	07/18/03	7.3	07/29/03	57.4	50.8	6.5
530212- Twelvemile Cr Below CC CG Rd			06/26/03	10/05/03	07/27/03	67.0	10/04/03	40.5	07/18/03	14.2	07/29/03	66.3	53.5	12.8
530213-Rock Creek Mouth			06/26/03	10/05/03	07/18/03	58.9	07/04/03	42.1	07/18/03	15.3	07/19/03	58.4	43.9	14.5
530214-Twelvemile Cr Below Rock Cr			06/26/03	10/05/03	07/22/03	64.7	10/04/03	43.6	07/18/03	14.6	07/20/03	64.1	50.1	14.0
530215-Ward Cr Mainstem			06/27/03	10/05/03	07/23/03	56.6	10/04/03	41.3	07/30/03	6.1	07/21/03	56.3	50.8	5.5
530216-North FK of Little Joe Creek			06/27/03	10/06/03	07/24/03	57.8	10/04/03	43.6	07/04/03	4.5	07/25/03	57.4	54.3	3.1
530217-Little Joe Creek			06/27/03	10/06/03	07/22/03	52.2	10/04/03	41.6	07/20/03	8.4	07/20/03	52.0	44.0	8.0
530218-St Regis at USGS			06/27/03	10/06/03	07/22/03	69.0	10/04/03	44.1	07/10/03	11.9	07/20/03	68.1	57.1	11.0
530219-Twin Creek			06/27/03	10/01/03	07/22/03	72.3	09/30/03	42.2	07/04/03	19.1	07/29/03	71.5	54.6	16.9
530220-St Regis River	47 25.443	115 38.260	06/24/03	09/30/03	07/31/03	64.1	09/30/03	41.0	07/31/03	14.7	07/29/03	63.7	49.9	13.9
530221-St Regis At Taft	47 25.145	115 36.136	06/24/03	09/30/03	07/22/03	63.8	06/25/03	41.6	07/15/03	15.2	07/20/03	63.2	49.3	13.9
530222-St Regis Below Randolph	47 24.972	115 34.863	06/24/03	09/30/03	07/22/03	65.3	06/24/03	41.8	07/18/03	15.8	07/20/03	64.5	49.7	14.8
530223-St Regis Near Haugen	47 23.646	115 26.077	06/24/03	09/30/03	07/22/03	71.1	09/30/03	43.3	07/15/03	17.9	07/29/03	70.4	53.9	16.5
530224-Big Creek	47 21.733	115 25.671	06/25/03	09/30/03	07/22/03	59.0	09/30/03	43.1	06/29/03	10.9	07/20/03	58.7	49.6	9.1
53028-Big Creek Mainstem			06/25/03	10/01/03	10/01/03	75.9	09/30/03	41.9	10/01/03	33.5	07/29/03	65.6	49.4	16.2
5325-W Fork Big Creek			06/26/03	09/30/03	07/22/03	65.8	09/30/03	43.0	07/15/03	14.3	07/20/03	65.1	52.2	12.9
5329-Middle Fork Big Creek			06/26/03	09/30/03	08/07/03	62.9	09/22/03	41.1	08/10/03	12.1	07/29/03	62.5	51.1	11.4
5333- E Fork of Big Creek			06/25/03	09/30/03	07/27/03	61.8	06/25/03	41.9	07/30/03	10.7	07/29/03	61.4	51.6	9.9
578061-St Regis Below Deer Creek	47 21.847	115 19.747	06/26/03	10/01/03	07/22/03	64.3	06/26/03	46.9	07/18/03	12.4	07/20/03	63.7	51.8	11.9
578167-Twelvemile Above Mineral MTN	47 26.027	115 14.543	06/26/03	10/05/03	07/30/03	64.5	10/04/03	39.6	07/30/03	14.1	07/29/03	63.7	51.2	12.5
578177-Twelvemile Above Flat Rock	47 23.734	115 15.363	06/26/03	10/05/03	07/27/03	65.2	10/04/03	40.5	07/15/03	13.7	07/29/03	64.7	52.4	12.2
584730-Twelvemile Cr Above CC	47 22.676	115 15.394	06/26/03	10/05/03	07/27/03	65.1	10/04/03	40.4	07/18/03	13.2	07/29/03	64.4	52.6	11.8

2003 Temperature Summary Data (continued)

Site Name	Days > 50 F	Days > 59 F	Days > 70 F	Hours > 50 F	Hours > 59 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum
233641-Flat Rock Creek At Mouth	81	26	1	1557.5	129.0	8.0	07/22/03	61.6	51.2
233682-Ward Creek-Upper	77	1	1	1459.5	7.5	7.0	07/23/03	56.9	52.2
233683-S. FK Little Joe Above Mouth	32	4	3	159.0	68.0	11.0	10/07/03	71.0	45.5
472546-ST REGIS ABOVE WARD CREEK	24	23	1	551.0	216.5	1.0	07/20/03	70.4	51.8
480933-Savenac Cr. Above Nursery	22	14	0	434.5	62.0	0.0	07/17/03	64.4	52.5
530205-Big Sunday Creek	84	20	0	1482.0	43.0	0.0	08/01/03	60.5	52.1
530206-Silver Creek at F.B.	88	46	0	1645.0	306.5	0.0	08/01/03	64.6	52.4
530207-E FK Savenac Creek	56	0	0	947.5	0.0	0.0	08/01/03	53.0	50.2
530209-E. Fork Twin Creek	82	0	0	1497.5	0.0	0.0	08/01/03	56.3	52.2
530210-Deer Cr Above DNRC	79	0	0	1499.0	0.0	0.0	07/22/03	56.2	51.8
530211-Deer Creek	89	0	0	1247.5	0.0	0.0	07/27/03	57.8	51.4
530212- Twelvemile Cr Below CC CG Rd	97	66	0	1806.0	499.0	0.0	07/27/03	67.0	54.4
530213-Rock Creek Mouth	100	0	0	811.0	0.0	0.0	07/18/03	58.9	43.5
530214-Twelvemile Cr Below Rock Cr	102	52	0	1518.0	245.5	0.0	07/22/03	64.7	50.3
530215-Ward Cr Mainstem	74	0	0	1299.0	0.0	0.0	07/22/03	56.6	51.1
530216-North FK of Little Joe Creek	78	0	0	1685.0	0.0	0.0	07/23/03	57.8	54.2
530217-Little Joe Creek	57	0	0	204.5	0.0	0.0	07/20/03	52.2	43.8
530218-St Regis at USGS	102	73	0	2206.5	907.5	0.0	07/22/03	69.0	57.828
530219-Twin Creek	96	74	19	1978.5	851.5	58.5	07/27/03	72.0	55.3
530220-St Regis River	93	44	0	1467.0	240.5	0.0	07/31/03	64.1	49.4
530221-St Regis At Taft	95	37	0	1489.5	181.0	0.0	07/22/03	63.8	49.7
530222-St Regis Below Randolph	96	50	0	1550.0	293.5	0.0	07/22/03	65.3	50.2
530223-St Regis Near Haugen	99	72	12	2004.0	747.5	22.5	07/27/03	70.8	54.5
530224-Big Creek	95	1	0	1237.0	1.0	0.0	07/22/03	59.0	49.8
53028-Big Creek Mainstem	98	64	1	1501.5	359.0	5.5	08/01/03	66.4	49.4
5325-W Fork Big Creek	88	55	0	1756.5	442.0	0.0	07/22/03	65.8	53.1
5329-Middle Fork Big Creek	91	41	0	1442.0	161.5	0.0	08/01/03	62.9	51.1
5333- E Fork of Big Creek	93	32	0	1538.0	113.5	0.0	07/27/03	61.8	52.2
570861-St Regis Below Deer Creek	98	46	0	2272.0	285.5	0.0	07/22/03	64.3	52.4
58167-Twelvemile Above Mineral MTN	91	43	0	1459.0	170.0	0.0	07/27/03	64.5	51.8
578177-Twelvemile Above Flat Rock	94	52	0	1671.0	342.0	0.0	07/27/03	65.2	53.3
584730-Twelvemile Cr Above CC	94	53	0	1738.5	380.5	0.0	07/27/03	65.1	53.5

2002 Temperature Summary Data

Site Name	Latitude	Longitude	Start Date	Stop date	Seasonal Maximum Date	Value	Seasonal Minimum Date	Value	Seasonal Max ΔT Date	Value	7-Day averages Date	Maximum	Minimum	ΔT
530219-TWIN CREEK	47 22.629	115 20.975	07/23/02	09/30/02	07/25/02	66.1	09/22/02	39.4	08/13/02	16.3	07/26/02	63.7	52.4	11.2
530220- EF TWIN CR 2002	47 24.635	115 19.995	07/23/02	10/01/02	07/25/02	55.0	10/01/02	42.7	08/03/02	4.7	07/26/02	53.7	50.7	3.0
5325- WF BIG CR 2002	47 22.124	115 27.044	07/19/02	09/30/02	07/25/02	61.2	09/22/02	41.1	07/22/02	11.8	07/24/02	60.0	50.0	10.0
5333- EF BIG CREEK 2002	47 21.499	115 25.866	07/18/02	09/30/02	07/25/02	57.5	09/22/02	41.1	07/22/02	8.9	07/24/02	56.7	49.2	7.5
5329- MF BIG CREEK 2002	47 21.165	115 25.269	07/18/02	09/30/02	07/25/02	57.5	09/22/02	38.8	08/13/02	10.6	07/23/02	56.3	48.1	8.2
530218-ST REGIS RIVER @USGS GAGE 2002			07/26/02	10/02/02	07/26/02	63.2	10/02/02	43.6	08/09/02	10.7	08/15/02	61.6	52.0	9.6
530217-LITTLE JOE CR-MOUTH 2002			07/26/02	10/01/02	07/30/02	51.9	10/01/02	42.1	08/14/02	7.5	08/15/02	50.9	43.8	7.2
530216 NF LITTLE JOE AT TRAIL			07/19/02	10/01/02	07/25/02	55.3	10/01/02	41.6	08/10/02	3.6	07/23/02	54.5	51.6	2.9
530215 WARD CR			07/19/02	10/01/02	07/26/02	55.5	09/22/02	41.6	08/01/02	5.3	07/23/02	55.1	51.1	4.0
530214TWELVE MILE CR-MOUTH			07/19/02	10/01/02	07/25/02	60.6	09/21/02	41.4	08/01/02	13.7	07/23/02	59.5	49.0	10.5
530212 EFTWELVE MILE Cr Above mouth	47 22.085	115 15.462	07/19/02	10/01/02	07/20/02	48.3	09/22/02	41.9	07/21/02	2.2	07/22/02	48.1	46.3	1.8
530211 TWELVE MILE CR			07/19/02	10/01/02	07/24/02	62.6	09/22/02	39.3	08/13/02	12.0	07/23/02	61.6	51.4	10.1
530213 ROCK CR MOUTH			07/19/02	10/01/02	07/22/02	62.0	09/22/02	42.1	08/01/02	17.9	07/23/02	60.9	44.9	16.0
530209 DEER CR			07/19/02	10/01/02	07/25/02	56.6	09/22/02	43.8	08/13/02	7.2	07/25/02	55.9	50.9	5.0
BIG CR AT FOREST BOUNDARY			07/18/02	09/30/02	07/24/02	62.0	09/22/02	42.2	08/13/02	14.0	07/23/02	61.0	49.7	11.3
SILVER CR AT LAKE OUTLET	47 21.685	115 33.883	07/18/02	09/30/02	07/18/02	66.9	09/30/02	48.5	09/11/02	9.1	08/28/02	64.5	58.4	6.1
BIG SUNDAY CR(MOUTH)			07/18/02	09/30/02	07/25/02	56.6	09/22/02	40.1	08/13/02	7.8	07/25/02	55.5	49.6	5.9
SILVER CR @FOREST BOUNDARY			07/18/02	09/30/02	07/24/02	60.0	09/22/02	39.5	08/13/02	10.9	07/23/02	58.6	49.7	8.9
SF Little Joe Cr Above Mouth			07/19/02	10/01/02	09/13/02	60.8	09/22/02	37.4	09/24/02	18.4	09/22/02	55.7	39.9	15.8
St Regis R above Saltese	47 24 42	115 30 55	07/18/02	09/30/02	08/28/02	72.3	09/22/02	41.1	08/12/02	26.2	08/12/02	63.4	47.2	16.2
Flat Rock Cr-mouth			07/19/02	10/01/02	07/24/02	59.0	09/22/02	39.7	08/01/02	9.5	07/23/02	58.1	50.2	8.0
MFSavenac Cr above F.B.	47 25.766	115 23.076	07/23/02	10/01/02	07/25/02	51.9	10/01/02	41.9	08/03/02	3.1	07/26/02	51.1	49.3	1.9
SAVANAC CR above NURSERY			07/23/02	09/30/02	07/25/02	61.8	09/22/02	40.8	08/13/02	11.2	07/26/02	59.9	51.8	8.0

2002 Temperature Summary Data (continued)

Site Name	Days > 50 F	Days > 59 F	Days > 70 F	Hours > 50 F	Hours > 59 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum
530219-TWIN CREEK	68	43	0	1204.0	248.0	0.0	07/24/02	66.1	52.5
530220- EF TWIN CR 2002	49	0	0	547.0	0.0	0.0	07/24/02	55.0	50.8
5325- WF BIG CR 2002	64	7	0	1016.5	30.5	0.0	07/24/02	61.2	50.3
5333- EF BIG CREEK 2002	63	0	0	748.5	0.0	0.0	07/24/02	57.5	49.4
5329- MF BIG CREEK 2002	63	0	0	579.0	0.0	0.0	07/24/02	57.5	48.6
530218-ST REGIS RIVER @USGS GAGE 2002	65	34	0	1425.0	197.0	0.0	08/14/02	62.9	53.6
530217-LITTLE JOE CR-MOUTH 2002	21	0	0	56.5	0.0	0.0	08/14/02	51.6	44.1
530216 NR LITTLE JOE AT TRAIL	49	0	0	823.5	0.0	0.0	07/25/02	55.3	52.5
530215 WARD CR	46	0	0	548.0	0.0	0.0	07/24/02	55.5	51.3
530214TWELVE MILE CR-MOUTH	67	4	0	703.5	13.0	0.0	07/24/02	60.6	48.6
530212 EFTWELVE MILE Cr Above mouth	0	0	0	0.0	0.0	0.0	07/19/02	48.3	47.2
530211 TWELVE MILE CR	65	12	0	1069.0	51.5	0.0	07/24/02	62.6	51.9
530213 ROCK CR MOUTH	72	26	0	604.5	78.0	0.0	07/20/02	62.0	45.2
530209 DEER CR	63	0	0	764.5	0.0	0.0	07/25/02	56.6	51.3
BIG CR AT FOREST BOUNDARY	71	28	0	954.5	81.0	0.0	07/24/02	62.0	49.9
SILVER CR AT LAKE OUTLET	74	58	0	1775.0	710.0	0.0	08/28/02	66.0	58.3
BIG SUNDAY CR(MOUTH)	60	0	0	648.5	0.0	0.0	07/24/02	56.6	49.6
SILVER CR @FOREST BOUNDARY	64	2	0	872.5	7.5	0.0	07/24/02	60.0	50.2
SF Little Joe Cr Above Mouth	46	3	0	226.5	3.0	0.0	09/19/02	59.1	41.0
St Regis R above Saltese	70	20	3	1120.5	74.5	2.0	08/12/02	72.3	46.1
Flat Rock Cr-mouth	61	1	0	779.5	1.5	0.0	07/24/02	59.0	50.6
MFSavenac Cr above F.B.	13	0	0	97.0	0.0	0.0	07/25/02	51.9	49.7
SAVANAC CR above NURSERY	61	7	0	1063.0	22.0	0.0	07/25/02	61.8	52.8

2001 Temperature Summary Data

Site Name	Latitude	Longitude	Start Date	Stop date	Seasonal Maximum Date	Seasonal Maximum Value	Seasonal Minimum Date	Seasonal Minimum Value	Seasonal Max ΔT Date	Seasonal Max ΔT Value	7-Day averages Date	7-Day averages Maximum	7-Day averages Minimum	7-Day averages ΔT
St Regis River @ USGS gage	N47 17 47.19	W115 07 19.89	07/14/01	10/18/01	08/07/01	69.8	10/06/01	41.8	08/06/01	12.6	08/08/01	68.5	56.8	11.7
Little Joe Cr @ mouth	N47 17 47.74	W115 07 20.31	07/14/01	10/18/01	08/07/01	53.8	10/18/01	42.1	08/06/01	8.1	08/09/01	53.4	45.8	7.7
N Fk Little Joe Cr @ Rd 282 under trail bridge	N47 15 40.88	W115 10 35.89	07/14/01	10/18/01	08/13/01	56.6	10/18/01	39.3	08/02/01	3.6	08/15/01	56.0	53.4	2.6
Ward Cr @ mouth	N47 18 32	W115 14 09	07/14/01	10/18/01	08/07/01	55.1	10/06/01	39.0	07/27/01	6.1	08/08/01	54.5	49.4	5.1
Twelve Mile Cr @ mouth	N47 21 14.60	W115 17 19.23	07/17/01	10/18/01	08/07/01	64.2	10/18/01	41.5	07/27/01	12.9	08/08/01	63.5	52.0	11.6
Twelve Mile Cr @ Cabin City Campground	N47 22 19.03	W115 15 41.02	07/17/01	10/18/01	08/07/01	67.2	10/06/01	35.3	08/26/01	14.0	08/08/01	66.1	53.1	13.0
Rock Cr @ mouth (Twelve Mile Cr trib)	N47 21 15.78	W115 17 18.38	07/17/01	10/18/01	08/27/01	68.1	10/05/01	37.2	08/29/01	21.5	08/08/01	66.1	47.4	18.8
Deer Cr @ mouth	N47 22 25.74	W115 21 32.63	07/19/01	10/18/01	08/07/01	57.9	10/18/01	42.3	07/27/01	7.5	08/09/01	57.3	50.1	7.2
Big Cr @ Sect 27 bridge crossing	N47 22 24.71	W115 23 54.38	07/19/01	10/18/01	08/07/01	66.3	10/05/01	36.8	08/26/01	18.2	08/08/01	65.4	48.4	17.0
Silver Cr below lake	N47 21 41.08	W115 33 54.01	07/20/01	10/09/01	08/14/01	72.6	10/09/01	47.5	09/11/01	9.9	08/15/01	71.3	63.7	7.6
Sunday Cr @ mouth	N47 23 51.84	W115 31 14.07	07/20/01	10/09/01	08/07/01	58.6	10/06/01	37.1	07/27/01	8.1	08/09/01	57.8	50.6	7.2
Silver Cr @ FS boundary	N47 24 17.12	W115 30 48.15	07/20/01	10/09/01	08/07/01	63.1	10/06/01	35.6	07/27/01	12.6	08/09/01	62.1	50.6	11.5
SF Little Joe near mouth	N47 16 12.13	W115 08 30.91	07/14/01	10/18/01	07/14/01	48.8	10/05/01	43.3	07/27/01	3.0	08/08/01	48.3	45.8	2.5
St Regis R. abv Saltese, MT	N47 24 41.82	W115 30 54.68	07/21/01	10/09/01	08/07/01	67.3	10/06/01	38.0	08/06/01	15.6	08/08/01	65.9	51.6	14.3
Flat Rock Cr near mouth	N47 23 14.77	W115 14 52.25	07/17/01	10/18/01	08/07/01	60.7	10/06/01	35.7	07/27/01	10.6	08/08/01	59.8	51.0	8.8
Savenac Cr near mouth?	N47 23 55.42	W115 23 40.41	07/19/01	10/18/01	08/07/01	67.3	10/06/01	37.1	08/26/01	14.6	08/09/01	66.1	52.3	13.9

2001 Temperature Summary Data (continued)

Site Name	Days > 50 F	Days > 59 F	Days > 70 F	Hours > 50 F	Hours > 59 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum
St Regis River @ USGS gage	83	58	0	1850.0	614.0	0.0	08/07/01	69.8	57.7
Little Joe Cr @ mouth	61	0	0	293.0	0.0	0.0	08/07/01	53.8	46.0
N Fk Little Joe Cr @ Rd 282 under trail bridge	63	0	0	1283.0	0.0	0.0	08/13/01	56.6	54.4
Ward Cr @ mouth	52	0	0	652.7	0.0	0.0	08/07/01	55.1	49.8
Twelve Mile Cr @ mouth	80	32	0	1349.0	148.5	0.0	08/07/01	64.2	52.4
Twelve Mile Cr @ Cabin City Campground	78	39	0	1397.5	275.0	0.0	08/07/01	67.2	53.8
Rock Cr @ mouth (Twelve Mile Cr trib)	85	49	0	1316.5	370.0	0.0	08/07/01	67.2	47.6
Deer Cr @ mouth	67	0	0	815.0	0.0	0.0	08/07/01	57.9	50.4
Big Cr @ Sect 27 bridge crossing	77	45	0	963.5	219.5	0.0	08/07/01	66.3	48.8
Silver Cr below lake	80	73	10	1902.5	1172.0	33.5	08/14/01	72.6	63.8
Sunday Cr @ mouth	63	0	0	827.0	0.0	0.0	08/07/01	58.6	51.1
Silver Cr @ FS boundary	70	22	0	1012.0	116.0	0.0	08/07/01	63.1	51.3
SF Little Joe near mouth	0	0	0	0.0	0.0	0.0	08/05/01	48.5	45.8
St Regis R. abv Saltese, MT	75	41	0	1336.5	307.5	0.0	08/07/01	67.3	52.5
Flat Rock Cr near mouth	66	13	0	1013.5	33.0	0.0	08/07/01	60.7	51.5
Savenac Cr near mouth?	77	41	0	1389.0	273.0	0.0	08/07/01	67.3	53.1

APPENDIX E
PHYSICAL ASSESSMENT OF THE ST. REGIS RIVER AND TRIBUTARIES

Prepared by Land and Water Consulting, Inc.

Introduction

The St. Regis River was divided into 10 reaches for the TMDL assessment. Ten percent of each reach (except Reach 10 in the headwaters) was walked and physical measurements were made (**Table E-1**). Assessment sites were selected using aerial photographs and on-the ground observations to represent conditions at the reach scale. Overall, 3.7 miles (19,700 feet) of the St. Regis River were assessed in the field between July 7 and July 11, 2003. Pool and large woody debris inventories were adapted from the R1/R4 methodology employed by the Lolo National Forest (USDA 1997). In addition, cross section measurements were taken in Reaches 3, 5, and 6 to compliment reaches surveyed by the Lolo National Forest. Once the walk-thru was completed for each reach, the overall condition of the reach was assessed by the two person field crew based on the Proper Functioning Condition protocol developed by the Bureau of Land Management (BLM 1998). Three tributaries were also assessed: Little Joe Creek, Twelvemile Creek, and Big Creek. Tributary reaches were assessed from the National Forest boundary to the confluence with the St. Regis River between October 1 and October 3, 2002, except for the cross section measurements on Twelvemile Creek, which were made in July of 2003. Overall, 1.0 mile of Little Joe Creek, 2.3 miles of Twelvemile Creek, and 0.3 miles of Big Creek were assessed. In addition, several culverts were assessed for fish passage during field work in the summer of 2003.

Table E-1. Physical Stream Assessment Sites along the St. Regis River

Reach	Description	Length (Feet)	Stationing
1	Clark Fork River to Twomile Creek	2,300	16,500-18,800
2	Twomile Creek to Ward Creek	1,900	23,600-25,500
3	Ward Creek to Twelvemile Creek	2,600	65,400-68,000
4	Twelvemile Creek to Deer Creek	2,300	81,000-83,300
5	Deer Creek to Haugan	2,300	104,200-106,500
6	Haugan to Saltese	2,500	130,500-133,000
7	Saltese to Taft	2,400	142,000-144,400
8	Taft to Hanakar Creek	1,600	167,700-169,300
9	Hanakar Creek to Northern Pacific Railroad Grade	1,800	179,000-180,800

Methods

Pools

The size and frequency of pools were measured in the mainstem of the St. Regis River and in three tributaries. The first ten pools encountered were measured in each of the nine subreaches along the mainstem of the St. Regis River. The length, width, maximum depth, and pool tail-out depth were measured for each pool (USDA 1997). The length and width of each pool was determined based on channel bed features, while depth measurements are related to the stream flow during field work, which was conducted during low flow conditions ranging from approximately 200-400 CFS (USGS 2003, provisional data). The length, width, maximum depth, and pool tail-out depth were measured for every pool within the three tributary reaches. In the tributaries, the length of stable bank along each pool for both the right and left banks was quantified and the quality of each pool was described as low, medium, high, or very high. Pool quality assessments were based on best professional judgment. Shallow pools that lacked cover were described as low quality, while deep pools with good cover were described as high quality.

Pool measurements were used to determine mean pool dimensions, pool area, and pool frequency. Pool area, which provides a measure of the relative amount of pool habitat available in the stream, was calculated as the overall percent of the reach occupied by pools. Pool area was determined using the sum of individual pool areas, the mean bankfull channel width, and the overall reach length. Pool area was also calculated based on wetted width for Little Joe Creek and Big Creek so that comparisons to reference conditions on the Lolo National Forest, which are based on wetted width, could be made (Riggers et al. 1998). In addition, pool frequency was calculated as the total number of pools per mile.

Large Woody Debris

The amount of large woody debris was determined for each reach along the mainstem of the St. Regis River and in the three tributary reaches. Large woody debris was defined as relatively stable pieces of woody material greater than 9 feet in length with a diameter greater than 4 inches one third of the way from the base that are hydrologically functioning (USDA 1997). The number of large woody debris, the number of aggregates, and the number of logs per aggregate were determined in each of the 9 reaches. The amount of large woody debris per mile was determined by multiplying the number of aggregates by the average number of large woody debris per aggregate and adding this to the single pieces of large woody debris.

Cross Section Measurements

Channel cross section measurements were made in riffles in Reaches 3, 5, and 6 along the St. Regis River, as well as in Little Joe Creek, Twelvemile Creek, and Big Creek. Bankfull width, flood prone width, mean bankfull depth, and maximum bankfull depth were measured at 3 transects in each mainstem reach using a line level and a stadia rod. Cross section measurements were made at three sites along Little Joe Creek and Twelvemile Creek, and at two sites along Big Creek. A pebble count and 3 grid tosses were also performed along each transect in the mainstem, while only the pebble count was performed in the tributaries. A grid with 49 intersections was used for the grid toss in riffles and all particles smaller than the 6 mm intersections were counted (Kramer et al. 1993). In addition, the dominant size large particle on adjacent gavel bars was sampled at each transect in the mainstem following methods developed by Kappeser (2002). Cross section measurements were used to determine the width/depth ratio, the entrenchment ratio, Rosgen stream type, the D50 particle size, the D84 particle size, and the percent of surface fines (PSF). The riffle stability index, which is an indicator of sediment load, was determined using pebble count results and dominant large particle size measurements from adjacent gravel bars.

Fish Passage Assessment
Twelve culverts were assessed for their ability to allow fish passage. Best professional judgment was used to determine if a culvert was a potential barrier to fish passage. This was based on the length and slope of the culvert, and whether there was a drop at the outlet. Nine culverts were assessed on tributaries and three on the mainstem of the St. Regis River. Culverts running under Interstate 90 were assessed on Twelvemile, Twin, Savenac, and Randolph Creeks along with the St. Regis River. Frontage Road crossings over Twin Creek and Savenac Creek were also assessed, along with several other tributary crossings.

Results

Mainstem Pools
Pool dimensions, frequency, and area along the mainstem of the St. Regis River varied based on the size and type of the stream channel as well as the relative amount of channel alterations. The maximum depth and tail-out depth of pools generally increased progressing downstream, while the length and width of pools remained fairly constant throughout the sampled reaches. The exception was Reach 3, in which the pools were smaller than in any other reach, with maximum depths and tail-out depths lower than upstream and downstream reaches. Reach 3 also had the highest amount of stream bank alterations (see channel report). Pool frequency, as indicated by the number of pools per mile, ranged from 0 in Reach 6 to more than 29 in Reach 9 (**Table E-2**). Reaches 4, 8, and 9 had the highest frequency of pools, with the number of pools per mile ranging from 18 to 23. Overall, pools occupied a small portion of the St. Regis River, covering only 0% to greater than 1.49% of the overall bankfull surface area. Reach 7, which is a highly channelized step-pool B-type channel, had the highest amount of pool area, followed by Reaches 4, 8, and 9. Reaches with F-type stream channels had the least amount of pools with the lowest pool area values of any sampled reaches. The F-type stream channels along the St. Regis River are likely former C-type channels that are now confined by riprap.

Table E-2. Mean Pool Dimensions for Reaches 1-9 along the St. Regis River Measured on July 7-11, 2003 (measurements in feet)

Reach	Length	Width	Maximum Depth	Tail-Out Depth	#/ Mile	Pool Area	Channel Type
1	18.4	9.2	5.7	3.8	11	0.24%	C3
2	13	9	4.6	3.2	3	0.08%	F3
3	7.8	5.3	3.1	2.5	8	0.09%	F3
4	14.8	8.1	4.1	3	21	0.55%	C3
5	14.5	9.8	4.7	3.6	9	0.23%	C4
6	0	0	0	0	0	0.00%	F3
7	14.6	8.6	3.2	2.1	18	1.46%	B3c
8	13.3	8.4	2.4	1.7	23	1.14%	C4
9	11	6	2.1	1.5	>29	>1.49%	C3b

Pools occurred more frequently in the tributaries than in the mainstem of the St. Regis River. Wetted width measurements for Little Joe Creek and Big Creek indicate pools occupy 7.2% and 7.8% of these reaches respectively (**Table E-3**). This value is below the reference condition of 23% for C4 channels in these two tributaries (Riggers et al. 1998). Little Joe Creek had 0% eroding banks associated with pools, while Twelvemile Creek had 1.7-2.7%, and Big Creek had

54.0-69.0%. Reference conditions of 0.36% for these stream types are exceeded in Twelvemile Creek and Big Creek (Riggers et al. 1998). Overall, Big Creek had the most eroding bank and the largest and shallowest pools. Eighty percent of the pools in the sampled reach of Little Joe Creek were low quality, 26% were medium quality, and 56% were high to very high quality pools, while Twelvemile Creek had 40% low quality pools, 25% medium quality pools, and 29% high to very high quality pools, and Big Creek had 80% low quality pools, 13% medium quality pools, and 7 % high to very high quality pools. Thus, Little Joe Creek had the highest quality pools overall, followed by Twelvemile Creek, while Big Creek had the lowest quality pools.

Table E-3. Mean Pool Dimensions in St. Regis River Tributaries Measured on October 1-3, 2002 (measurements in feet)

Tributary	Length	Width	Maximum Depth	Tail-out Depth	# / Mile	Pool Area	Left Eroding Bank	Right Eroding Bank
Little Joe	20.6	9.5	2.2	0.8	38	2.9%(7.2%)	0.0%	0.0%
Twelvemile	15.6	7.5	2.0	0.8	41	2.5%	1.7%	2.7%
Big	20.9	10.0	1.8	0.7	45	4.5%(7.8%)	54.0%	69.0%

Parentheses indicate the use of wetted width.

Mainstem Large Woody Debris

The amount of large woody debris was generally low along the majority of the mainstem of the St. Regis River. The highest amount of large woody debris was 230 pieces per mile (143 pieces/km) in Reach 4, which contains a large amount of both single pieces and aggregates (**Table E-4**). Reaches 1, 5, and 8 contained 66-73 pieces per mile, while the rest of the reaches contained very little large woody debris. A blow down has deposited numerous trees from the river left bank in Reach 2. However, these trees were not counted since they had not yet lead to any morphological change of the stream substrate.

Table E-4. Large Woody Debris in Reaches 1

Reach	Length (Feet)	LWD	Aggregates	#/Aggregate	Pieces/Mile
1	2,300	2	5	6	73
2	1,900	blow down	blow down	blow down	blow down
3	2,600	2	0	0	4
4	2,300	9	7	13	230
5	2,300	11	4	5	71
6	2,500	0	0	0	0
7	2,400	3	1	5	18
8	1,600	8	2	6	66
9	1,800	1	1	4	15

Tributary Large Woody Debris

The amount of large woody debris was considerably higher in the tributaries than in the mainstem of the St. Regis River. Little Joe Creek had the highest amount of large woody debris per mile, while both Twelvemile Creek and Big Creek were higher than reference conditions of 156 pieces per mile for 3-4th order streams in the Lolo National Forest (Riggers et al. 1998) (**Table E-5**).

Table E-5. Large Woody Debris in Little Joe Creek, Twelvemile Creek, and Big Creek

Tributary	Singles	Aggregates	#/Aggregate	Pieces/Mile
Little Joe Creek	1,072	51	17	1,205
Twelvemile Creek	445	46	10	195
Big Creek	106	1	20	329

Mainstem Cross Section Measurements

Cross section measurements for each of the three transects per reach were combined and reach averages were determine. Cross sections in Reaches 3 and 6 were performed in channelized portions of the river, while the sample site in Reach 5 was located in a wide aggraded section. Reaches 3 and 6 were F-type channels, while Reach 5 was a C-type channel (Rosgen 1996). Mean bankfull widths of 85.6 feet in Reach 3, 115.9 feet in Reach 5, and 60.1 feet in Reach 6 were measured in the riffle cross-sections (**Table E-6**). Rosgen (1996) maintains that a width/depth ratio greater than 10 to 12 characterizes both C and F-type stream channels, with higher values expected for streams with greater bankfull widths. Riggers et al. (1998) suggests a range from 10 to 33 for the width/depth ratios in C-type channels using data consistent with the reference approach that DEQ uses for interpreting water quality standards and setting TMDL targets. While there is no reference description for F-type channels, both Reach 3 and Reach 6 have high mean width/depth ratios indicating that the channel was generally wide and shallow in these two reaches.

Table E-6. Mean Cross Section Measurements for Reaches 3, 5, and 6 (measurements in feet)

Reach	Bankfull Width	Flood Prone Width	Mean Bankfull Depth	Maximum Bankfull Depth	Width/ Depth Ratio	D50 (mm)	D84 (mm)	Riffle PSF**	Channel Type
3	85.6	98.8	2.0*	2.8	42.9	96.7	207.3	3.6	F3
5	115.9	260.9	1.9*	2.7	61.2	56.6	112.0	3.9	C4
6	60.1	75.5	1.7	2.1	36.3	76.4	156.3	4.5	F3

*Mean bankfull depths for Reaches 3 and 5 were estimated from the measured maximum bankfull depths. Mean bankfull depths were estimated as 0.7 of the maximum bankfull depth. This number was determined by comparing the differences between mean bankfull depth and maximum bankfull depth measurements for the other 7 reaches along the St. Regis River.

** PSF – Percent Surface Fines < 6 mm

The D50 particle size was 96.7, 56.6, and 76.4 mm in Reaches 3, 5, and 6 respectively, while the D84 particle size was 207.3, 112.0, and 156.3 mm. The overall distribution of particle sizes is presented in **Figure E-1**. The mean percent surface fines < 6mm in riffles based on the grid-toss methodology was 3.6%, 3.9%, and 4.5% in Reaches 3, 5, and 6 respectively. These compare favorably with surface fines results < 6 mm based on grid toss methodology in undeveloped streams in the Lolo National Forest, where the data indicate a mean value of 7.6% surface fines in B channels and 8% surface fines in C-type channels in metasedimentary geologies under natural conditions (Riggers et al. 1998). However, surface fines assessments documented by Riggers are a composite of grid-toss measurements made in low gradient riffles and lateral scour pools along a reach of stream. Overall, it does not appear that a high amount of surface fines are accumulating in riffles of these three reaches. A mean riffle stability index value of 89 indicates excess sediment loads in Reach 5 (Kappesser 2002). Riffle stability index values were not calculated in the Reaches 3 and 6 due to the lack of bars.

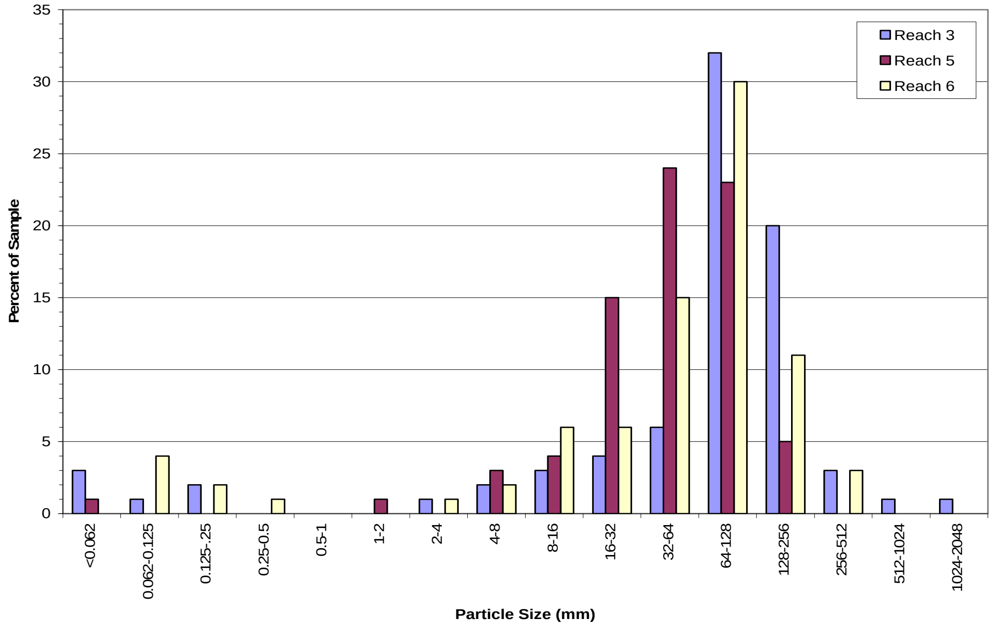

Figure E-1. Particle Size Distribution in Riffles in Reaches 3, 5, and 6 along the St. Regis River

Tributary Cross Section Measurements

Tributary measurements on Big Creek, Little Joe Creek and Twelvemile Creek conducted from the National Forest boundary to the confluence with the St. Regis River indicated these three tributaries were all C-type channels (**Table E-7**). Mean width/depth ratios fell within the range of 10 to 33 described as reference conditions for C3 and C4 channels on the Lolo National Forest (Riggers et al. 1998). Little Joe Creek had a D50 particle size of 27.3 mm and D84 particle size of 96.0 mm, while the D50 and D84 were 69.8 mm and 164.9 mm respectively for Twelvemile Creek. The D50 for Big Creek was 60.8 mm, while the D84 was 152.2 mm. Particle size distribution analysis indicates Little Joe Creek had the smallest substrate and the highest amount of fine sediment (**Figure E-2**).

Table E-7. Mean Cross Section Measurements for Little Joe Creek, Twelvemile Creek, and Big Creek between the National Forest Boundary and the Confluence with the St. Regis River (measurements in feet)

Tributary	Bankfull Width	Flood Prone Width	Mean Bankfull Depth	Maximum Bankfull Depth	Width/Depth Ratio	D50 (mm)	D84 (mm)	Channel Type
Little Joe	64.2	350.0	2.3	2.6	27.9	27.3	96.0	C4
Twelvemile	39.8	93.3	1.7*	2.3	23.4	69.8	164.9	C3
Big	47.3	175.0	2.0	2.8	23.7	60.8	152.3	C4

* Mean bankfull depths for Twelvemile Creek were estimated from the measured maximum bankfull depths. Mean bankfull depths were estimated as 0.7 of the maximum bankfull depth. This number was determined by comparing the differences between mean bankfull depth and maximum bankfull depth measurements for 7 reaches along the St. Regis River.

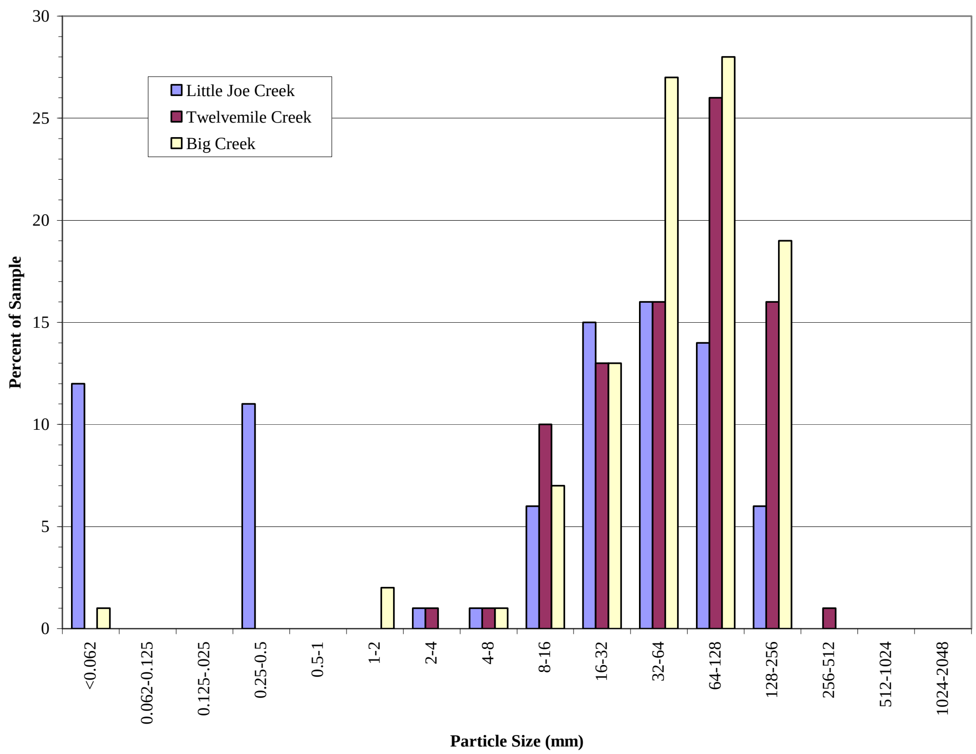

Figure E-2. Particle Size Distribution in Little Joe Creek, Twelvemile Creek, and Big Creek between the National Forest Boundary and the Confluence with the St. Regis River

Proper Functioning Condition

Sample sites in Reaches 4, 8, and 9 were in proper functioning condition, while sites in Reaches 1, 2, and 6 were functional at risk and sites in Reaches 3, 5, and 7 were nonfunctional (**Table E-8**). Based on the survey reaches, 29% of the overall length of the St. Regis River (excluding the headwaters in Reach 10) was in proper functioning condition, 35% was functional at risk, and 36% was nonfunctional. Assuming Reach 10 was in proper functioning condition indicates that 34% of the St. Regis River was in proper functioning condition, 32% was functional at risk, and 34% was nonfunctioning. Reaches in proper functioning condition were generally located away from Interstate 90. Essentially natural channel conditions and well-vegetated riparian corridors characterized these reaches. Reaches in a functional at risk category have adjusted to partially channelized conditions within a narrow but defined riparian corridor. However, functioning at risk reaches generally lacked in-stream habitat diversity. Reaches that were nonfunctional have been dramatically altered, either directly or indirectly, by the development of the transportation corridor. Nonfunctional reaches tended to be highly channelized and lacked development of anything beyond a streamside band of riparian vegetation. Reaches 3 and 7 met this description, while Reach 5 was aggraded with an extremely wide and braided channel.

Table E-8. The Condition of Reaches 1-9 along the St. Regis River Based on the Proper Functioning Condition Protocol Developed by the Bureau of Land Management (BLM 1998)

Reach	1	2	3	4	5	6	7	8	9
Proper Functioning Condition				X				X	X
Functional at Risk	X	X				X			
Nonfunctional			X		X		X		

Fish Passage Assessment

The majority of culverts associated with Interstate 90 and Frontage Road were large diameter, with low gradients and deep water in the bottom that did not appear to present any fish passage problems at low flows (**Table E-9**). Most of the surveyed culverts were corrugated metal pipes (CMP), though 2 concrete box culverts and a concrete arch culvert were assessed. Culverts under Interstate 90 ranged from approximately 125 to 300 feet long. These culverts may present problems at high flows due to their substantial lengths. The culvert on the St. Regis River mainstem at river station 185,000 was a fish barrier. This culvert, which was on Forest Service land, was an aging concrete arch with a three foot drop at the outlet. The culverts under Interstate 90 at river stations 178,500 and 187,000 may present fish passage barriers, especially at higher flows. The culvert transporting Randolph Creek under Interstate 90 may also be a fish passage barrier. The culvert on Silver Creek was not assessed, though it has been affirmed to be a fish passage barrier.

Table E-9. Culverts Assessed Relative to Fish Passage

Stream	Road	River Station	Length (Feet)	Diameter (HxW) (Feet)	Alignment (Degrees)	Type	Material	Outlet Drop	Bankfull Width Upstream (Feet)	Fish Barrier	Condition
Twelvemile	I90	68500	125	18	0	cmp	steel	none	35.3	no	good
Twin	I90	88200	300	8	15	cmp	steel	none	18	no	good
Twin	Frontage	89000	49	7 X 13	0	box	concrete	none	19	no	good
East Twin	Twin Cr	NA	48	4	15	cmp	steel	slight	9.2	no	good
Savenac	I90	98500	150	8 X 10	0	cmp	steel	none	28	no	good
Savenac	Frontage	98500	47	9 X 17	0	box	concrete	none	33.4	no	fair
Randolph	I90	158500	140	10	0	cmp	steel	1 foot	14.7	possible	good
Packer	?	NA	30	6	0	cmp	steel	none	15.7	no	good
Packer	?	NA	55	8	0	cmp	steel	none	16.8	no	good
St. Regis	I90	178500	160	8	0	cmp	steel	none	20	possible	good
St. Regis	?	185000	63	14 X 14	45	arch	concrete	3 foot	19	yes	poor
St. Regis	I90	187000	200	15	90	cmp	steel	none	20	possible	good

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APPENDIX F
CANOPY DENSITY ASSESSMENT FOR THE ST. REGIS RIVER TMDL

Prepared by Land and Water Consulting, Inc.

Introduction

Factors influencing stream temperature include solar radiation, the density of riparian vegetation, channel morphology, discharge, and stream aspect. Shade provided by riparian vegetation decreases the amount of solar radiation reaching the channel. A decrease in the canopy density along the stream channel can increase the amount of solar radiation reaching the stream channel, which leads to increased water temperatures (Hostetler 1991). An examination of stream temperature within the Lochsa River of Idaho found that a reduction in average canopy density and tree height in riparian stands as a result of human disturbance led to increased water temperatures (HDR, 2002).

Methods

The magnitude and location of canopy density along the St. Regis River was assessed using the 2000 aerial photographs (1:15,840 scale) and a mirror stereoscope. Ten reaches previously delineated along the St. Regis River using the 1996 orthophoto quads were divided into 70 subreaches based on channel aspect, land ownership, and changes in valley type. Reaches 1 through 9 were divided into subreaches varying in length from 700 to 8,500 feet. Average reach length was approximately 3,000 feet. Aerial coverage allowed for 5,300 feet to be measured within Reach 10. Overall, canopy density was assessed along 202,000 feet (96%) of the St. Regis River, as well as the lower portions of nine tributaries.

Stereo aerial photography was used to assess several parameters using the 2000 aerial photographs. For each subreach the stationing, length, aspect, canopy density along the left and right banks, bankfull channel width, distance from Interstate 90, the percent of the reach containing at least 100 feet of riparian buffer, land ownership, and valley type were recorded. Subreach stationing and length were measured progressing upstream using the 1996 orthophoto quads with 500-foot increment mid-channel stationing. Left and right banks were analyzed individually assuming a downstream perspective. Channel aspect was measured on the 1996 orthophoto quads by placing a compass at the lower end of a subreach and recording the angle upstream. Channel aspect categories were defined as 0 (north/south), +45 (northeast/southwest), 90 (east/west), and –45 (northwest/southeast).

Canopy density, which influences the amount of streamside shading and the amount of solar radiation reaching the stream, was determined separately for both the left and right banks within each subreach. Canopy density was measured in 5% increments using a crown density/percent crown cover scale while viewing paired images from the year 2000 under a mirror stereoscope. The use of paired images created a 3-dimensional perspective upon which canopy density was measured. The mean canopy density for each subreach was visually determined for each bank individually. Canopy densities along the left and right banks were then averaged to give an overall subreach canopy density. Canopy density was also assessed along the privately owned lower reaches of Little Joe, Twelvemile, Twin, Savenac, Big, Packer and Silver Creeks. Ward Creek and Deer Creek, which are almost entirely on National Forest lands, were assessed as possible reference conditions.

The bankfull channel width, distance from Interstate 90, and the percent of each subreach containing at least 100 feet of riparian buffer were measured using an engineering scale and the mirror stereoscope with the 2000 aerial photographs. The 100 foot buffer distance was chosen as a measure of the amount of anthropogenic impacts to the riparian zone and the stream channel. The percent of each subreach with 100 feet of buffer was averaged for both sides of the river.

Land ownership was determined using the NRIS Stewardship Map. Land ownership was described as Forest Service land (fs), private lands (pl), or Plum Creek timber lands (pc). Valley type was determined from USFS data employing the Rosgen classification system (Rosgen 1996). In addition, stream order along the St. Regis River was determined using USGS 7.5 minute series topographic maps (Scale 1:24,000).

Weighted averages based on the length of each subreach in comparison to the overall reach were calculated. Thus, the results of the subreach assessment were summarized as overall reach averages.

Results and Discussion

Land ownership analysis using the NRIS Stewardship map as a reference indicates that 14.9 miles (37%) of the St. Regis River corridor are privately owned, while 25 miles (63%) are located within the Lolo National Forest. Applying a 0.5-mile buffer along the St. Regis River upon the NRIS Stewardship map indicates that the Lolo National Forest occupies 71% of the area, 24% is privately owned, Plum Creek Timber owns 3%, while state trust lands occupy the remaining 2%. There are 18.3 miles of stream with a –45 degree aspect, 15.9 miles with a 90 degree aspect, 3.6 miles with a 0 degree aspect, and 2.1 miles with a 45 degree aspect. Thus, the majority of the St. Regis River flows from northwest to southeast and west to east. Three valley types are present along the St. Regis River. The mainstem of the St. Regis River alternates between Type 2 valleys and Type 8 valleys, while the headwater reaches are found in Type 5 valleys (Rosgen 1996). The St. Regis River is a 5^{th} order stream for 25.9 miles from the mouth upstream to the confluence with Packer Creek. From Packer Creek upstream to Randolf Creek, the St. Regis River is a 4^{th} order stream for 9.3 miles. From Randolph Creek upstream to Brimstone Creek the St. Regis River is a 3^{rd} order stream for 1.1 miles. Upstream of Brimstone Creek the St. Regis River is a 2^{nd} order stream, except for the 1^{st} order tributaries flowing out of the lakes at the headwaters.

Mean bankfull width at the subreach scale varies from approximately 90 feet in Reach 1 to less than 5 feet in the headwaters. Bankfull width is generally correlated with valley type along the St. Regis River. Wider Type 8 valleys have greater floodplain development and higher bankfull widths than the more constricted Type 2 valleys (**Table F-1**). However, channelization is also greater in the narrow Type 2 valleys and may play a role in reduced bankfull widths.

Table F-1. Reach Scale Comparison of Mean Canopy Density along the Left Bank, Right Bank, and Overall Stream Length

Reach	Density Left Bank	Density Right Bank	Density Overall	% Reach with 100-foot Buffer	Bankfull Width (Feet)	Valley Type
1	25	40	35	45	90	8
2	30	45	40	5	55	2
3	20	30	25	20	55	2
4	35	50	45	85	80	8
5	25	40	35	65	90	8
6	35	55	45	45	45	2
7	25	40	35	35	30	2
8	25	75	50	60	20	2
9	40	60	50	75	10	5
10	60	70	65	100	5	5
Overall	*30*	*50*	*40*	*50*		

Mean canopy density for the St. Regis River averages 30% along the river left bank and 50% along the river right bank. Thus, the overall mean canopy density along the St. Regis River is 40%. Mean canopy density ranges from 20% to 60% along the left bank and 30% to 75% along the right bank at the reach scale. Overall, mean canopy density within each reach ranges from 25% to 65% (**Table F-1, Figure F- 1**). Individual subreach values are presented in **Table F-2**.

Table F-2. Canopy Cover Assessment along the St. Regis River (measurements in feet)

Reach	River Station	Length	Aspect	Density Left	Density Right	Density Overall	Distance to I-90	Ownership
1.0	0-2700	2700	90	0	40	20	190	pl
1.1	2700-5600	2900	-45	45	50	48	150	pl
1.2	5600-7200	1600	90	30	50	40	80	pl
1.3	7200-9700	2500	45	20	10	15	300	pl
1.4	9700-12200	2500	-45	25	35	30	250	pl
1.5	12200-1400	1800	45	25	55	40	60	pl
1.6	14000-19200	5200	90	25	40	33	30	fs
1.7	19200-21000	1800	-45	40	55	48	110	fs
1.8	21000-22500	1500	45	15	35	25	30	fs
1.9	22500-23200	700	-45	15	55	35	15	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
2.0	23200-26200	3000	-45	40	50	45	60	pl
2.1	26200-27000	800	0	0	15	8	20	pl
2.2	27000-32000	5000	90	10	40	25	90	fs
2.3	32000-36500	4500	-45	40	50	45	100	fs
2.4	36500-42500	6000	90	35	50	43	55	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
3.0	42500-49000	6500	-45	20	40	30	60	fs
3.1	49000-50200	1200	0	20	30	25	50	pl
3.2	50200-51600	1400	90	20	30	25	50	pl
3.3	51600-53200	1600	0	20	20	20	25	fs
3.4	53200-55000	1800	90	20	30	25	55	fs
3.5	55000-57000	2000	-45	20	20	20	70	pl
3.6	57000-58500	1500	0	20	30	25	70	pl
3.7	58500-59500	1000	90	30	30	30	200	fs
3.8	59500-61000	1500	0	20	10	15	95	fs
3.9	61000-62500	1500	-45	20	20	20	500	fs
3.11	62500-64000	1500	0	10	30	20	500	fs
3.12	64000-65500	1500	90	35	45	40	600	fs
3.13	65500-68500	3000	-45	5	35	20	100	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
4.0	68500-70000	1500	0	0	20	10	60	fs
4.1	70000-72000	2000	-45	35	35	35	190	fs

Table F-2. Canopy Cover Assessment along the St. Regis River (measurements in feet)

Reach	River Station	Length	Aspect	Density Left	Density Right	Density Overall	Distance to I-90	Ownership
4.2	72000-80500	8500	-45	40	50	45	230	pl
4.3	80500-84000	3500	-45	55	65	60	400	fs
4.4	84000-87000	3000	-45	35	60	48	250	pl
4.5	87000-93000	4500	-45	25	60	43	250	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
5.0	91500-93900	2400	90	55	75	65	370	fs
5.1	93900-95000	1100	-45	55	45	50	220	fs
5.2	95000-99000	4000	90	5	20	13	50	pl
5.3	99000-105500	6500	-45	10	40	30	160	pl
5.4	105500-10700	1500	0	10	40	30	250	pl
5.5	10700-108500	1500	90	35	55	35	200	pl
5.6	108500-111000	2500	-45	40	30	35	350	pl
5.7	111000-114000	3000	90	40	50	45	230	pc
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
6.0	114000-118500	4500	90	40	55	48	125	fs
6.1	118500-123000	4500	-45	40	60	50	105	fs
6.2	123000-124500	1500	90	20	50	35	115	fs
6.3	124500-127000	2500	-45	15	30	23	110	fs
6.4	127000-129500	2500	90	55	60	58	210	fs
6.5	129500-134000	4500	90	20	65	43	80	fs
6.6	134000-138500	4500	-45	50	55	52	180	pl
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
7.0	138500-144000	5500	-45	10	20	15	40	fs
7.1	144000-149000	5000	90	10	15	13	40	fs
7.2	149000-152000	3000	90	35	60	48	120	fs
7.3	152000-154500	2500	90	60	70	65	300	fs
7.4	154500-156000	1500	90	20	70	45	75	fs
7.5	156000-157000	1000	45	55	75	65	375	fs
7.6	157000-159500	2500	-45	20	30	25	170	pl
7.7	159500-160500	1000	90	20	75	48	200	pl
7.8	160500-16200	1600	-45	10	10	10	140	pl
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**

Table F-2. Canopy Cover Assessment along the St. Regis River (measurements in feet)

Reach	River Station	Length	Aspect	Density Left	Density Right	Density Overall	Distance to I-90	Ownership
8.0	162100-163500	1400	-45	0	75	38	190	pl
8.1	163500-169500	6000	90	20	75	48	150	fs
8.2	169500-172000	2500	-45	45	70	58	100	fs
8.3	172000-175000	3000	0	25	75	50	145	fs
8.4	175000-178500	3500	-45	30	75	53	120	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
9.0	178500-181000	2500	0	40	65	53	150	fs
9.1	181000-185000	4000	90	10	45	28	20	fs
9.2	185000-186700	1700	-45	50	60	55	195	fs
9.3	186700-193000	6300	-45	60	65	63	450	fs
9.4	193000-196700	3700	90	30	60	45	2000	fs
Reach	**River Station**	**Length**	**Aspect**	**Density Left**	**Density Right**	**Density Overall**	**Distance to I-90**	**Ownership**
10.0	196700-202000	5300	90	60	70	65	NA	fs

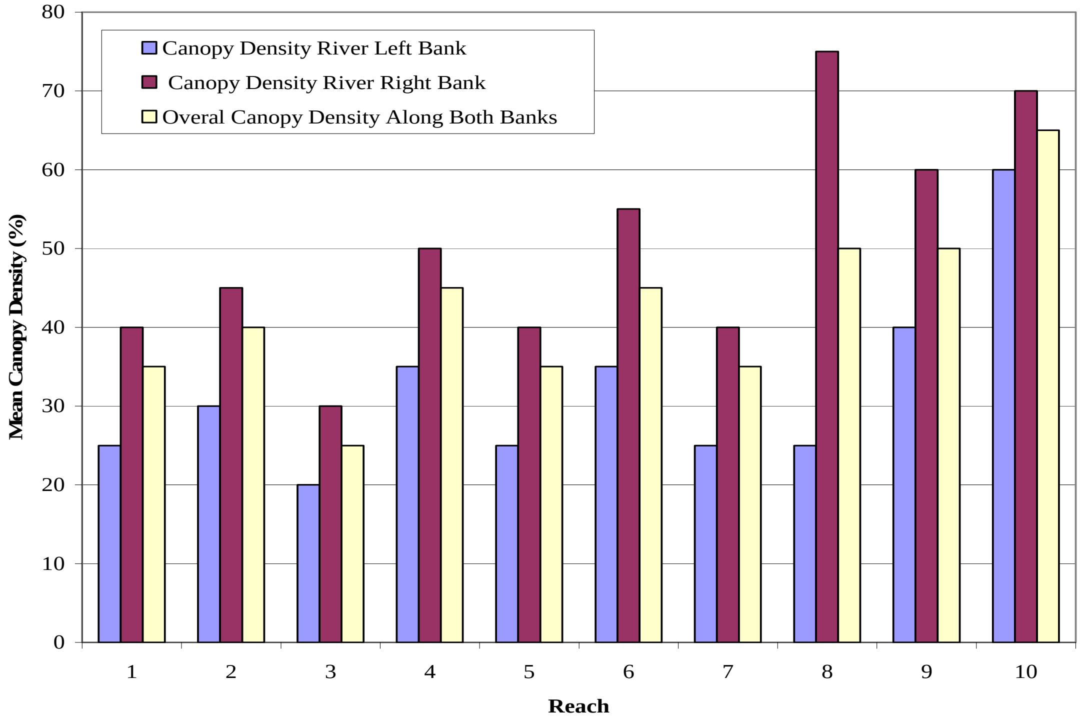

Figure F- 1. Mean Canopy Densities for the River Left Bank, River Right Bank, and Overall Density for Both Banks in Reaches 1-9 along the St. Regis River

The riparian corridor along the St. Regis River competes with the transportation corridor for space upon the floodplain. Interstate 90 is primarily situated above the left bank along the north side of the river. The average distance from the stream channel to the interstate shoulder in Reaches 1-9 is 180 feet. Interstate 90 and the old railroad grade, which is located primarily along the right bank on the south side of the river, have effectively reduced the width of the riparian corridor. At least 100 feet of riparian buffer exists along 50% of the St. Regis River (**Table F-1**). The overall length of stream reach with at least 100 feet of riparian buffer varies from 5% in Reach 2 to 85% in Reach 4 (**Table F-1**).

Canopy density at the reach scale varies between the left and right bank. Canopy density ranges from 0-60% along the river left bank. Ten percent of the river left bank has 60% canopy density, 8% has 50% canopy density, 22% of the left bank has 40% canopy density, 11% has 30% canopy density, 26% of the left bank has 20% canopy density, 17% has 10% canopy density, and 6% of the river left bank has 0% canopy cover (**Table F-3**). The close proximity of the interstate has reduced the amount of riparian coverage along the left bank of the St. Regis River. Overall, 40% of the left stream bank has canopy densities greater than 50%, while 60% of the left bank has canopy densities less than 50%.

Table F-3. Percent of Left Bank Containing Canopy Density Expressed in 10% Intervals along the St. Regis River

Reach	60%	50%	40%	30%	20%	10%	0%
1	0	0	21	7	52	9	11
2	0	0	39	31	0	26	4
3	0	0	0	10	74	5	11
4	0	15	37	22	20	0	6
5	0	16	24	7	0	36	17
6	0	29	37	0	24	10	0
7	0	4	30	0	15	51	0
8	0	0	15	21	55	0	9
9	35	9	14	20	0	22	0
10	100	0	0	0	0	0	0
Overall	*10*	*8*	*22*	*11*	*26*	*17*	*6*

Canopy density at the reach scale along the river right bank varies from 10-70%. Nineteen percent of the right bank has 70% canopy density, 17% has 60% canopy density, 22% of the bank has 50% canopy density, 18% has 40% canopy density, 11% of the bank has 30% canopy density, 8% has 20% density, and 5% of the river right bank has 10% canopy density (**Table F-4**). Canopy density is clearly greater along the right side of the river, though the presence of the old railroad grade reduce the shading potential in several locations due to their position in-between the stream bank and the densely forested hillsides. Interstate 90 also impacts canopy density along the right bank in a couple of locations. Overall, 58% of the right bank has greater than 50% canopy density, while 42% of the right bank has less than 50% canopy density.

Canopy cover was field verified at 7 sites in which aerial photo interpretation ranged from 35-75% canopy cover. Canopy cover measurements using a spherical densiometer averaged 10.7% higher than the aerial photo interpretation with the mirror stereoscope indicated.

Table F-4. Percent of Right Bank Containing Canopy Density Expressed in 10% Intervals along the St. Regis River

Reach	70%	60%	50%	40%	30%	20%	10%
1	0	0	39	34	17	0	10
2	0	0	70	46	0	0	4
3	0	0	0	31	45	19	5
4	0	48	37	0	9	6	0
5	11	0	20	41	0	28	0
6	0	47	43	0	10	0	0
7	38	0	0	0	11	23	28
8	100	0	0	0	0	0	0
9	0	78	0	22	0	0	0
10	100	0	0	0	0	0	0
Overall	*19*	*17*	*22*	*18*	*11*	*8*	*5*

Comparison to Forest Service Analysis

Canopy assessments conducted by the Lolo National Forest using satellite imagery data indicate similar results as the aerial stereoscope analysis. Canopy density was assessed along the mainstem of the St. Regis River by the Forest Service for three reaches: mouth to Twelvemile Creek, Twelvemile Creek to Saltese, and Saltese to northwest section 5. In addition, the Forest Service assessed canopy density along Big, Deer, Twelvemile, Ward, and Little Joe Creeks, as well as several upstream tributaries of these creeks. The Forest Service categorized canopy density as high (>70%), medium (40-70%), low (20-40%), and "canopy not mapped" (CNM). The "canopy not mapped" category generally consisted of rock, grassland, and meadow types of coverages that are considered to have a density of 0%. Mean canopy density derived from the Forest Service satellite imagery data and the stereo aerial photography analysis indicates the similarity of the results (**Table F-5**). Thus, Forest Service data will be used for canopy density assessment within St. Regis River tributaries.

Table F-5. Mean Canopy Density Determined by Averaging Satellite Imagery Data and Stereo Aerial Photography Data

Reach	Source	>70%	40-69%	20-39%	<20% (CNM)
mouth to Twelvemile	satellite imagery	6	39	31	24
Reaches 1, 2, and 3	aerial photographs	0	44	42	14
	mean	**3**	**42**	**36**	**19**
Twelvemile to Saltese	satellite imagery	7	70	13	10
Reaches 4, 5, and 6	aerial photographs	2	66	21	11
	mean	**5**	**68**	**17**	**10**
Saltese to nw sec 5	satellite imagery	15	48	16	21
Reaches 7, 8, and 9	aerial photographs	23	35	24	18
	mean	**19**	**42**	**20**	**19**

Recommended Reference Conditions for Canopy Density for the St. Regis River

Potential restoration sites were selected based on an observed lack of anthropogenic disturbances near the stream channel. These reaches have at least a 100-foot riparian buffer along 100% of the stream channel, except for subreach 8.2, which has at least 100 feet of buffer along 80% of the length. Subreach 8.2 was retained due to its applicability for shrub dominated wetland habitat types in Type 2 valleys. All subreach reference conditions have at least 60% overall canopy density. In-stream changes, such as alterations in sediment load, were not included in this assessment.

Subreaches 4.3 and 5.0 contain reference conditions for Type 8 valleys. Reference conditions in Subreaches 4.3 and 5.0 indicate large deciduous/coniferous floodplain areas have 45-65% canopy density, while coniferous hillsides tend to have canopy densities from 70%-80%. Subeach 4.3 contains a section of National Forest land in which the riparian areas contain a large amount of conifers along both sides of the river. There is 80% canopy density along the hillside above the river right bank and 55% along the floodplain. Floodplain forests along the river left bank are more mature, containing 55-65% coverage with a high proportion of conifers, while stands of deciduous vegetation are present closer to the channel. Average stream width is 90 feet in Subreach 4.3, with the low flow channel braiding through gravels bars. An appropriate reference reach average based on conditions in Subreach 4.3 would be 60% overall canopy density for Type 8 valleys (**Table F-6**). Subreach 5.0 contains reference conditions on Forest Service land just upstream of the Deer Creek confluence. Reference conditions exist for deciduous/coniferous floodplain conditions (55% canopy density) along river left and the coniferous hillside condition (75% canopy density) along river right for with an overall canopy density of 65% for this Type 8 valley (**Table F-5**). The right side of the river in Subreach 5.0 can be used as the reference condition for reaches where the old railroad grade runs between the channel and the forest.

The reference condition on Forest Service land in Subreach 6.4 has 60% canopy density overall with 55% in the deciduous riparian forests and 65%-70% along the coniferous dominated riparian stands, while dense coniferous forests on the hillside tend to average 75% canopy cover (**Table F-6**). The mean bankfull width along straight reaches is 40 feet, while the meander curves tend to be about twice as wide.

Subreach 7.3 represents reference conditions for Type 2 valleys. Conifer canopy densities range from 65-75% along the right bank, while there is less coverage (55-65%) along the left bank for an overall canopy density of 65% and a bankfull width of 30 feet (**Table F-5**).

Subreach 8.2 provides reference conditions for conifer and shrub dominated wetland habitat types in Type 2 valleys. There is a dense coniferous canopy along the right bank with 65-75% canopy cover at varying distances from the channel with shrubs in-between, while the less dense left bank has 45% conifer canopy density with some deciduous shrubs present. The channel is braided around a shrub complex requiring two bridge crossings at 172,000. Canopy density is 60% overall in Subreach 8.2, while the bankfull width averages from 20 to 25 feet (**Table F-5**).

Subreach 10.0 is a reference headwater condition that may be applicable to tributaries and Type 5 Valleys. There is 55-75% canopy density along this headwater subreach, with greater density along the right bank below the north-facing slope. Overall canopy density averages 65% (**Table F-5**). The stream meanders through a riparian shrub corridor that varies from 20-100 feet wide, while the bankfull width averages 5 feet.

Table F-6. Reference Sites

Reach	Station	Length (Feet)	Aspect	Bankfull Width (Feet)	Density Left Bank	Density Right Bank	Density Overall
4.3	80,500-84,000	3,500	-45	90	55	65	60
5.0	91,500-93,900	2,400	90	60	55	75	65
6.4	127,000-129,500	2,500	90	65	55	60	60
7.3	152,000-154,500	2,500	90	30	60	70	65
8.2	169,500-172,000	2,500	-45	25	45	70	60
10.0	196,700-202,000	5,300	90	5	60	70	65

Reference conditions along the St. Regis River indicate overall canopy density at the subreach scale ranges from 60-65% (**Table F-5**), with canopy density along the left bank ranging from 45-60% and canopy density along the right bank ranging from 60-75%. Mean canopy density across the six reference reaches averages 55% along the left bank and 69% along the right bank. An overall canopy density target level of 60-70% is proposed for riparian restoration geared toward increasing shading and reducing stream temperatures along the St. Regis River. However, potential conditions will need to be adjusted based on the proximity of the interstate and the old railroad grade, along with the associated riprap.

Restoration Potential

Based on this aerial assessment, potential sites for restoration were prioritized first by aspect class and then by canopy density. Subreaches with 90-degree and –45-degree aspects (34.2 miles, 86% of the channel length) were selected since these aspects were identified during stereoscope work to provide the most shading. Beneficial shading observed during stereoscope work occurred primarily along the right bank. Thus, all subreaches oriented at these two aspects with 40% or less canopy density along the river right bank were selected. This revealed 64,700 feet (12.2 miles, 31% of the channel length) of right bank along the St. Regis River oriented at 90-degree and –45-degree aspects currently possess 40% or less canopy density. Subreaches containing 20% or less canopy cover along the right bank were then selected within these two aspect classes, which narrowed the length to 19,700 feet. Subreaches 3.5, 3.9, 7.0, and 7.6 are at a –45-degree aspect and have 10-20% canopy density along both banks (**Table F-6**). Sites 3.5 and 7.6 are on private land, while sites 3.9 and 7.0 are on public land. These sites comprise 10,700 feet of stream channel or 21,400 feet of stream bank. Potential restoration projects could focus on increasing the canopy cover from 10-20% to 60-70% for the four separate reaches along 10,700 feet of the river right bank. Subreaches 5.2 and 7.1 are at the 90-degree aspect and have 5-20% canopy coverage along both banks (**Table F-7**). Subreach 5.2 is on private land, while Subreach 7.1 is on public land. These two subreaches cover 9,000 feet of channel of 18,000 feet of stream bank. Restoration efforts could increase canopy cover along the right bank of these sites by 50% overall.

The St. Regis River is a 5^{th} order stream in Reaches 3 and 5 and a 4^{th} order stream in Reach 7. Riparian shade generally has a moderate influence on stream temperature in 4^{th} order streams and a low influence on stream temperature in 5^{th} order streams (Poole and Berman 2001). Thus, restoration sites in Reach 7 may be assigned a higher priority. Subreaches 7.0, 7.1, and 7.6 cover a total stream length of 12,100 feet. A 50% increase from 10-20% canopy density to 60-70% canopy cover along the right bank in these three subreaches would restore thermal protection to 6% of the St. Regis River. Restoration of canopy densities to 60-70% coverage along the right bank within all six selected subreaches totaling 19,700 feet would increase thermal protection along 10% of the St. Regis River.

Table F-7. Potential Restoration Sites Identified Using the Criteria of -45 or 90-Degree Aspect and 20% or Less Canopy Density along the Right Bank

Reach	Station	Length (Feet)	Aspect	Bankfull Width (Feet)	Density Left Bank	Density Right Bank	Density Overall
3.5	55,000-57,000	2,000	-45	50	20	20	20
3.9	61,000-62,500	1,500	-45	45	20	20	20
5.2	95,000-99,000	4,000	90	85	5	20	15
7.0	138,500-144,000	5,500	-45	30	10	20	15
7.1	144,000-149,000	5,000	90	25	10	15	15
7.6	160,500-162,100	1,700	-45	20	10	10	10

Analysis of reach scale canopy densities reveals that Reach 3 has the lowest canopy density, with only 25% canopy density overall and 30% along the right bank (**Table F-1**). Reaches 1, 5, and 7 have 40% canopy density along the right bank, Reach 2 has 45% canopy density along the right bank, while the other reaches have at least 50% canopy density along the right bank (**Table F-1**). To obtain 60-70% canopy density along the right bank in all the reaches riparian coverage should be increased by 40% in Reach 3, 30% in Reaches 1, 5, and 7, and 20% in Reach 2. Possible restoration sites in Reaches 3, 5, and 7 are described in **Table F-7**. Unfortunately, all 6 subreaches identified using the given criteria are confined by riprap to some degree, which may make restoration difficult. Poole and Berman (2001) caution that placing shade trees along channelized reaches only adds permanence to the degraded condition. Identification of a portion of the floodplain where channelization may be removed and floodplain connectivity reestablished, followed by the reestablishment of riparian vegetation, may provide the best long-term restoration (Poole and Berman 2001).

Reach 5 contains a large moderately unconfined floodplain area located on private property that may be an excellent location for stream channel restoration. The overall channel is flowing from the northwest to the southeast in this reach. Upstream of the Big Creek Road bridge the channel is extremely wide, with the bankfull width averaging 200 feet. The large bankfull width allows for greater solar input and may lead to increased stream temperatures. Based on reference conditions in subreach 6.4 the bankfull width should average 65 feet. Riparian vegetation along the left bank is converting to coniferous vegetation, which indicates that the floodplain is not receiving floodwaters. Restoration could address 8,300 feet of channel (1.6 miles) from Big Creek Road bridge at 103,200 upstream to the washed out old railroad crossing at 111,500. The channel could be narrower with more meanders for 3,700 feet from 104,800 to 108,500 along which vegetated areas have a canopy density of 35-55% on the river left bank (except where the road abuts the channel), while canopy density along the right bank ranges from 10-45%. In addition, canopy density could be increased along the right bank, which is currently lined with railroad riprap for 1,300 feet from 108,500-109,800 (**Table F-6**). Thus, restoration efforts along 1.6 miles of the St. Regis River geared towards reducing channel width and increasing the amount of riparian vegetation could lead to lower stream temperatures.

Reach 7 upstream of the Rainy Creek confluence contains approximately 2,000 feet of duplicate roads confining the St. Regis River. The left bank is lined with riprap that protects the more northerly road downstream of the FR 506 bridge. A portion of the more southerly road could be removed along with the bridge/culvert (at 160,700) and the confluence with Rainy Creek could be improved.

Canopy Density along the Lower Reaches of St. Regis River Tributaries

Lower Little Joe Creek for approximately 0.6 miles contains a wide riparian wetland complex in which deciduous trees along both sides of the river have a canopy density of 35% and the meandering channel has a bankfull width of 60 feet. The valley narrows and the road draws closer to the channel for approximately 0.6 miles further upstream. The canopy becomes denser, with 55% along river left and 65% along river right (**Table F-9**). There is a large private field along river right, though there is a buffer between the field and the stream channel. National Forest land extends upstream to the confluence of the North Fork and the South Fork along which the vegetation becomes dominated by conifers packed closely along the channel with 65-75% canopy density.

Ward Creek is located on National Forest land. The lower 0.7 miles of Ward Creek have a canopy density of 65% along the right bank below a southeast facing hill slope and 75% along the left bank below a northwest facing hill slope (**Table F-9**).

Twelvemile Creek flows for 0.4 miles from the interstate through a wet meadow area upstream toward the road where it becomes channelized for 0.5 miles. There is 15% canopy density in the wet meadow along river left and 45-65% canopy density along river right. The channelized section has a road along the right bank with 0% canopy density and a steep hill along river left that has 75% canopy density. The bankfull width in this reach is approximately 20 feet. Timber harvest along the left bank hillside starts in the channelized reach and extends upstream with an average buffer of 60 feet. Upstream of the channelized reach the corridor between the road and the hillside widens to an average of 250 feet for another 0.5 miles before the river veers to the west and goes under a bridge. The open riparian area has canopy density of 10% while the harvested hillside was assigned a density of 45% to account for the buffer. The river meanders through a valley with several residences for 0.3 miles before going under another bridge and onto public land. There is a stand on either side of the river with 55% canopy density while the rest of the area is relatively open for a reach average of 30% (**Table F-9**).

The confluence of East and West Twin Creeks occurs 0.2 miles upstream from the culvert entrance where Twin Creek flows under the road and then the interstate for 350 feet. There is a tilled field directly abutting the steam channel extending 150 feet up the West Fork upstream of the confluence and 250 feet below the confluence along the mainstem. Other residential and agricultural developments are evident, though the stream appears to be buffered. Canopy density averages 30% along lower Twin Creek (**Table F-9**).

The lower 1-mile of Deer Creek has dense canopy cover along both sides of the stream. The lower 0.4 miles of this reach contain a meandering stream through braided gravel bars with a bankfull channel averaging 40 feet wide, while the upper 0.6 miles is more constricted with shrubs along a much narrower channel. Canopy density along the overall reach is 65-75% (**Table F-9**).

The lower 0.6 miles of Savenac Creek flows through a wetland complex that is confined between the interstate and the hill slope to a width varying from 20 feet to 350 feet. There is a large eroding slope feeding into this wet area. Hill slope canopy density along the left side of the river is 55%, while there is no coverage beside the road along the right side of the river. Upstream, the creek runs for 0.2 miles through a small developed area that includes a bridge. Large conifers with 65% density surround both sides of the stream (**Table F-9**).

The lower 0.2 miles of Big Creek has several residences and a canopy density of 20% along both banks. The bankfull channel averages 90 feet wide while the wetted width is only 15 feet wide in the aerial photographs from 2000. The next 0.4 miles upstream to the bridge appear more natural. The canopy density averages 45% along the left bank and 50% along the right bank (**Table F-9**). Canopy density remains the same on National Forest lands upstream, though the riparian floodplain through which the channel meanders is comprised of dense shrub vegetation and the bankfull width is reduced to 60 feet.

The lower 900 feet of Silver Creek are completely channelized, though there is vegetation along both sides. There is rural residential development along the lower 0.4 miles of Silver Creek that has 55% canopy coverage provided by large deciduous trees (**Table F-9**). National Forest lands upstream are in a relatively undisturbed condition with 75% canopy coverage on the hillsides and shrubs with widely dispersed conifers along the narrow valley bottom.

The lower 0.2 miles of Packer Creek flow through a rural residential area in Saltese where canopy coverage averages 55%. Upstream of the bridge for 0.7 miles to the confluence of the forks is a riparian meadow with an extensive shrub understory and large conifer trees having 50-60% canopy density. There is rural residential development upstream of the forks, though the shrub dominated riparian appears to be largely intact (**Table F-9**).

Table F-9. Canopy Density along Privately Owned Tributary Reaches as well as Ward Creek and Deer Creek

Tributary	Length (Miles)	Density Left Bank	Density Right Bank	Density Overall
Little Joe Creek	0.6	35	35	35
	0.6	55	65	60
Ward Creek	0.7	65	75	70
Twelvemile Creek	0.4	15	60	40
	0.5	0	75	40
	0.5	10	45	30
	0.3	30	30	30
Twin Creek	0.2	30	30	30
Deer Creek	0.4	65	65	65
	0.6	75	75	75
Big Creek	0.2	25	25	25
	0.4	45	50	50
Savenac Creek	0.6	55	0	30
	0.2	65	65	65
Silver Creek	0.4	55	55	55
Packer Creek	0.2	55	55	55
	0.7	50	60	55

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APPENDIX G
AN ASSESSMENT OF CHANNEL ALTERATIONS, STREAM BANK ALTERATIONS, AND CHANNEL ENCROACHMENT ALONG THE ST. REGIS RIVER

Prepared by Land and Water Consulting, Inc.

Methods

Channel Alterations, Stream Bank Alterations and Channel Encroachment
Stream channel and bank alterations and channel encroachment associated with construction and maintenance of two highways and two railroads are suspected to have influenced the hydrology, sediment transport capacity, water quality, and aquatic habitat features of the St. Regis River. This project attempted to evaluate and quantify stream alterations along the St. Regis River and to identify key impact areas and causes. For purposes of this investigation, stream channel alterations are defined as the straightening of meanders or cutting through of meander curves with a new channel of less distance than the original. Stream bank alterations are defined as structural practices, such as riprap, jetties and dikes, used in an attempt to stabilize stream banks. Channel encroachment is defined as an unnatural confinement or constriction of the stream channel, and an accompanying loss of the stream's access to its natural floodplain.

Stream reaches along the St. Regis River were selected using 1996 orthophoto quads and analyzed using 1993 aerial photographs of the river corridor. Stream reach selection was based on valley type, land-use activities, natural breaks such as tributary confluences, and man-made breaks such as bridges and towns. A total of 10 reaches were delineated along the St. Regis River progressing upstream from its confluence with the Clark Fork River (**Table G-1**).

The vast majority of alterations along the St. Regis River were found to be associated with the placement of riprap along the stream banks. This project evaluated the length of stream banks impacted by riprap and encroachment using a visual assessment procedure. In addition, Interstate 90 construction plans obtained from the Montana Department of Transportation (MDT) were used to identify and quantify stream channel alterations specifically associated with the interstate highway project, along with the length and quantity of riprap added during highway construction.

Linear extent of riprap was measured on the 1996 orthophoto quads with 500-foot increment mid-channel stationing, beginning at the Clark Fork River confluence and extending upstream to the river's headwaters at St. Regis Lake. Channel impacts associated with Interstate 90 were compared to preexisting impacts associated with two railroads by examining aerial photographs from 1963-64, 1993, 1996, and 2000, together with the MDT construction plans for Interstate 90. St. Regis River tributary features and evidence of channel alterations were also assessed.

Table G-1. St. Regis River Reach Delineations

Reach	Description	Mile	Length	Stationing	Length
1	Clark Fork River to Twomile Creek	0 - 4.4	4.4	0 - 23,300	23,200
2	Twomile Creek to Ward Creek	4.4 - 8.1	3.7	23,200 - 42,500	19,300
3	Ward Creek to Twelvemile Creek	8.1 - 13.0	4.9	42,500 - 68,500	26,000
4	Twelvemile Creek to Deer Creek	13.0 - 17.3	4.3	68,500 - 91,500	23,000
5	Deer Creek to Haugan	17.3 - 21.6	4.3	91,500 - 114,000	22,500
6	Haugan to Saltese	21.6 - 26.3	4.7	114,000 - 138,500	24,500
7	Saltese to Taft	26.3 - 30.7	4.4	138,500 - 162,100	23,600
8	Taft to Hanaker Creek	30.7 - 33.9	3.1	162,100 - 178,500	16,400
9	Hanaker Creek to Northern Pacific Railroad Grade	33.9 - 37.3	3.5	178,500 - 196,700	18,200
10	Northern Pacific Railroad Grade to St. Regis Lake	37.3 - 39.9	2.6	196,700 - 210,500	13,800

Reaches delineated on the 1996 orthophoto quads were superimposed onto the 1963-64 and 2000 aerial photos. A Tamaya Super Planix β digitizing area-line meter was used to measure sinuosity of the St. Regis River channel from the 1963-64 (scale 1:20,000) and 2000 (scale 1:15,840) aerial photographs. Channel slope was determined using elevation data taken from the 2000 National Geographic Montana Seamless USGS Topographic Maps on CD-ROM (www.topo.com).

Results and Discussion

Channel Alterations, Stream Bank Alterations and Channel Encroachment

This analysis showed an extensive amount of stream channel alterations, stream bank alterations, and channel encroachment along the nearly 40-mile length of the St. Regis River. Development of a transportation corridor in the St. Regis River drainage has included the construction of the Chicago-Milwaukee-St. Paul and Northern Pacific railroads, U.S. Highway 10 and, most recently, Interstate 90 in the early 1980s. An analysis performed by the Montana Fish and Game Commission in 1963 found 17.9 miles of riprap along the banks of the St. Regis River, and 5.4 miles of relocated channel that removed natural meanders, and caused a loss of 0.9 miles of total river length. This report indicated that as much as 68 percent of the entire St. Regis River had been altered prior to the construction of Interstate 90 (Alvord and Peters, 1963). A report by the Superior Ranger District of the Lolo National Forest addressing probable impacts of the construction of Interstate 90 on the St. Regis River upstream of Saltese predicted an additional 1,900 feet (0.4 miles) of stream would be lost due to channel alterations (Howse 1969).

The current analysis indicates the presence of approximately 15.2 miles of riprap along the St. Regis River, with 10.5 miles along the river left bank and 4.7 miles along the river right bank. Collectively, about 26 percent of the river left bank is lined with riprap, while riprap covered about 12 percent of the right bank (**Table G-2, Figure G-1**). The majority of riprap used in stabilizing stream banks adjacent to Interstate 90, which generally parallels the north side of the river, was located along the river left bank. The majority of the riprap installed to protect the railroad is located along the river right bank. A total of 7.4 miles of riprap are associated with Interstate 90, while 7.8 miles of riprap are related to the construction and maintenance of Highway 10 and the railroads (**Table G-3**).

Table G-2. Linear Estimates and Percentages of St. Regis River Stream Banks Altered By the Placement of Blanket Rock Riprap

Reach No.	Reach Length (feet)	River Left (feet)	%	River Right (feet)	%	Total Alterations (feet)	Total Alterations (%)
1	23,200	4,900	21	3,400	15	8,300	18
2	19,300	6,300	33	2,600	13	8,900	23
3	26,000	11,500	44	3,200	12	14,700	28
4	23,000	2,200	10	0	0	2,200	5
5	22,500	6,800	30	2,700	12	9,500	21
6	24,500	7,700	31	3,800	16	11,500	23
7	23,600	7,100	30	6,600	28	13,700	29
8	16,400	5,800	35	0	0	5,800	18
9	18,200	3,000	16	2,400	13	5,400	15
10	13,800	0	0	0	0	0	0
Total	210,500	55,300	26	24,700	12	80,000	19
	39.9 miles	10.5 miles		4.7 miles		15.2 miles	

The impacts of stream channel alterations, stream bank alterations, and stream channel encroachment due to the development of the transportation corridor are found to vary in intensity along the length of the St. Regis River (**Table G-2, Figure G-1**) and by cause (**Table G-3**).

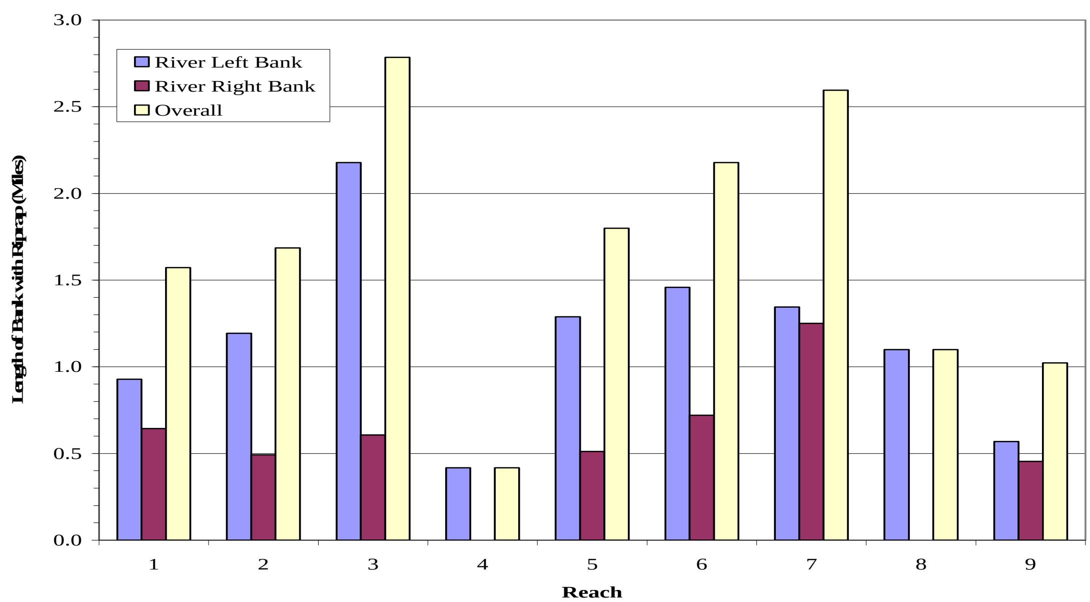

Figure G-1. Linear Estimates of the Length of St. Regis River Stream Banks Altered By the Placement of Blanket Rock Riprap

Reach 1 is heavily impacted by the construction of Interstate 90 with 18 percent of all stream banks lined with riprap. Reach 2 appears to retain extensive impacts from Highway 10 and the railroads, as does Reach 3, with 23 percent and 28 percent of the banks riprapped, respectively. Both of these reaches are also heavily impacted by the construction of Interstate 90. There is a 2,000-foot section of channel alteration in Reach 3 between Drexel and Ward Creek where the stream channel was relocated during the construction of Interstate 90. Reach 4 is the least impacted reach of the St. Regis River within the transportation corridor and could serve as a reference reach. Five percent of Reach 4 is lined with riprap, four percent of which was added during the construction of the railroads and Highway 10. Reach 5 is heavily impacted by Interstate 90 relative to stream bank alterations (19 % of all banks), while the major stream bank impacts in Reach 6 are caused by the railroads and Highway 10 (19%).

There is a 6,800-foot section of channel alteration within Reach 5, extending from the Big Creek Road Bridge downstream beyond the Big Creek confluence, where several meander curves have been cut off.

Reach 7 is highly impacted by both the railroad (17%) and Interstate 90 (12%), with a 10,000-foot section containing three separate channel alterations consisting of meander curve cut offs. Reach 8 is primarily impacted by riprap associated with the Interstate, with a total of 13 percent of the reach so affected by this source. Reach 9 is impacted relatively equally by both the railroad (8%) and the Interstate (7%), while Reach 10 is located outside the zone of influence of either Interstate 90 or the railroads and Highway 10.

Table G-3. Linear Estimates and Percentages of St. Regis River Stream Bank Alterations (Blanket Rock Riprap) Associated With the Construction of Interstate 90 or U.S. Highway 10 and the Chicago-Milwaukee-St. Paul and Northern Pacific Railroads

Reach No.	Reach Length	I-90 Alterations (right plus left banks)	%	Hwy10/RR Alterations(right plus left banks)	%
1	23,200	6,100	13	2,200	5
2	19,300	3,800	10	5,100	13
3	26,000	6,000	12	8,700	17
4	23,000	300	1	1900	4
5	22,500	8,400	19	1,100	2
6	24,500	2,300	5	9,200	19
7	23,600	5,500	12	8,200	17
8	16,400	4,200	13	1,600	5
9	18,200	2,400	7	3,000	8
10	13,800	0	0	0	0
Total	210,500	39,000	9	41,000	10
	39.9 miles	7.4 miles		7.8 miles	

The relative degree of impact resulting from St. Regis River stream bank alterations can be summarized by stream reach and for the river as a whole (Tables 2 and 3). For purposes of this discussion, a relatively low level of impact from stream bank alterations is defined as 0-10 percent of a given reach's total bank length (both banks) containing riprap. A moderate level of impact is defined as 11-25 percent of all banks containing riprap, while reaches having more than 25 percent of all banks with blanket rock riprap are considered to be heavily impacted from stream bank alterations. Applying this scale to the St. Regis River indicates that Reaches 1, 3, 5, 7 and 8 are moderately impacted by riprap associated with Interstate 90, while Reaches 2, 3, 6, and 7 are moderately impacted by stream bank alterations resulting from a combination of the railroads and Highway 10. It is important to note here that preexisting riprap associated with the construction of the railroads and Highway 10 is seen to provide a dual benefit of protecting Interstate 90 in some sub-reaches of the river. Interstate 90 minimally impacts Reaches 2, 4, 6, and 9, while Reaches 1, 4, 5, 8, and 9 are minimally impacted by the railroad. Reach 10 is unaffected by either Interstate 90 or the railroads and Highway 10.

On a river-wide basis, cumulative stream bank impacts resulting from both Interstate 90 and the earlier development of the transportation corridor can be classified as having a moderate level of impact (19 % of all banks affected), based on the previously described classification system. Individual reaches, including 3 and 7, have sustained heavy impacts (28 and 29 %, respectively). Reaches 1, 2, 5, 6, 8, and 9 have moderate impacts associated with stream bank alterations, while reaches 4 and 10 have minor or no impacts (**Table G-2**).

If we consider that the presence of riprap along either bank of the stream can negatively affect the proper functioning of the channel on a site-specific as well as river-wide basis, the St. Regis River has sustained a greater degree of impact. Approximately one-third of the entire 40-mile length of the St. Regis River has experienced stream bank alterations in the form of rock riprap placement along at least one of its stream banks (**Table G-4**). Individual stream reaches ranged from 10 to 58 percent of at least one bank with riprap, except Reach 10, which is unaffected. Approximately four percent of the St. Regis River has both banks riprapped, with individual reaches ranging from less than one to nearly 15 percent of both banks containing rock riprap.

Table G-4. Linear Estimates and Percentages of the St. Regis River with Blanket Rock Riprap Present along One or Both Stream Banks

Reach No.	Reach Length (feet)	Riprap present on at least one bank	%	Riprap present on both banks	%
1	23,200	8,000	34	300	1.3
2	19,300	8,500	44	100	0.5
3	26,000	14,500	58	200	0.8
4	23,000	2,200	10	0	0.0
5	22,500	8,700	39	800	3.5
6	24,500	10,100	41	1,400	5.7
7	23,600	10,200	43	3,600	15.0
8	16,400	5,800	35	0	0.0
9	18,200	3,400	19	2,000	10.9
10	13,800	0	0	0	0.0
Total	210,500	71,400	34	8,400	3.9
	39.9 miles	13.5 miles		1.6 miles	

Development of the transportation corridor has clearly impacted the St. Regis River by confining the channel and reducing channel sinuosity and length in localized areas. However, an analysis of changes in channel slope and sinuosity from 1963-64 to 2000 for the entire length of each of the 10 study reaches of the St. Regis River failed to indicate substantial differences. This may be primarily due to the fact that most channel impacts occurred prior to 1963-64 and the construction of Interstate 90 in the 1980s. The other factor is that localized channel changes, like those associated with the Interstate 90 construction described earlier, tend to become less pronounced when averaged over the 2.6 to 4.9 mile lengths of the study reaches.

The Lolo National Forest predicted that construction of Interstate 90 would cause a decrease in the number and quality of pools, a decrease in bank cover where riprap encroached on the channel, and a loss of bank stability as water was forced into the opposite bank. Channel gradient and water velocity were also predicted to increase (Howse 1969). The mean channel sinuosity was measured at 1.2 in both 2000 and 1963-64, while the 2000 mean channel slope was 1.4% (**Table G-5**).

Table G-5. Channel Sinuosity, Slope and Vertical Rise along the St. Regis River

Reach No.	2000 Channel Sinuosity	1963-64 Channel Sinuosity	2000 Channel Slope	2000 Channel Vertical Rise
1	1.2	1.2	0.4%	85
2	1.1	1.1	0.4%	82
3	1.3	1.3	0.6%	159
4	1.2	1.1	0.5%	111
5	1.2	1.2	0.6%	125
6	1.1	1.1	0.8%	197
7	1.1	1.1	1.0%	236
8	1.2	1.2	1.6%	255
9	1.3	*	3.3%	593
10	1.3	*	8.0%	1,106
Mean	1.2	1.2	1.4%	2,949 total

* 1963-1964 aerial photographs were not available for these reaches.

Analysis of the Montana Department of Transportation construction plans for Interstate 90 provided further insight into the degree of channel alterations associated with this highway project. Overall, 14,700 feet (2.8 miles) of stream channel alterations resulted from the construction of Interstate 90, impacting 7% of the St. Regis River (**Table G-6**).
The Drexel East and West construction plans described 2,000 feet of channel alterations impacting 8% of Reach 3 upstream of Ward Creek. Construction plans also called for the addition of 51 boulder clusters to this reach using 570 cubic yards of riprap. The plans for DeBorgia East and West indicated channel alterations comprising 30% of Reach 5 along both sides of the river in the form of meander cutoffs along a 6,800-foot section extending from the Big Creek Road Bridge downstream past the confluence with Big Creek. Twelve hundred willow cuttings were also called for in this reach. Construction plans for upstream of Saltese described 3,600 feet of channel alterations at three sites in Reach 7 covering 15% of the reach, while 2,300 feet of channel alterations at two sites impact 14% of Reach 8, including an extensive section between the Rest Area and the Taft Exit. Construction plans called for over 11,000 willow cuttings and several jetties upstream of Saltese. These plans also described 550 feet of channel alterations made to Silver Creek just upstream of the confluence with the St. Regis River.

Table G-6. Stream Channel Alterations in Reaches 3, 5, 7, and 8 Identified From the Montana Department of Transportation Construction Plans for Interstate 90

Reach No.	Reach Length (feet)	Length of Channel Alterations (feet)	%	No. of Sites
3	26,000	2,000	8	1
5	22,500	6,800	30	1
7	23,600	3,600	15	3
8	16,400	2,300	14	2
Total	210,500	*14,700*	*7*	*7*
	39.9 miles	2.8 miles		

Reach-Specific Descriptions

Reach 1 includes the St. Regis River from its confluence with the Clark Fork River upstream to Twomile Creek. The valley is open along this reach and is classified as a Valley Type 8 containing a meandering river with alluvial terraces and floodplains capable of producing a high sediment supply (Rosgen 1996). This 23,200-foot (4.4 mile) stretch of river has been heavily impacted by Interstate 90, which crosses the river four times on nine bridges. There are also four other bridge crossings, including FR 282 at Little Joe Creek and FR 431 at Twomile Creek. A total of 6,100 feet of riprap associated with Interstate 90 is located primarily along the left side of the river. The river runs between the East and West bound lanes for 5,200 feet, which includes 2,100 feet of riprap on river left and 1,200 feet of riprap along river right. There is also 2,200 feet of riprap associated with the railroad, which is located along the right side of the St. Regis River.

Reach 2 extends 19,300 feet (3.7 miles) along the St. Regis River from Twomile Creek upstream to Ward Creek. The river is naturally straight in a tight valley throughout this section, though Interstate 90 along river left and the railroad along river right confine the river channel further. This is a Valley Type 2, which tends to contain stable stream types and a low sediment supply (Rosgen 1996). However, extensive road cuts along the hill slopes above Interstate 90 may provide a significant source of sediment to this reach. The road cuts on the hillside are much deeper since the construction of Interstate 90 indicating that they cut into the hillside extensively during construction. There is 6,100 feet of riprap associated with Interstate 90, although 2,600 feet of the total appears to be remnants of Highway 10 riprap. Most of this (6,000 feet) is located along the left bank, while 100 feet are along right bank at one of the two Interstate 90 bridges that cross the river within this reach. There are also two U.S. Forest Service road bridges located at the upstream and downstream end of this reach. There is 2,500 feet of riprap along the river right bank associated with the railroad.

Reach 3 extends 26,000 feet (4.9 miles) from Ward Creek upstream to Twelvemile Creek. The river flows through a Valley Type 2 with larger meander curves than downstream (Rosgen 1996). This reach has been extensively impacted by the development of the transportation corridor. Channel condition is poor all the way down to Drexel. Channel alterations occurred between Drexel and Ward Creek during Interstate 90 construction. Road cuts are present along this reach as well. There are four Interstate 90 bridges in this reach and a 1,100-foot section in which the river is confined between the east and west bound lanes. Downstream of the Drexel Interchange (stations 45,100-47,400) there is extensive riprap in a 2,000 foot section resulting from a channel change involving the left bank of the river where it has been transformed into a straight canal. Boulder clusters were added in this section during the construction of Interstate 90. There is a total of 5,700 feet of riprap from Interstate 90 on river left and 300 feet of riprap on river right. There is an additional 5,800 feet of riprap associated with Highway 10 along river left for a total of 11,800 feet of riprap along the river left bank. There is 2,700 feet of riprap due to the railroad along the river right bank.

Reach 4 extends 23,000 feet (4.3 miles) from Twelvemile Creek upstream to Deer Creek. The St. Regis River is located to the south side of all roads and DeBorgia is on the river left side downstream of the Deer Creek confluence. The valley widens here and is considered a Valley Type 8 (Rosgen 1996). The river meanders though the valley and is relatively unconstricted from station 75,000 (mile 14.2) to 88,800 (mile 16.8), for a total of 13,000 feet (2.6 miles). Several large logs were observed stranded on gravel bars in the aerial photographs. There are numerous roads on both hillsides and signs of recent timber harvest above the right bank were apparent in the 2000 aerial photos. There is 2,200 feet of riprap along the river right bank primarily resulting from construction of Highway 10 and the railroad, with only 300 feet attributed to the construction of Interstate 90. Most of the riprap is located at the downstream end of the reach directly above the Twelvemile Creek confluence. There are no Interstate 90 crossings in this reach, though a bridge on FR 236 leads up Deer Creek.

Reach 5 extends 22,500 feet (4.3 miles) from Deer Creek upstream to Haugan. Reach 5 ends just upstream of Haugan. The wide valley here is considered a Valley Type 8 (Rosgen 1996). This reach remains heavily impacted by Interstate 90, though there are no Interstate bridge crossings. The major impacts occur from just upstream of the Big Creek Road Bridge downstream past the confluence with Big Creek to the railroad bridge, where the St. Regis River meanders away from the Interstate. The impacted section of stream channel contains alterations totaling 6,800 feet (1.3 miles) long and containing riprap along both sides of the river. The riprap is set back from the channel along much of this reach to a width that appears to be at lest twice the bankfull channel width. Thus, the river meanders within an artificially straight channel formed by Interstate 90 along river left and the railroad on river right. There is some floodplain development evident within this channelized reach. There is also riprap along the outside of some of the meander bends contained within the wider riprapped channel. Immediate stream bank riprap within the channelized reach is addressed in this analysis. There is 5,400 feet of riprap close to or directly along the stream channel on river right bank and 1,600 feet of riprap along the river left bank that are associated with the channel change from Interstate 90 within Reach 5.

The Montana Department of Transportation plans for DeBorgia East and West contain a detailed description of planned channel change between the Big Creek Road Bridge, located across the river from the village of Haugan, and continuing downstream past the Big Creek confluence to the next railroad bridge. The impacted section of channel is 6,800 feet long and contains riprap along both sides of the river.

The St Regis River meanders through a broad gravel bar complex upstream of the Big Creek Road Bridge. This section may be aggraded due to the fact that this is the first place the river is allowed to spread out below the tightly confined upstream reach. Aggradation often occurs at the downstream end of channelized reaches as the slope decreases and excess sediment is deposited against the banks (Knighton 1998). There is an additional 1,400 feet of riprap associated with Interstate 90 along river right above the highly impacted section, with 1,100 feet of additional riprap along river left from the railroad. The broad nature of the river in this reach may be very susceptible to solar radiation leading to increased stream temperatures. A 7,000 (1.3 mile) portion of this reach (stations 104,500-111,500) may be a prime location for restoration efforts. The broad floodplain would allow room for more length to be added to the river, while the depth could be increased and a narrower tree-lined channel created that would help reduce thermal loading.

Reach 6 extends 24,500 feet (4.7 miles) from upstream of Haugan to upstream of Saltese. Interstate 90 crosses the St. Regis River twice in this reach, at the upstream and downstream boundaries of Saltese. The downstream portion of this reach is tightly confined in a Type 2 valley, while the upstream end of the reach, located just downstream of Saltese, is a wider Type 8 valley (Rosgen 1996). Road cuts on the hillside are evident in the Valley Type 2 portion of this reach and may be a significant source of sediment. The major impacts within this reach have resulted from railroad construction, with 5,600 feet of riprap along river left and 4,100 feet along river right, for a total of 9,700 feet. There is also 2,100 feet of riprap along river left and 200 feet along river right for a total of 2,300 feet of riprap associated with Interstate 90. Thus, 7,700 feet of the river left bank have been riprapped while 4,300 feet of right bank has been riprapped. There is a minimally impaired 2,500-foot (0.5 mile) section (stations 127,300-129,800) that may serve as an example of a minimally impacted reach to assist with reference development for the Valley Type 8 condition.

Reach 7 extends 23,600 feet (4.4 miles) from upstream of Saltese to Taft where the frontage road bridge crosses the St. Regis River. The Dominion Creek Road (FR 506) Bridge also crosses the river in this reach. The valley is a constricted Type 2 (Rosgen 1996). Road cuts are not quite as dramatic in this reach as in downstream reaches, though they still may be a significant source of sediment. Reach 7, which is highly impacted by both the railroad and the interstate, contains several channel alterations. There are 3,600 feet of channel alterations a three separate sites within a 10,600-foot section (2 mile) located directly upstream of the town of Saltese where the river now flows between the east and west bound lanes of I-90 (stations 138,500-149,100). There are 13,700 feet of riprap along this reach, with 7,100 along river left and 6,600 along river right. There is 4,300 feet of riprap from Interstate 90 along river left and 1,200 along river right. About 2,900 feet of the river left bank and 5,300 feet of the river right bank were riprapped during railroad construction.

Reach 8 extends 16,400 feet (3.1 miles) from Taft upstream to Hanakar Creek, which enters the St. Regis River directly downstream of the Interstate 90 bridge/culvert. The river flows through a Type 2 valley in this reach (Rosgen 1996). The St. Regis River has been altered by I-90 and extensively riprapped between the Rest Area and the Taft Exit for a distance of about 7,900 feet (1.5 miles), including 2,300 feet of channels alterations. The right bank is well vegetated with conifers that appear to provide a high degree of shade value. Just downstream of the I-90 Rest Area, there is an exposed hillside approximately 400 feet long (stations 167,000-167,400) which leads directly down to the right bank of the St. Regis River and which may be a significant sediment source. There is a total of 5,700 feet of riprap in this reach located entirely along the river left bank. Forty-two hundred feet of riprap are due to Interstate 90 and 1,500 feet of riprap are the result of railroad construction. The upper 1.6 miles of this reach contains a riparian area that may provide a good reference for the upper St. Regis River prior to the development of the transportation corridor, though there is still some interstate influence.

Reach 9 extends 18,200 feet (3.5 miles) from Hanakar Creek upstream to the old Northern Pacific railroad grade that crosses the St. Regis River. This reach flows through a Valley Type 5, which results from glacial scouring that creates wide U-shaped valleys containing streams with alluvial terraces and floodplains (Rosgen 1996). The lower portion of this reach is highly channelized including a 2000-foot section (0.4 mile) (stations 181,000-18300) that is confined by Interstate 90 on river right and a steep hillside supporting the old railroad along river left. There is a total of 5,400 feet of riprap in Reach 9, with 3,000 feet associated with the railroad along river left and 2,400 feet associated with the Interstate along river right. Upstream of the channelized reach the river flows through a culvert, marking the most westward Interstate 90 crossing.

Reach 10 extends 13,800 feet (2.6 miles) from the old Northern Pacific railroad grade up to St. Regis Lake. The stream flows through a Type 5 valley in this reach (Rosgen 1996). This reach is not impacted by Interstate 90 or the railroads.

Conclusion

This assessment clearly confirms that the St. Regis River has been heavily impacted by stream bank alterations, channel encroachment, and channel alterations/shortening. This analysis indicates the presence of approximately 15.2 miles of riprap, with a total of 7.4 miles of riprap associated with Interstate 90 and 7.8 miles of riprap related to the construction and maintenance of Highway 10 and the railroads. Overall, approximately one-third of the entire 40-mile length of the St. Regis River has experienced stream bank alterations in the form of rock riprap placement along at least one of its stream banks. Reaches with greater than 25% of the streambanks impacted by rock riprap include Reach 3, which is between Twelvemile Creek and Ward Creek, and Reach 7, which is between Taft and Saltese.

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APPENDIX H
UPLAND SEDIMENT ANALYSIS

Prepared by Lolo National Forest

Introduction

Sediment analysis was based on several different modeling tools. A spatial (GIS) model was used to calculate relative sediment production at the watershed scale, including natural sediment, sediment from roads, and sediment from timber harvest. Two site-specific models were used to determine sediment production from road segments and delivery to streams at specific delivery points (stream crossings) although the road components of this analysis are not used for the TMDL because the road analysis component accuracy was questionable.

It should be noted that models simplify extremely complex physical systems and are developed from a limited database. Although specific quantitative values for sediment are generated from this model, it is important to note that the results are used as a tool in the interpretation of how real systems may respond. Therefore, the models' use is realistically limited to providing a means of comparison, not an absolute measure against verifiable standards.

Methods

LoloSED
The LoloSED computer model was used to analyze sediment production at the watershed scale including the HUC 6 tributary watersheds to the St. Regis River and the St. Regis HUC 5. LoloSED was adapted from the WATSED model. WATSED is a sediment production model developed by USDA Forest Service Region One and others (USDA, 1991). LoloSED is a spatially based, GIS implementation of WATSED, and includes coefficients specific to resources on the Lolo National Forest. LoloSED uses GIS layers for soil and landform (LSI), topography (DEM), hydrology (streams), vegetation (TSMRS stands), transportation (roads), precipitation (average annual), and project specific layers.

The Lolo National Forest's Land System Inventory (LSI) provides a natural sediment production coefficient for every land unit. Land units in the LSI, also known as LSI units or LSI's, were delineated based on soil, landform, and habitat type (USDA, 1988).

Natural sediment production from National Forest land in the St. Regis watershed was calculated by first overlaying the HUC 6 watersheds layer for the St. Regis with the LSI layer. A DEM (digital elevation model) was used to determine the average side slope and topographic position for each LSI unit in the St. Regis watershed. Hillslope and topographic position determine the sediment delivery ratio for each unit. The natural sediment production coefficients and delivery ratios were multiplied together to get a sediment yield value for each HUC 6 and by specific areas using GIS (**Table H-1 and Figure H-1**).

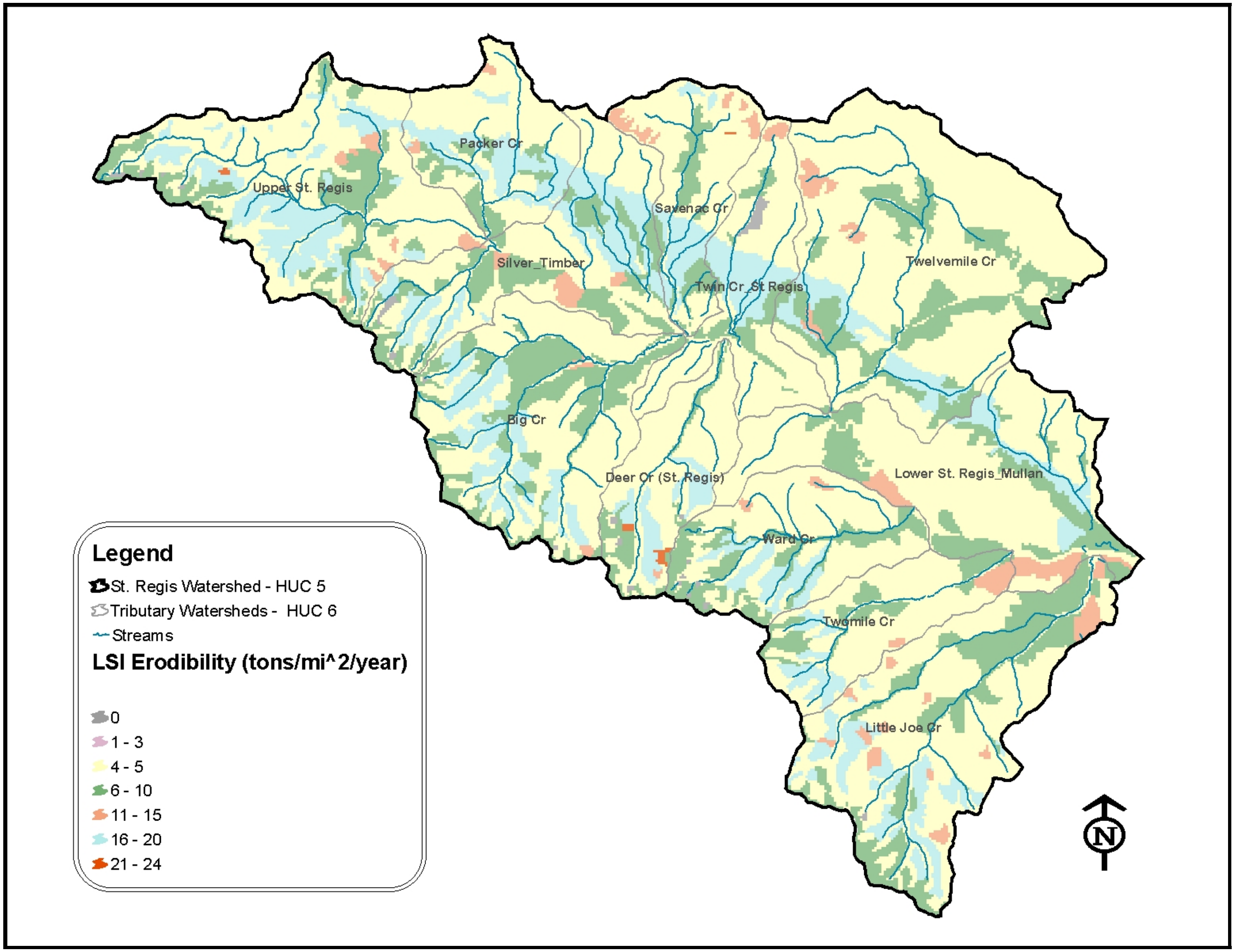

Figure H-1. Land System Inventory Units Classified By Relative Risk of Sediment Production

In addition to natural sediment production and delivery, sediment from roads and harvest activity was also analyzed (See also Harvest History Analysis write-up). For sediment production from roads, coefficients for closure level and natural revegetation, presence or absence of BMPs, and time since construction or re-construction were applied to road sediment production base rates. Base rates of road sediment production were calculated using road width, topography, and LSI. As for natural sediment production, delivery ratio coefficients were applied based on topographic position of each road segment. Similarly, for sediment production from timber harvest areas, production coefficients for the logging system used (tractor, skyline, or helicopter) were applied to the natural sediment production values.

Results

LoloSED modeled natural sediment

Natural sediment production based on average annual precipitation was calculated for each HUC 6 tributary to the St. Regis River. These results were then summarized for the St. Regis HUC 5 (**Table H-1**). LoloSED modeled annual, natural sediment production for the St. Regis HUC 5 is approximately 2400 tons/year (**Figure H-2**). HUC 6 sediment production normalized by area shows Silver-Timber to be most erosive at 7.72 tons/mi2/year and Twelvemile least erosive at 5.16 tons/mi2/year (**Figure H-3**).

Table H-1. LoloSED Modeled Natural Sediment Production in the St. Regis Watershed

Watershed (5th & 6th code HUC #)	Modeled Annual, Natural Sediment Production (tons/year)	Area (sqmi)	Natural Sediment Production Normalized by area (tons/mi2/year)
St. Regis	2399	363	6.6
Big Cr (804)	273	38	7.2
Deer Cr (806)	109	17	6.4
Little Joe Cr (811)	319	43	7.4
Lower St. Regis_Mullan (812)	219	38	5.8
Packer Cr (802)	132	18	7.3
Savenac Cr (805)	109	17	6.4
Silver_Timber (803)	232	30	7.7
Twelvemile Cr (808)	310	60	5.2
Twin Cr (807)	121	20	6.1
Twomile Cr (810)	117	17	6.9
Upper St. Regis (801)	306	41	7.5
Ward Cr (809)	152	23	6.6

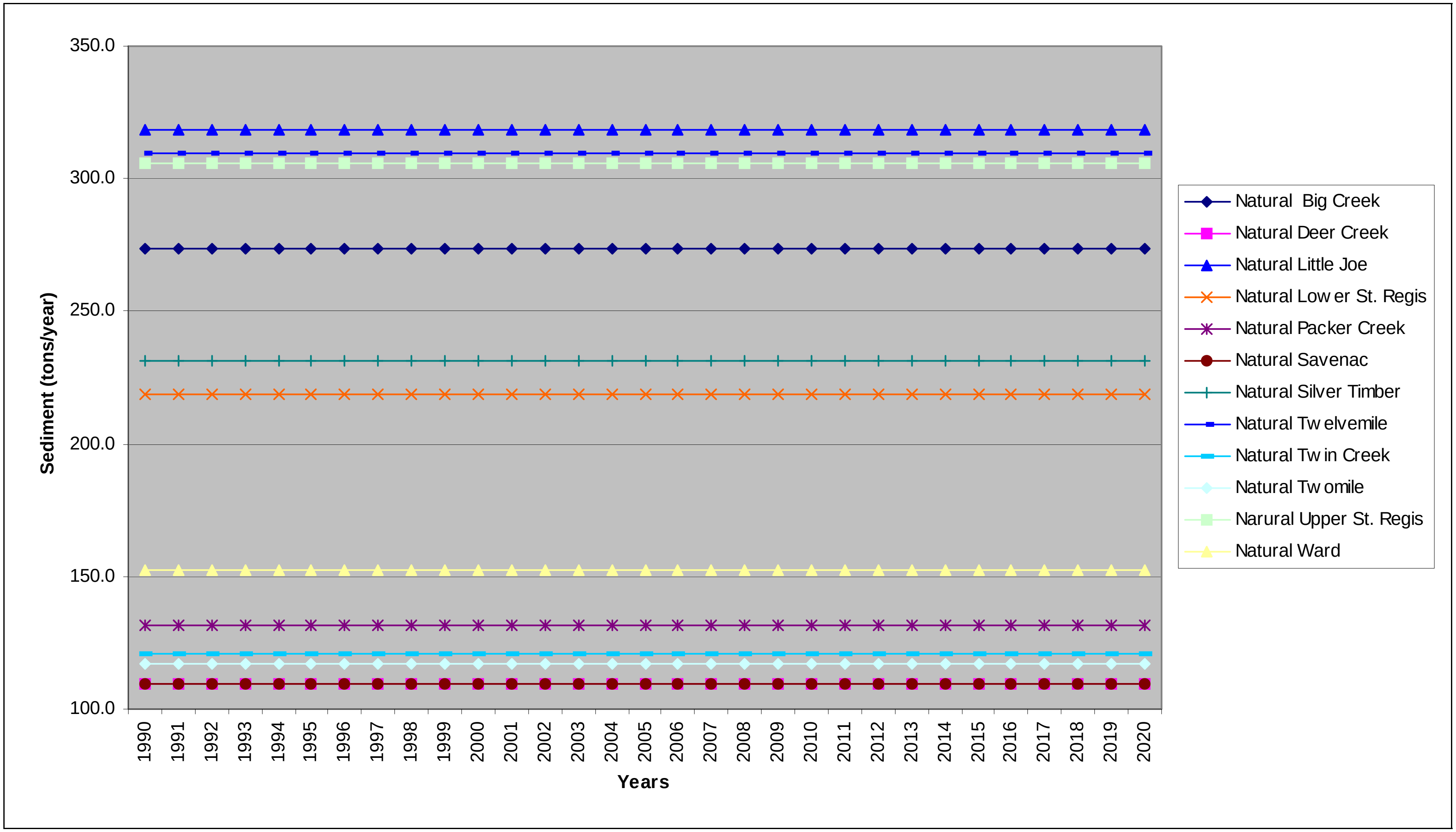

Figure H-2. LoloSED Modeled Natural Sediment Production for St. Regis River Tributary Watersheds

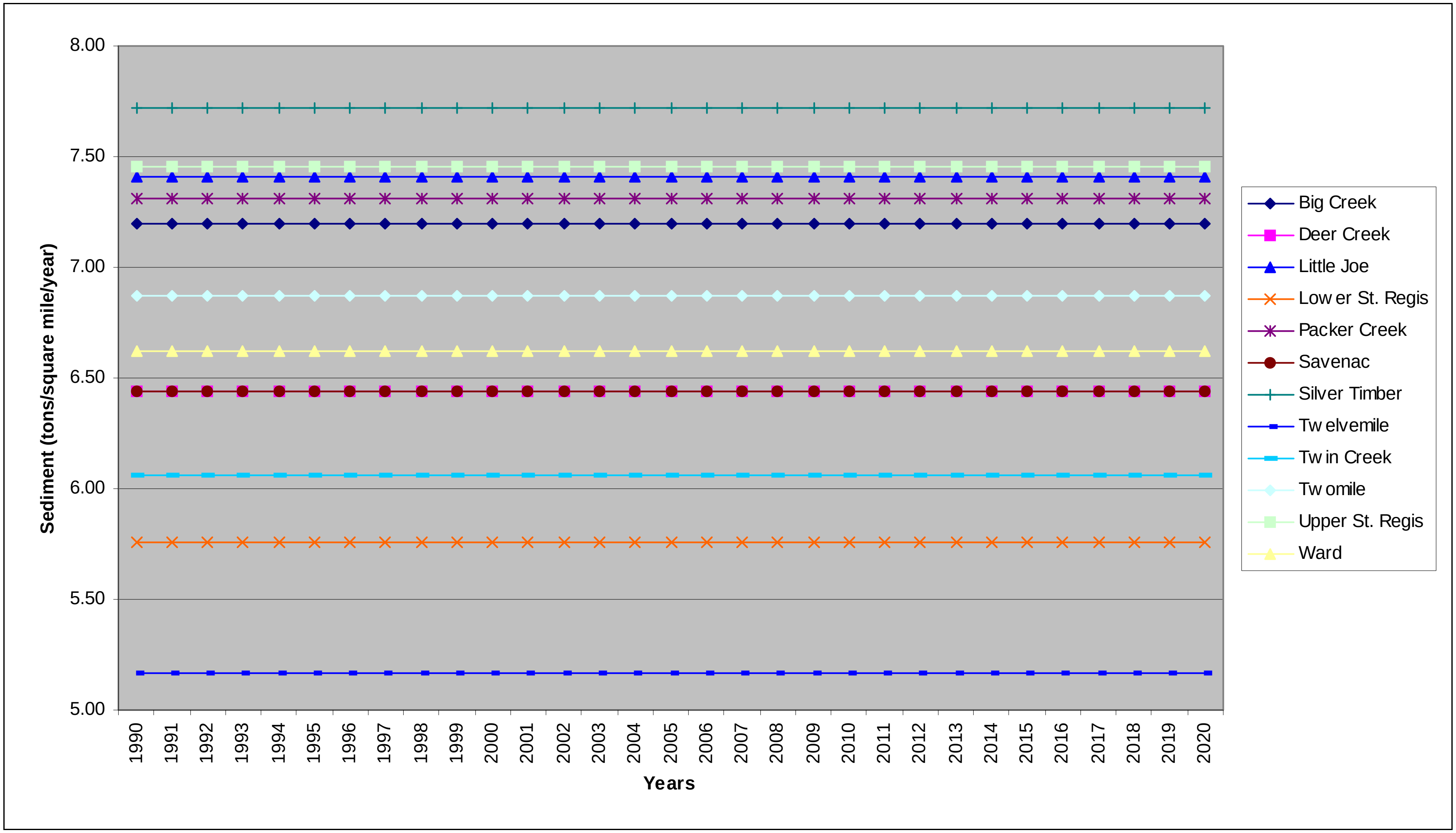

Figure H-3. LoloSED Modeled Natural Sediment Production for St. Regis River Tributary Watersheds, Normalized By Drainage Area

The LoloSED model was used to estimate current sediment production increases above natural due to timber harvest activities on record. This information is for National Forest service land only. LoloSED was run in April 2003 to generate these estimates. These estimates are based on the information provided in the TSMRS (timber stand management recording system) for this date, and will not include sediment produced from harvest operations not included in TSMRS.

Based on model results for years 1990 - 2020, sediment production from timber harvest peaked in the early 1990's at approximately 250 tons above natural, and continued to decline until 1997 (**Figure H-4**). In 1998, additional timber harvest activity resulted in a less than 50-ton increase followed by another decline in harvest-related sediment production through the remainder of the analysis period. Note that sediment projected in future years reflects a static condition. Future harvest may increase sediment above the static condition. Also note that this modeling does not include road sediment contributions at stream crossings, does not include any mass wasting that may have occurred from harvest, and assumes overall BMP implementation compliance. The results of this modeling will be used to provide an estimate of natural background sediment loading due to hill slope erosion and bank erosion. Results will also be used for timber harvest upland sediment production source assessment and allocations.

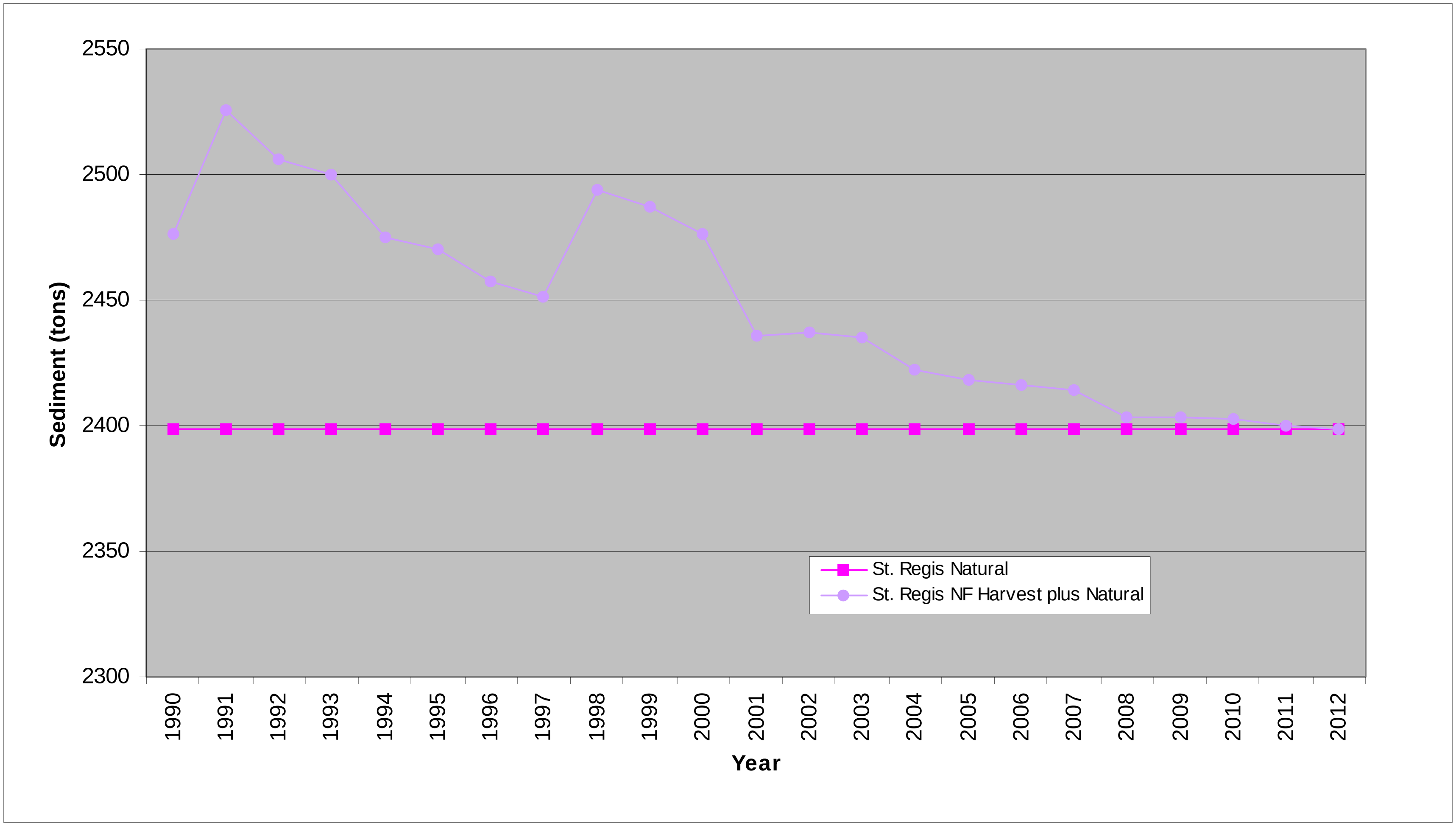

Figure H-4. LoloSED Modeled Sediment from National Forest Harvest Activity Compared to Natural Modeled Sediment Production for the St. Regis Watershed

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APPENDIX I
2006 SEDIMENT ASSESSMENT - BANK EROSION AND UNPAVED ROADS

St. Regis TMDL Planning Area

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Introduction

This report presents an assessment of sediment loading to streams listed as impaired due to sediment in the St. Regis TMDL Planning Area (TPA). Sediment loading due to streambank erosion, sediment inputs from the unpaved road network on non-federally managed lands, and sediment inputs from mass wasting were estimated based on field data collected in 2006. Streambank erosion data was collected at all observed eroding banks on the St. Regis River, Big Creek, Twelvemile Creek and Little Joe Creek, while sediment inputs from unpaved roads were assessed at a subset of identified unpaved road crossings on non-federally managed lands. Sediment inputs from mass wasting were estimated for eroding hillslopes observed along the St. Regis River and Twelvemile Creek. Additional information regarding this assessment can be found in *Field Monitoring and Temperature Modeling Sampling and Analysis Plan for the 2006 Field Season* (MDEQ 2006a).

Sediment Impairments

On the 1996 303(d) List, the St. Regis River, Little Joe Creek, North Fork Little Joe Creek, and Twelvemile Creek were listed as impaired due to sediment. On the 2004 303(d) List, the St. Regis River, Big Creek, Little Joe Creek, North Fork Little Joe Creek, and Twelvemile Creek were listed as impaired due to sediment.

Sediment Loading Due to Streambank Erosion

An inventory and assessment of eroding banks was performed on the St. Regis River, Big Creek, Twelvemile Creek, Little Joe Creek, and North Fork Little Joe Creek. Sediment loading due to streambank erosion was assessed on all the stream segments listed as impaired due to sediment on the 1996 and 2004 303(d) List.

Field Data Collection and Load Calculations

Streambank erosion assessments were performed on a total of 39 eroding streambanks, including 25 streambanks on the St. Regis River, 5 streambanks along Big Creek, 2 streambanks along Little Joe Creek, and 7 streambanks along Twelvemile Creek. Along the St. Regis River, stream bank erosion assessments were performed on eroding banks visible from Interstate 90 and the Frontage Road. Since Interstate 90 parallels the St. Regis River along the majority of its length, selection of sample sites through this technique was thought to capture all of the large eroding banks and the majority of smaller eroding banks. On tributary streams, eroding bank assessment sites were selected in the field based on observations made from the forest roads paralleling the stream channel, along with information from previous assessment work. Sections of Big Creek and Twelvemile Creek away from the road were walked, providing detailed coverage for these segments. Previous assessment work, along with local inquires, did not identify any other stream segments in the watershed in which streambank erosion was a significant source of sediment. Eroding streambank locations are presented in **Figure I-1**.

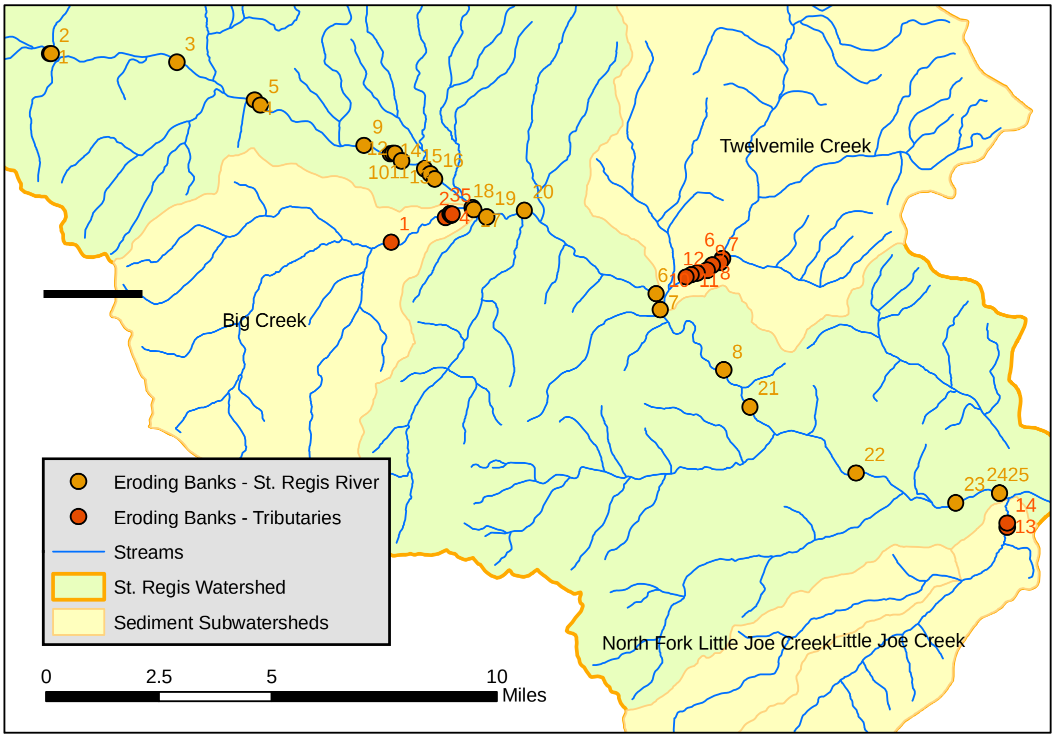

Figure I-1. Eroding Streambanks in the St. Regis TPA

Streambank Erosion Assessment Methodology

Streambank erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements and estimating the Near Bank Stress (NBS) (Rosgen 1996, 2004). The BEHI score was determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle and surface protection. BEHI categories range from “very low” to “extreme”. At each eroding streambank, the NBS was visually estimated for a bankfull flow event. NBS categories range from “very low” to “extreme”. The length, height, and composition of each eroding streambank were noted and the source of streambank instability was identified based on the following near-stream source categories:

- Transportation
- Riparian Grazing
- Cropland
- Mining
- Silviculture
- Irrigation-shifts in stream energy
- Natural Sources
- Other

The source of streambank erosion was evaluated based on observed anthropogenic disturbances and the surrounding land-use practices. For example, an eroding streambank in an area affected by logging was assigned a source of “100% silviculture,” while an eroding streambank due to road encroachment upstream was assigned a source of "100% transportation". If multiple sources were observed, then a percent was noted for each source, while naturally eroding streambanks were considered the result of "natural sources". The "other" category was chosen when streambank erosion resulted from a source not described in the list. In the St. Regis TPA, observed sources of streambank erosion included transportation, cropland, silviculture, and natural sources. In addition, bank stabilization projects along Big Creek, the utility corridor along the St. Regis River and a fishing access point along the St. Regis River were identified sources of streambank erosion in the "other" category. Sources of streambank erosion for individual banks are included in the electronic database accompanying this project.

Estimating Sediment Loads from Field Data

The length of eroding streambank, mean height, and the annual retreat rate were used to determine the annual sediment input from eroding streambanks (in cubic feet). The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between BEHI and NBS scores. Streambank retreat rates measured in the Lamar River in Yellowstone National Park (Rosgen 1996) were applied to streambanks in the St. Regis TPA (**Table I-1**). The annual sediment input in cubic feet was then converted into cubic yards (divided by 27 cubic feet per yard) and finally converted into tons per year based on the bulk density of the streambank to provide an annual sediment load.

Table I-1. Annual Streambank Retreat Rates (Feet/Year) (adapted from Rosgen 1996)

		Near Bank Stress				
		Very Low	Low	Moderate	High	Very High
BEHI	Low	0.019	0.042	0.089	0.19	
	Moderate	0.082	0.17	0.33	0.62	1.3
	High - Very High	0.29	0.44	0.7	1.1	1.7
	Extreme	0.6	0.83	1.3	1.7	2.3

Streambank Composition

Bulk density of streambanks in the St. Regis TPA was determined based on streambank composition data collected in the field and standard soil weights compiled by the U.S Department of the Interior (USDI 1998). Soil weights in the "well-graded" category were selected to most accurately reflect streambank composition, since "well-graded" suggests a wide array of size classes, which is likely what is found in nature. Streambank composition data from the St. Regis River, Big Creek and Twelvemile Creek most closely resembles the soil group described as "well-graded gravel with silt". Based on the minimum value of the USDI dry unit weight for "well-graded gravel with silt," a value of 89 pounds/foot^3 (1.20 tons/yard^3) was estimated as the average weight of the streambank material (USDI 1998). The minimum value was selected to account for plant roots within the streambank that would decrease the overall soil density. Streambank composition data from Little Joe Creek most closely resembles the soil group described as "well-graded sand". Based on the minimum value of the USDI dry unit weight for "well-graded sand," a value of 107 pounds/foot^3 (1.44 tons/yard^3) was estimated as the average bulk density of streambank material (USDI 1998).

Streambank Erosion on Listed Stream Segments

Sediment loading due to streambank erosion was estimated for the St. Regis River, Big Creek, Little Joe Creek, and Twelvemile Creek. Estimated sediment loads are provided for each stream segment in the following sections.

St. Regis River

Eroding streambank assessments were performed at all observed eroding streambanks along the St. Regis River. A total of 25 eroding streambanks were assessed covering 1.3 miles (6,601 feet) of stream. A total sediment load of 518.1 tons/year was attributed to eroding streambanks (**Table I-2**). Along the St. Regis River, 75% of the bank erosion was attributed to transportation, 7% was attributed to croplands, 3% was attributed to natural sources, and 15% was attributed to "other," which refers primarily to utility corridor infrastructure maintenance that has resulted in the clearing of vegetation along the stream corridor. The impact of the transportation corridor on streambank erosion results from extensive channelization and the placement of rock riprap associated with Interstate 90 and the historic railroads, which has lead to increased stream power along "unprotected" streambanks.

Much of the streambank erosion along the St. Regis River was observed in a wide and aggraded area near Haugen, where 7 eroding streambanks were assessed upstream of the Big Creek Road crossing (BEHI measurements 10-16) and 3 eroding streambanks were assessed downstream of the road crossing (BEHI measurements 17-19) (Figure I-2). A sediment load of 249.5 tons/year was estimated due to streambank erosion around the Haugan area. This accounts for 48% of the total sediment load due to streambank erosion along the St. Regis River. Sediment loading due to the shifting of sparsely vegetated gravel bars likely represents an additional source of sediment within this area, though this additional sediment load was not quantified in the streambank erosion assessment. This gravel bar complex is comprised of a sediment size class that would most likely affect overall channel form, including pool formation, rather than contributing to the concentration of fine sediment. A high capacity for sediment transport upstream of this reach due to extensive channelization is the likely reason for aggradation in this relatively wide and flat area. A second area of aggradation along the St. Regis River was observed downstream of the Little Joe Creek confluence, though no eroding banks were noted. Sediment loading due to shifting unvegetated gravel bars in this area may also be significant.

Figure I-2. Eroding Streambanks in the Haugan Vicinity

Big Creek

Eroding streambank assessments were performed at all observed eroding banks along the mainstem of Big Creek (BEHI measurements 1-5). A total of 5 eroding streambanks were assessed covering 0.1 miles (555 feet) of stream. A total sediment load of 45.5 tons/year was attributed to eroding streambanks (**Table I-2**). Along Big Creek, 30% of the bank erosion was attributed to transportation, 30% was attributed to silviculture, 10% was attributed to natural sources, and 30% was attributed to "other," which refers primarily to streambank stabilization projects performed at several large eroding streambanks near the mouth of Big Creek. Silviculture was cited as a source at sites which may have been influenced by increased sediment loads and water yields due to logging within the upper watershed, while transportation was cited as a source due to a bridge which constricts the floodplain area, leading to bank erosion on the downstream bends.

Bank erosion along Big Creek was primarily observed in the lower reach of the stream near the confluence with the St. Regis River. This area was over-widened with tall exposed banks on which streambank stabilization projects have been implemented. Previous streambank stabilization projects were implemented on at least 4 eroding streambanks with varying levels of success, while a new streambank stabilization project was performed on one bank immediately prior to field data collection in September of 2006.

Little Joe Creek

Eroding streambank assessments were performed at all observed eroding streambanks along the mainstem of Little Joe Creek (BEHI measurements 13 and 14). A total of 2 eroding streambanks were assessed covering 0.02 miles (96 feet) of stream. A total sediment load of 36.4 tons/year was attributed to eroding streambanks (**Table I-2**). Along Little Joe Creek, 100% of the streambank erosion was attributed to silviculture. The majority of the observed streambank erosion resulted from a slumped hillslope that is revegetating.

North Fork Little Joe Creek

No streambank erosion was observed along North Fork Little Joe Creek, which is paralleled by Little Joe Creek Road along much of its length. North Fork Little Joe Creek is a moderately steep mountain stream with streambanks comprised of large gravels and cobbles that are highly resistant to erosion.

Twelvemile Creek

Eroding streambank assessments were performed at all observed eroding streambanks along the mainstem of Twelvemile Creek (BEHI measurements 6-12). A total of 7 eroding streambanks were assessed covering 0.2 miles (1,041 feet) of stream. A total sediment load of 47.8 tons/year was attributed to eroding streambanks (**Table I-2**). Along Twelvemile Creek, 88% of the streambank erosion was attributed to transportation, 5% was attributed to silviculture, and 7% was attributed to natural sources. The majority of the observed streambank erosion was in the lower portion of Twelvemile Creek where the stream has been channelized by Camels Hump Pass Highway.

Along Twelvemile Creek, two large eroding hillslopes were included in the eroding bank assessment (BEHI measurements 11 and 12) since it appeared that sediment at the base of these hillslopes was readily transported at bankfull and higher flows. In order to keep sediment contributions due to streambank erosion separate from sediment contributions due to hillslope erosion, the mean bank height was considered to be the height at the floodprone elevation (2x maximum bankfull depth). In the reach between the National Forest boundary and the mouth in which these two hillslopes were located, an average maximum depth of 2.3 feet was measured during stream channel assessments in 2004. Thus, the mean bank height for these two banks was set at 4.6 feet for sediment load calculation purposes.

Table I-2. Sediment Loads due to Eroding Streambanks in the St. Regis TPA by Source

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources					Total Load
			Transportation	Cropland	Silviculture	Natural Sources	Other	
St. Regis River	38.6	Tons/Year	389.1	35.3	0.0	16.6	77.8	518.7
		Percent	75%	7%	0%	3%	15%	
Big Creek	3.4	Tons/Year	13.9	0.0	13.7	4.5	13.4	45.5
		Percent	30%	0%	30%	10%	30%	
Little Joe Creek	3.1	Tons/Year	0.0	0.0	36.4	0.0	0.0	36.4
		Percent	0%	0%	100%	0%	0%	
Twelvemile Creek	13.4	Tons/Year	42.2	0.0	2.3	3.3	0.0	47.8
		Percent	88%	0%	5%	7%	0%	

Sediment Loading From Unpaved Roads

An assessment of sediment loading from unpaved roads on non-federally managed lands was undertaken to provide a comparison to sediment loading from federally managed lands. Several unpaved road crossings on National Forest lands were also examined. This assessment is complimentary to the assessment performed by the Lolo National Forest on federally managed lands, which is described in Appendix G (Item 4: Sediment Analysis) of the *Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs* completed in June of 2006 (MDEQ 2006b). While the Lolo National Forest comprises the vast majority of the St. Regis River TPA, additional land owners include Plum Creek Timber Company, Montana State Trust Lands, and private lands. In this assessment, the unpaved road network outside of the Lolo National Forest will be described as roads occurring on “non-federally” managed lands. However, some of these roads are maintained by the Lolo National Forest.

Field Data Collection

Prior to field data collection, the number of unpaved road crossings on non-federally managed lands was determined using GIS. A total of 52 unpaved crossings were identified and a subset of 10 crossings was selected for field data collection. In 2006, data was collected at 9 sites on private lands. In addition, data was collected at 16 sites on the Lolo National Forest. Of the 9 sites assesses on non-federally managed lands, 4 of the sites (SR-X-32, SR-X-27, SR-X-22 and SR-X-13) were on roads maintained by the Lolo National Forest, 2 of the sites (SR-X-14 and

SR-X-3) were maintained by Mineral County, and 3 of the sites (SR-X-185, SR-X-20 SR-X-40) were privately maintained. At each unpaved road assessment site the following parameters were collected:

- Road design
- Road surface
- Traffic level
- Road grade
- Road length
- Road width
- Fill grade
- Fill length
- Buffer grade
- Buffer width
- Rock content

WEPP Model

The WEPP:Road model was used to estimate sediment loads from unpaved roads in the St. Regis TPA. The WEPP:Road model provides an estimate of sediment runoff from unpaved roads based on physical road characteristics, the soil type on which the road occurs and the climate. Physical road characteristics used in the model were measured in the field. The soil type used in the model was determined based on the National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, which is available at http://www.mt.nrcs.usda.gov/soils/mtsoils/official.html. The Wallace Idaho climate station was used in the model, with an average annual precipitation of 36 inches. This is the same climate station used in the assessment performed by the Lolo National Forest. WEPP:Road batch results were run using version 2006.09.04, which is based on WEPP version 2000.100. Sediment loads were modeled as annual loads over a 30-year period. WEPP:Road input data are presented in **Attachment A**. WEPP:Road input data with the application of Best Management Practices in present in **Attahcment B**. Additional information regarding the WEPP model can be found at http://forest.moscowfsl.wsu.edu/fswepp/.

When field data was entered into the model it was determined that several field measured parameters needed to be slightly adjusted to meet the input requirements of the WEPP:Road Model. The following adjustments were made:

1. Fill gradient/length and buffer gradient/length cannot be reported as zero in the model. Minimum values allowed by the model (0.3 for gradient and 1 for length) were used when zero values were entered on the field form.
2. Contributing road length cannot exceed 1000 feet. Road lengths exceeding 1000 feet were reduced to 1000 feet.
3. Buffer gradient cannot exceed 100%. Buffer gradients exceeding 100% were reduced to 100%.
4. Traffic levels of High, Low and None are available in the model. Traffic levels reported as “Moderate” on the field forms were reduced to “Low” in the model.

Non-Federally Managed Lands

A total of nine crossings on non-federally managed lands were assessed in 2006 (**Figure I-3**). Six crossings occurred on silt loam soils, one crossing occurred on a clay loam soil, and the remaining two crossings occurred on soils described in the SSURGO soils database as "Alluvial Lands," which were estimated to be "sandy loam" soils in the WEPP model. The WEPP model predicted that 0.0052 tons/year of sediment are delivered to the stream channel ("mean annual sediment leaving buffer") (**Table I-3**). Extrapolating the sediment load from the assessed sites to the 52 crossings on non-federally managed lands indicates 0.27 tons of sediment are delivered to stream channels each year. Through the application of Best Management Practices (BMPs) that could reduce contributing road lengths to a maximum of 200 feet at each crossing (100 feet from either side), the WEPP model predicted annual sediment delivery could be reduced to 0.0035 tons/year from the nine assessed sites and 0.18 tons/year from all 52 crossings. Thus, the application of BMPs could reduce sediment inputs by 33% from unpaved road crossings on non-federally managed lands. This is based on an assessment of 17% of the unpaved crossings on non-federally managed lands in the St. Regis River watershed.

Table I-3. WEPP Modeled Sediment Loads from Road Crossings on Non-Federally Managed Lands

Site	Soil Type	Mean Annual Sediment Leaving Buffer (Tons)	Mean Annual Sediment Leaving Buffer with BMPs (Tons)
SR-X-32	silt loam soil	0.002	0.001
SR-X-27	silt loam soil	0.006	0.003
SR-X-185	silt loam soil	0.001	0.001
SR-X-14	silt loam soil	0.006	0.003
SR-X-22	silt loam soil	0.003	0.002
SR-X-20	silt loam soil	0.002	0.001
SR-X-40	sandy loam soil	0.000	0.000
SR-X-3	sandy loam soil	0.028	0.021
SR-X-13	clay loam soil	0.001	0.001
Mean Annual Sediment Load from Assessed Sites		**0.0052**	**0.0035**
Total Sediment Load from Non-Federally Managed Lands		**0.27**	**0.18**
Potential Reduction in Sediment Load		**0.09**	
Percent Reduction in Sediment Load		**33%**	

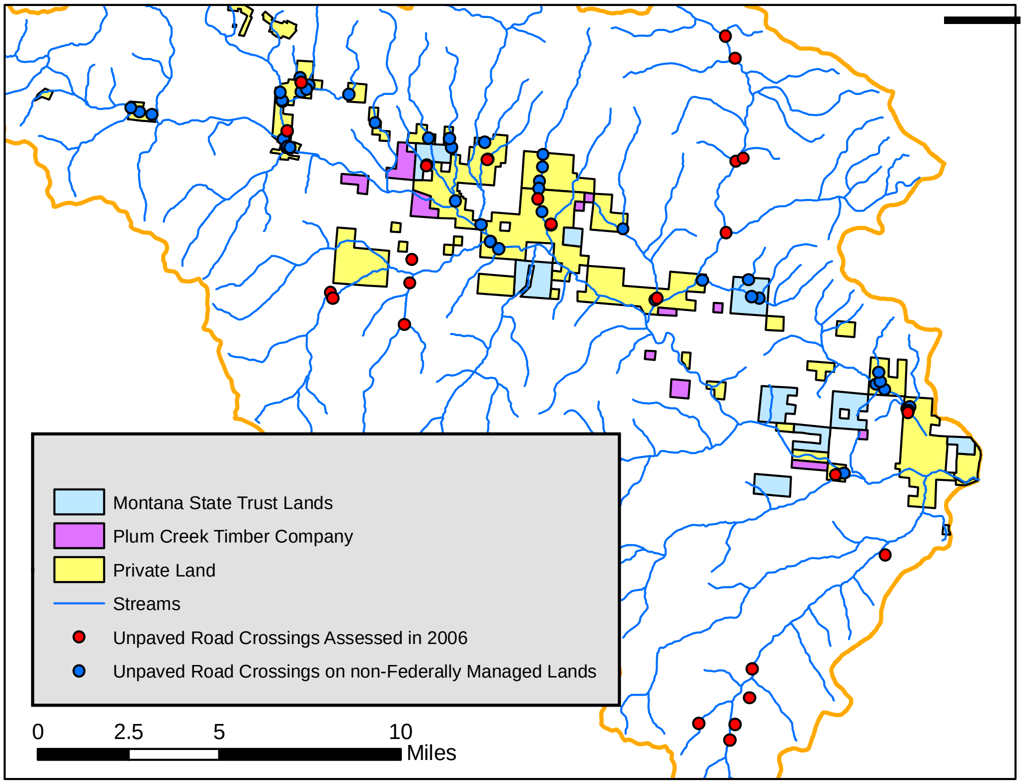

Figure I-3. Unpaved Road Assessment Sites

National Forest Lands

A total of 16 unpaved road sediment sources were assessed on National Forest lands in 2006, with 14 crossings and 2 near-stream road segments (**Figure I-3**). Since the SSURGO soils database lacked information on National Forest lands, the "silt loam" type was used in the WEPP model to provide a "worst case scenario" estimate based on the most erosive soil type within the St. Regis watershed. The WEPP model predicted an average sediment load of 0.53 tons/year leaving the buffer for each unpaved road crossing (**Table I-4**). Application of BMPs to reduce the contributing road length to a maximum of 400 feet at each crossing (200 feet from either side) could lead to an average sediment load of 0.27 tons/year leaving the buffer. Thus, the application of BMPs could reduce sediment inputs by 48% from unpaved road crossings on National Forest lands. Table 4S-5 in Appendix G of the *Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs* (MDEQ 2006b) indicates there are 621 unpaved road crossings on the Lolo National Forest in the St. Regis River watershed. Thus, 2% of the unpaved crossings were considered in this assessment.

Table I-4. WEPP Modeled Sediment Loads from Road Crossings on National Forest Lands

Site	Mean Annual Sediment Leaving Buffer (Tons)	Mean Annual Sediment Leaving Buffer with BMPs (Tons)
USFS-02	1.73	1.18
USFS-03	0.71	0.10
USFS-04	1.14	0.77
USFS-05	0.01	0.01
USFS-06	0.58	0.19
USFS-07	0.05	0.05
USFS-08	1.28	0.51
USFS-10	0.48	0.11
USFS-11	0.00	0.00
USFS-12	0.00	0.00
USFS-13	0.01	0.01
USFS-14	0.00	0.00
USFS-15	0.00	0.00
USFS-16	1.39	0.90
Mean Annual Sediment Load from Assessed Sites	**0.53**	**0.27**
Potential Reduction in Sediment Load	**0.25**	
Percent Reduction in Sediment Load	**48%**	

Watershed Sediment Loads

Sediment loading from unpaved roads at the watershed scale for Big Creek, Little Joe Creek, Twelvemile Creek and the St. Regis River was determined based on modeled sediment loads from both National Forest and non-federally managed lands. Table 4S-5 in Appendix G of the *Draft St. Regis Watershed Water Quality Restoration Plan: Sediment and Temperature TMDLs* (MDEQ 2006b) indicates there are 621 unpaved road crossings on National Forest land in the St. Regis River watershed, with 40 crossings in the Big Creek watershed, 83 crossings in the Little Joe Creek watershed, 30 crossings in the North Fork Little Joe Creek watershed, and 142 crossings in the Twelvemile Creek watershed. The crossing estimates assume that GIS analysis over-estimated the number of crossings by 20-30%. An additional 2 crossings were identified on non-federally managed lands in the Big Creek watershed, while 6 additional crossings were identified in the Twelvemile Creek watershed. In the St. Regis TPA, there are an estimated 52 crossings on non-federally managed lands. Throughout the St. Regis TPA, an estimated 33% reduction in sediment loads can be achieved on non-federally managed lands (**Table I-5**) and an estimated 48% reduction in sediment loads can be achieved on National Forest lands (**Table I-6**). Total sediment loads from unpaved roads in the St. Regis TPA are estimated at 327.5 tons/year (**Table I-7**). Through the application of BMPs, it is estimated that the sediment load could be reduced by 157.2 tons/year, which is a 48% reduction in sediment loading.

Table I-5. Sediment Loads from Unpaved Road Crossings on Non-Federally Managed Lands

Watershed	Estimated Number of Unpaved Road Crossings	Mean Sediment Load per Crossing (Tons/Year)	Total Sediment Load (Tons/Year)	Mean Sediment Load per Crossing with BMPs Limiting Contributing Length to 200 Feet (Tons/Year)	Total Sediment Load with BMPs Limiting Contributing Length to 200 Feet (Tons/Year)	Potential Load Reduction (Tons/Year)	Percent Reduction
Big Creek	2	0.0052	0.01	0.0035	0.0070	0.0034	33%
Little Joe Creek	0	0.0052	0.00	0.0035	0.0000	0.0000	0%
North Fork Little Joe Creek	0	0.0052	0.00	0.0035	0.0000	0.0000	0%
Twelvemile Creek	6	0.0052	0.03	0.0035	0.0210	0.0102	33%
St. Regis River	52	0.0052	0.27	0.0035	0.1820	0.0884	33%

Table I-6. Sediment Loads from Unpaved Road Crossings on National Forest Lands

Watershed	Estimated Number of Unpaved Road Crossings	Mean Sediment Load (Tons/Year)	Total Sediment Load (Tons/Year)	Mean Sediment Load per Crossing with BMPs Limiting Contributing Length to 400 Feet (Tons/Year)	Total Sediment Load with BMPs Limiting Contributing Length to 400 Feet (Tons/Year)	Potential Load Reduction (Tons/Year)	Percent Reduction
Big Creek	40	0.527	21.1	0.274	11.0	10.1	48%
Little Joe Creek	83	0.527	43.7	0.274	22.7	21.0	48%
North Fork Little Joe Creek	30	0.527	15.8	0.274	8.2	7.6	48%
Twelvemile Creek	142	0.527	74.8	0.274	38.9	35.9	48%
St. Regis River	621	0.527	327.3	0.274	170.2	157.1	48%

Table I-7. Sediment Loads from Unpaved Road Crossings in the St. Regis TPA

Watershed	Estimated Number of Unpaved Road Crossings	Total Sediment Load (Tons/Year)	Sediment Load with BMPs (Tons/Year)	Potential Load Reduction (Tons)	Percent Reduction
Big Creek	42	21.1	11.0	10.1	48%
Little Joe Creek	83	43.7	22.7	21.0	48%
North Fork Little Joe Creek	30	15.8	8.2	7.6	48%
Twelvemile Creek	148	74.9	38.9	35.9	48%
St. Regis River	673	327.5	170.3	157.2	48%

Sediment Loading Due to Mass Wasting

Sediment loading due to mass wasting was estimated for two large eroding hillslopes along the St. Regis River and two large eroding hillslopes along Twelvemile Creek using the Disturbed WEPP model, which is available at http://forest.moscowfsl.wsu.edu/fswepp/. In the model, the "Low Severity Fire" disturbance was selected since this was "the most appropriate treatment to describe a sparsely vegetated, newly exposed surface following excavation where material has not been highly compacted, such as a road cut" (Elliot et al. 2000). While these surfaces are not freshly exposed, they did resemble road cuts and this description was determined to be the most accurate out of the available selections. Input parameters for gradient, horizontal length, percent cover and percent rock were derived through field data and a review of field photographs. As in the WEPP:Road model, the Wallace Idaho climate station was used and sediment loads were simulated over a thirty year period. Disturbed WEPP input data and estimated sediment loads are presented in **Attachment C**.

St. Regis River

Two large eroding hillslopes were identified along the St. Regis River. The development of the transportation corridor along the St. Regis River was the identified source of hillslope erosion. Field observations indicated that the old highway may have been primarily responsible for erosion of "Hillslope 1" and the railroad may have been primarily responsible for erosion of "Hillslope 2," though channelization, which increased as the transportation corridor was developed, is also likely influencing erosion at both sites. Soils information was lacking for these sites, though the "silt loam" soil was selected based on other soils within the watershed where SSURGO database coverage was available. From "Hillslope 1," the estimated annual sediment load was 6.24 tons/year, while "Hillslope 2" produced 3.74 tons year. The WEPP Disturbed model indicated a 97% delivery rate for this sediment load.

Table I-8. Hillslope Inputs along the St. Regis River

Field Data		WEPP Results	Sediment Erosion from Hillslope (Tons/Year)
Stream Segment	Site	Average Sediment (Tons/Acre)	
St. Regis River	Hillslope 1	11.05	6.24
St. Regis River	Hillslope 2	13.91	3.74

Twelvemile Creek

Two large eroding hillslopes were identified along the lower reaches of Twelvemile Creek. Channelization caused by the Camel Hump Pass Highway was the source of erosion for both hillslopes, while logging above the eroding hillslopes may have exacerbated the situation. The "silt loam" soil type was selected based on the SSURGO database. From "BEHI 1," the estimated annual sediment load was 2.20 tons/year, while "BEHI 2" produced 1.20 tons year. The WEPP Disturbed model indicated a 93% delivery rate for this sediment load.

Table I-9. Hillslope Inputs along Twelvemile Creek

Field Data		WEPP Results	Sediment Erosion from Hillslope (Tons/Year)
Stream Segment	Site	Average Sediment (Tons/Acre)	
Twelvemile Creek	BEHI 11	7.50	2.20
Twelvemile Creek	BEHI 12	9.19	1.20

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ATTACHMENT A

WEPP:Road Input

St. Regis TMDL Planning Areas

Field Data			WEPP Batch Input Specifications											
Site	Latitude	Longitude	Road Design	Road Surface	Traffic Level	Road Gradient	Road Length	Road Width	Fill Gradient	Fill Length	Buffer Gradient	Buffer Length	Rock Fragment	Comment
SR-X-32	47.32148	115.13473	OU	N	L	2	300	25	0.3	1	2	12	10	SR-X-32
SR-X-13	47.29456	115.17455	OU	N	L	2	180	15	5	5	3	15	10	SR-X-13
SR-X-27	47.35964	115.28656	OU	G	L	5	400	25	100	10	3	40	40	SR-X-27
SR-X-40	47.39559	115.36071	OU	N	L	2	520	15	35	6	2	30	10	SR-X-40
SR-X-185	47.38581	115.35213	OU	G	L	2	350	15	0.3	1	3	15	40	SR-X-185
SR-X-14	47.40953	115.39222	OU	N	L	8	355	23	40	10	4	25	10	SR-X-14
SR-X-22	47.40513	115.42736	OU	G	L	2	270	24	0.3	1	3	10	40	SR-X-22
SR-X-3	47.41498	115.51086	OU	G	H	2	260	26	90	10	10	10	40	SR-X-3
SR-X-20	47.43462	115.50468	OU	N	L	5	350	14	0.3	1	3	8	10	SR-X-20
USFS-01	47.36757	115.43198	IV	G	H	5	410	16	0.3	1	0.3	1	40	USFS-01
USFS-02	47.35814	115.43198	IB	N	H	8	480	18	0.3	1	5	15	10	USFS-02
USFS-03	47.35214	115.47796	IV	N	L	5	1000	12	0.3	1	40	3	15	USFS-03
USFS-04	47.35000	115.47653	OR	N	L	11	480	12	110	30	40	30	20	USFS-04
USFS-05	47.34148	115.43340	OU	N	L	2	344	18	100	15	100	30	10	USFS-05
USFS-06	47.38758	115.24879	IV	G	H	3	1000	18	40	10	90	50	20	USFS-06
USFS-07	47.41616	115.24634	IV	G	H	1	121	35	110	5	30	25	30	USFS-07
USFS-08	47.41762	115.24218	IB	N	L	7	600	12	50	10	50	20	10	USFS-08
USFS-09	47.45707	115.25112	IV	G	H	6	1000	27	50	2	100	3	35	USFS-09
USFS-10	47.46563	115.25772	IB	G	L	5	1000	24	20	2	20	35	50	USFS-10
USFS-11	47.26439	115.14196	OU	G	L	4	100	21	60	8	10	30	30	USFS-11
USFS-12	47.18640	115.22499	OU	N	L	5	150	13	0.3	1	70	20	15	USFS-12
USFS-13	47.19268	115.22263	OU	N	L	4	150	13	0.3	1	50	1	5	USFS-13
USFS-14	47.20357	115.21542	OU	N	L	6	120	14	0.3	1	100	8	5	USFS-14
USFS-15	47.19200	115.24384	OU	N	L	4	150	21	0.3	1	10	35	15	USFS-15
USFS-16	47.21515	115.21509	IV	N	H	6	500	15	100	15	0.3	1	10	USFS-16

ATTACHMENT B

WEPP:Road Input with BMPs

St. Regis TMDL Planning Areas

Field Data			WEPP Batch Input Specifications											
Site	**Latitude**	**Longitude**	**Road Design**	**Road Surface**	**Traffic Level**	**Road Gradient**	**Road Length**	**Road Width**	**Fill Gradient**	**Fill Length**	**Buffer Gradient**	**Buffer Length**	**Rock Fragment**	**Comment**
SR-X-32	47.32148	115.13473	OU	N	L	2	200	25	0.3	1	2	12	10	SR-X-32
SR-X-13	47.29456	115.17455	OU	N	L	2	180	15	5	5	3	15	10	SR-X-13
SR-X-27	47.35964	115.28656	OU	G	L	5	200	25	100	10	3	40	40	SR-X-27
SR-X-40	47.39559	115.36071	OU	N	L	2	200	15	35	6	2	30	10	SR-X-40
SR-X-185	47.38581	115.35213	OU	G	L	2	200	15	0.3	1	3	15	40	SR-X-185
SR-X-14	47.40953	115.39222	OU	N	L	8	200	23	40	10	4	25	10	SR-X-14
SR-X-22	47.40513	115.42736	OU	G	L	2	200	24	0.3	1	3	10	40	SR-X-22
SR-X-3	47.41498	115.51086	OU	G	H	2	200	26	90	10	10	10	40	SR-X-3
SR-X-20	47.43462	115.50468	OU	N	L	5	200	14	0.3	1	3	8	10	SR-X-20
USFS-02	47.35814	115.43198	IB	N	H	8	400	18	0.3	1	5	15	10	USFS-02
USFS-03	47.35214	115.47796	IV	N	L	5	400	12	0.3	1	40	3	15	USFS-03
USFS-04	47.35000	115.47653	OR	N	L	11	400	12	110	30	40	30	20	USFS-04
USFS-05	47.34148	115.43340	OU	N	L	2	344	18	100	15	100	30	10	USFS-05
USFS-06	47.38758	115.24879	IV	G	H	3	400	18	40	10	90	50	20	USFS-06
USFS-07	47.41616	115.24634	IV	G	H	1	121	35	110	5	30	25	30	USFS-07
USFS-08	47.41762	115.24218	IB	N	L	7	400	12	50	10	50	20	10	USFS-08
USFS-10	47.46563	115.25772	IB	G	L	5	400	24	20	2	20	35	50	USFS-10
USFS-11	47.26439	115.14196	OU	G	L	4	100	21	60	8	10	30	30	USFS-11
USFS-12	47.18640	115.22499	OU	N	L	5	140	13	0.3	1	70	20	15	USFS-12
USFS-13	47.19268	115.22263	OU	N	L	4	150	13	0.3	1	50	1	5	USFS-13
USFS-14	47.20357	115.21542	OU	N	L	6	120	14	0.3	1	100	8	5	USFS-14
USFS-15	47.19200	115.24384	OU	N	L	4	150	21	0.3	1	10	35	15	USFS-15
USFS-16	47.21515	115.21509	IV	N	H	6	400	15	100	15	0.3	1	10	USFS-16

ATTACHMENT C

Disturbed WEPP Input

St. Regis TMDL Planning Areas

Field Data							WEPP Input						WEPP Results	Sediment Erosion from Hillslope (Tons/Year)
Stream Segment	**Site**	**Latitude**	**Longitude**	**Height (Feet)**	**Width (Feet)**	**Area (Acres)**	**Element**	**Treatment**	**Gradient**	**Horizontal Length**	**Cover (%)**	**Rock (%)**	**Average Sediment (Tons/Acre)**	
St. Regis River	Hillslope 1	47.41811	-115.62022	60	410	0.56	**Upper**	**Low Severity Fire**	100 100	60	20	70	11.0493	6.24
							Lower	**Low Severity Fire**	100 0	60	20	70		
St. Regis River	Hillslope 2	47.40453	-115.49011	65	180	0.27	**Upper**	**Low Severity Fire**	0 100	65	0	60	13.9107	3.74
							Lower	**Low Severity Fire**	100 0	65	0	60		
Twelvemile Creek	BEHI 11	47.36097	-115.27877	25	511	0.29	**Upper**	**Low Severity Fire**	0 100	25	10	40	7.4983	2.20
							Lower	**Low Severity Fire**	100 0	25	10	40		
Twelvemile Creek	BEHI 12	47.36000	-115.28102	35	163	0.13	**Upper**	**Low Severity Fire**	0 100	35	10	40	9.1892	1.20
							Lower	**Low Severity Fire**	100 0	35	10	40		

APPENDIX J
ASSESSMENT OF POTENTIAL SEDIMENT RISK FROM CULVERT FAILURES

Prepared by Lolo National Forest with additions by Montana Department of Environmental Quality

Introduction

Spatial analysis of roads and stream GIS layers indicates 895 road-stream intersections within the St. Regis watershed. Due to limited mapping accuracy of GIS layers, many of the 846 crossings are spurious. Based on field verification, there are more realistically about 621 stream crossings in the St. Regis watershed. In 2002, 247 of these culverts were screened as part of a Forest-wide inventory of culvert fish passage capabilities, and a formal survey was completed for a sub-sample of 124 culverts on fish-bearing streams. Fish-bearing streams were defined as those with intermittent or perennial flow and less than 25% gradient. Surveyed culverts represent approximately 20% of the 621 stream crossings in the St. Regis watershed. Culverts were surveyed in each of the St. Regis River tributary watersheds (**Table J-1** and **Figure J-1**). Surveyed culverts are all located on roads within the National Forest boundary or on roads outside the National Forest boundary but maintained by the Forest Service. Data collected include culvert dimensions, average fill height, road width, bankfull width, and other parameters.

Table J-1. Stream Crossing Culverts on Fish-Bearing Streams in St. Regis Watershed Surveyed In 2002 as Part of Culvert Fish Passage Analysis

HUC 6 No. (1701020408xx)	HUC 6 Name	Number Surveyed	Estimated number of crossings in the watershed	Percent of culverts measured in the watershed
04	Big Cr	9	36	25
06	Deer Cr (St. Regis)	6	12	50
11	Little Joe Cr	11	88	13
12	Lower St. Regis_Mullan	3	116	3
02	Packer Cr	9	40	23
05	Savenac Cr	4	13	31
03	Silver_Timber	13	45	29
08	Twelvemile Cr	29	122	24
07	Twin Cr_St Regis	3	28	11
10	Twomile Cr	9	34	26
01	Upper St. Regis	22	73	30
09	Ward Cr	6	27	22
St. Regis HUC 5		**124**	**620**	**20**

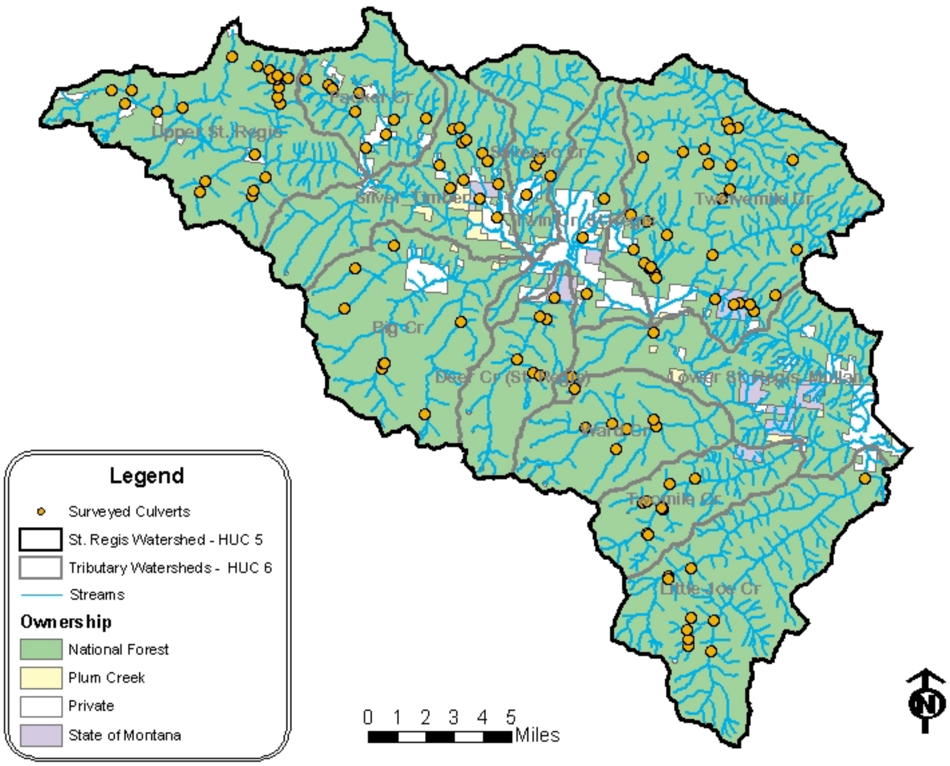

Figure J-1. Stream Crossing Culverts on Fish-Bearing Streams in St. Regis Watershed Surveyed In 2002 as Part of Culvert Fish Passage Analysis

The culvert fish passage analysis revealed that almost all of the culverts surveyed span less than the bankfull width of the streams they cross. This relationship is expressed as a ratio of culvert width to bankfull width, also known as constriction ratio. Ninety-eight percent of culverts surveyed have a constriction ratio less than 1.0 (**Figure J-2**).

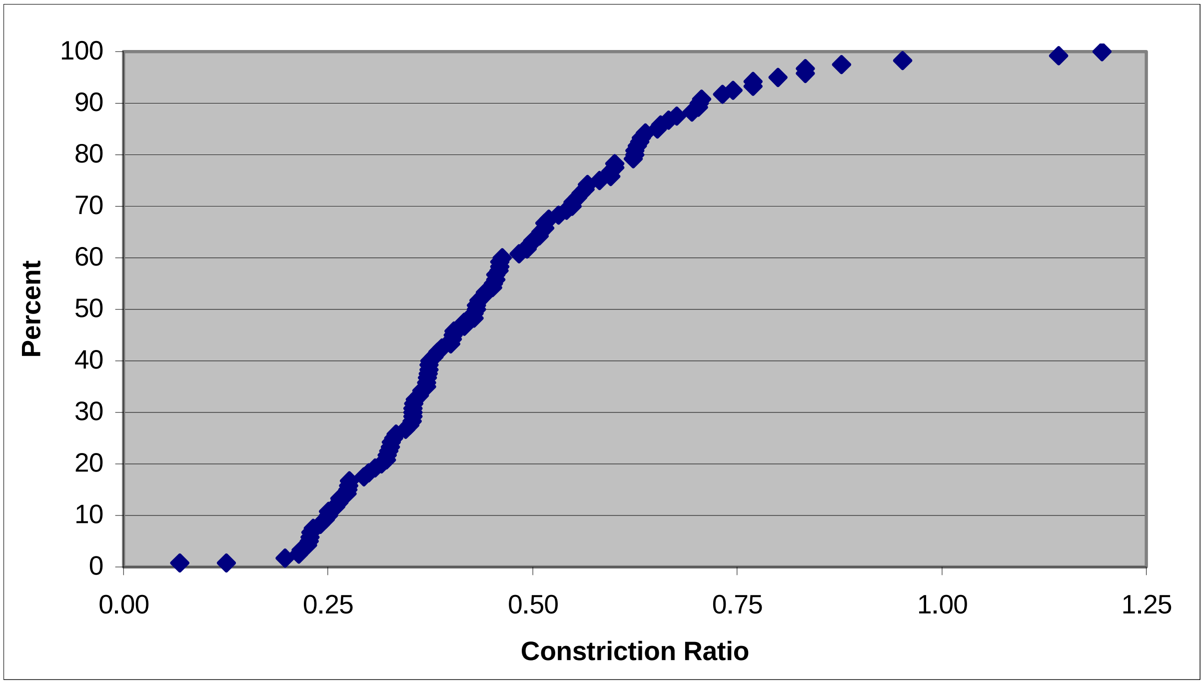

Figure J-2. Cumulative Percent Distribution of Constriction Ratio for Culverts on Fish-Bearing Streams in the St. Regis Watershed

The ability of fish to pass through a culvert with a corrugated bottom is limited, especially when the constriction ratio is less than one. Fish passage capabilities of 119 culverts were evaluated by modeling with the culvert survey data using Region 1 Fish Passage Evaluation Criteria (USDA, 2003). Based on analysis of the culvert survey data, 3 (2.5%) of these culverts allow for passage of both adult and juvenile fish, while 103 (86.6%) pass neither adult nor juvenile fish. For the remaining 13 culverts (10.9%), passage is possible by at least adult fish or juvenile fish but is not determined for the other category (5 culverts), or passage is not determined for both categories (8 culverts). (**Table J-2** and **Figure J-3**).

Table J-2. Fish Passage Capability Results

		Juvenile Fish Passage			
		Green	**Natural Simulation**	**Grey**	**Red**
Adult Fish Passage	Green	2	0	1	0
	Natural Simulation	0	1	0	0
	Grey	0	0	8	4
	Red	0	0	0	103

Green = hydraulically possible, **Natural Simulation** = conditions are natural (bridge or bottomless arch); passage is possible, **Grey** = too close to call by hydraulic calculations, **Red** = hydraulically impossible

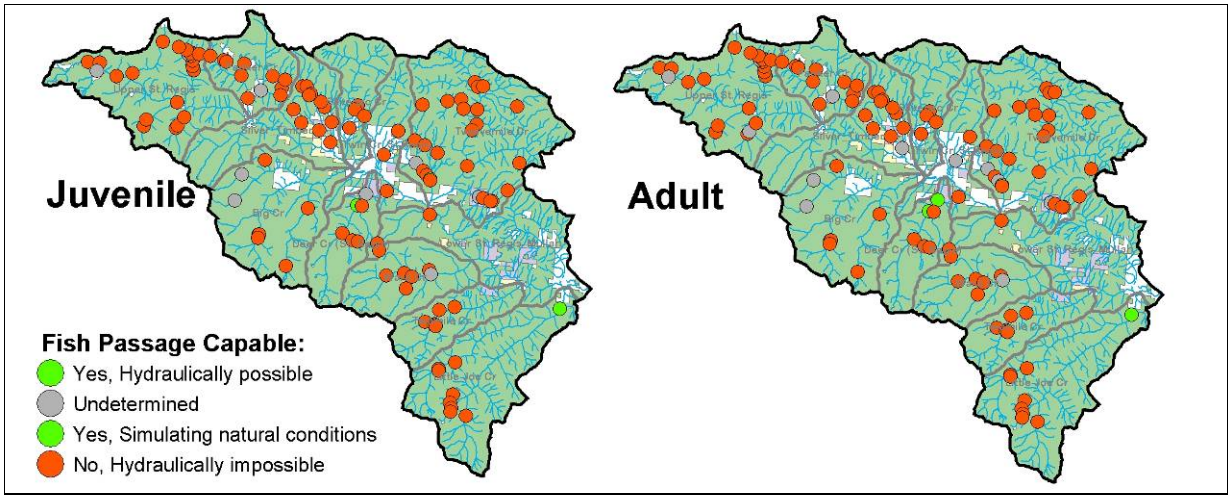

Figure J-3. Map of Fish Passage Capabilities of Surveyed Culverts in the St. Regis Watershed

Not only are undersized culverts often incapable of fish passage, they are also susceptible to failure or blow-out due to the ponding or bottleneck of water at the culvert inlet. Culvert failure results in direct contribution of road fill material to the stream. This study determined the road fill volume subject to erosion and direct delivery from culvert failure. Modeled discharge and associated headwater depth to culvert depth ratio (Hw:D) was used to assess culvert flow capacities and failure risk.

The total volume of potential sediment contribution associated with failure of culverts incapable of passing modeled flows was then summarized. Total road fill failure is not always the response to ponded water at the inlet of undersized culverts. In some instances, only part of the road fill may be contributed to the stream as a result of culvert failure. In other cases, culvert failure occurs when ponded water overflows onto the road causing erosion of the road surface.

Methods

The magnitude of peak discharge (Q) for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals was modeled for each surveyed stream crossing culvert using regression equations developed by Omang (1992). Independent variables in the equations are drainage area (square miles) and mean annual precipitation (inches). Drainage area above each stream crossing was determined using a digital elevation model (DEM) in ArcMap 8.1 Hydrology Tools (ESRI, 2001). Mean annual precipitation for the area drained by each surveyed stream crossing culvert was derived from a GIS raster layer of precipitation (Daly and Taylor, 1998).

Headwater depths (Hw, depth of water ponded at culvert inlet) were determined using software from the US Department of Transportation, Federal Highway Administration (FHWA). The program HDS5eq.exe was downloaded from FHWA's Hydraulic Engineering Software Archive website (FHWA, 2001). HDS5eq.exe is a nomograph calculator for FHWA "Hydraulic Design of Highway Culverts" (HDS-5) which uses the nomograph charts in HDS-5 Appendix D and inlet control equations found in HDS-5 Appendix A. Based on culvert material, shape, mitering, height, width, discharge, and/or culvert slope, the headwater depth of each culvert was calculated for each modeled discharge.

Analysis of sediment risk from culvert failure was completed for 119 of the surveyed culverts. (Due to incomplete data, 5 of the 124 surveyed culverts could not be included in the sediment risk analysis). Modeled discharge, headwater depth to culvert depth ratio (Hw:D), and road fill volume subject to erosion should culvert failure occur, assuming culvert failure results in 100% delivery of affected road fill volume to the stream were evaluated to determine sediment risk. If the Hw:D exceeded the recommended Hw:D for a given modeled Q at a particular culvert, the associated road fill volume estimate was counted as a potential sediment contribution. Culverts with Hw:D greater than 1.0 are considered at risk of failure due to the forces of ponded water at the culvert inlet. Culvert failure does not occur every time Hw:D exceeds 1.4. However, corrugated steel pipe manufacturers recommend a Hw:D maximum of 1.5 (ponding 50% above the top of the culvert), and if at all possible less than or equal to 1.0 (American Iron and Steel Institute, 1994). In this analysis, a maximum Hw:D of 1.4 was considered. At the Hw:D = 1.4 level, culverts capable of passing a given discharge without exceeding Hw:D = 1.0 were considered not at risk to failure and therefore the potential sediment contribution was 0. These assumptions likely over predict long term average annual loading.

Results

As modeled discharge increases, so does the number of culverts incapable of passing the greater discharges. Ninety-seven percent of the surveyed culverts evaluated are capable of passing the Q2 discharge with a Hw:D less than 1.4 and 1.0, while 43% cannot pass Q100 with Hw:D less than 1.0 and 29% cannot pass Q100 with Hw:D less than 1.4 (**Table J-3** and **Figure J-4**). The number of culverts capable of passing flows at Hw:D < 1.0 is always less than (or equal to in the case of Q2) the number of culverts capable of passing flows at Hw:D < 1.4.

Table J-3. Percent of Culverts Surveyed Capable of Passing Flows with Hw:D≤1.0 And 1.4

	Hw:Depth	
	1	**1.4**
Q2	97%	97%
Q5	87	95
Q10	81	87
Q25	72	83
Q50	66	79
Q100	57	71

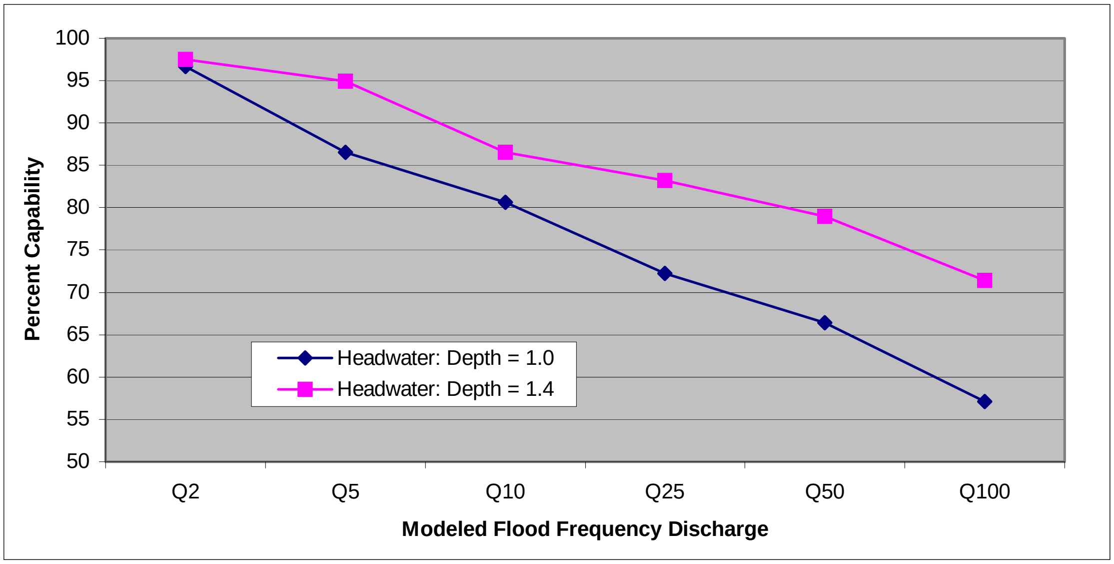

Figure J-4. Percent of Culverts Surveyed Capable of Passing Flows

Potential sediment associated with culvert failure was summarized by HUC 6 under each modeled discharge / headwater to depth ratio combination (**Table J-4**). For the St. Regis HUC 5, total potential sediment ranges from 96 tons for Q2 and Hw:D = 1.4 to 5283 tons for Q100 and Hw:D 1.0.

Among the HUC 6 tributary watersheds, distribution of potential sediment from culvert failure is not directly related to the distribution of culverts surveyed. Ten and a half percent of the culverts surveyed are located in the Silver-Timber HUC 6 (**Figure J-5**), and account for 73% of the potential sediment from culvert failures in the St. Regis HUC 5 at Q2 and Hw:D = 1.0 (**Figure J-6**). The remaining potential sediment from culvert failures at Q2 flows is in the Upper St. Regis HUC 6 (20% of total potential sediment) and the Twelvemile HUC 6 (7% of total potential sediment).

For modeled Q25 flows and Hw:D 1.0, 52% of the total potential sediment from culvert failures is in the Little Joe HUC 6 representing 9% of the surveyed culverts, and 12% is in the Silver-Timber HUC 6 representing 10.5% of surveyed culverts. The remaining 36% of total potential sediment comes from 80.5% of the surveyed culverts in other tributary watersheds, with proportions ranging from 1 to 7% of the total potential sediment for the St. Regis HUC 5.

Nine percent of the culverts surveyed are located in the Little Joe HUC 6, and account for 34% of the total potential sediment contribution from culvert failures at Q100 and Hw:D 1.0. Forty and a half percent of surveyed culverts are located in Silver-Timber, Twelvemile, and Big Creek tributary watersheds and account for 13% each of total potential sediment. The remaining 27% of total potential sediment is from culvert failures in the other tributary watersheds, with potential sediment proportions ranging from 1 to 7%.

Table J-4. Potential Sediment Contribution (Road Fill Estimate, Tons) At Risk from Culvert Failures Based on Modeled Discharge and Headwater Depth to Culvert Depth Ratio

	Q2		Q5		Q10		Q25		Q50		Q100	
Headwater: Depth	**1.0**	**1.4**	**1.0**	**1.4**	**1.0**	**1.4**	**1.0**	**1.4**	**1.0**	**1.4**	**1.0**	**1.4**
Big Creek	0	0	109	0	197	109	197	197	197	197	679	197
Deer Creek	0	0	0	0	42	0	121	42	375	121	375	121
Little Joe Creek	0	0	53	0	291	53	1664	291	1664	291	1815	1548
Lower St. Regis	0	0	126	0	126	126	126	126	126	126	126	126
Packer Creek	0	0	29	0	29	29	29	29	194	29	194	29
Savenac Creek	0	0	0	0	0	0	15	0	49	0	49	49
Silver Timber	87	65	198	87	198	198	379	198	637	198	702	379
Twelvemile	8	8	154	100	199	154	201	180	353	198	697	220
Twin Creek	0	0	0	0	0	0	0	0	77	0	77	0
Two Mile Creek	0	0	0	0	66	0	103	0	103	103	103	103
Upper St. Regis	23	23	23	23	136	23	136	23	136	136	255	136
Ward Creek	0	0	0	0	0	0	213	0	213	0	213	213
St. Regis	118	96	692	209	1284	692	3183	1086	4124	1398	5283	3120

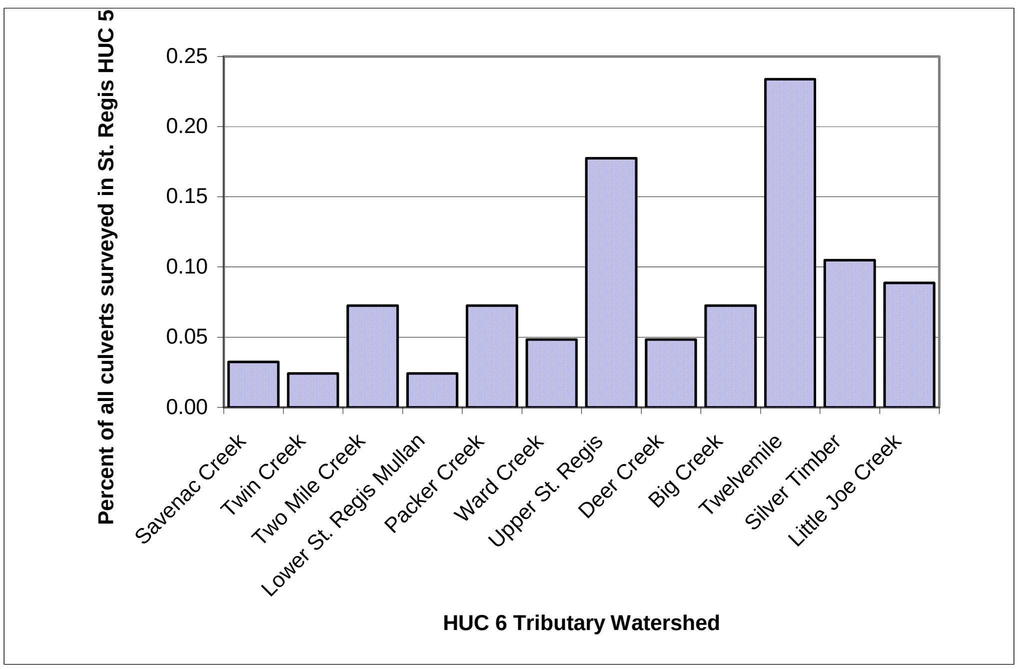

Figure J-5. Distribution among HUC 5 Tributary Watersheds of All Culverts Surveyed in the St. Regis River HUC 5

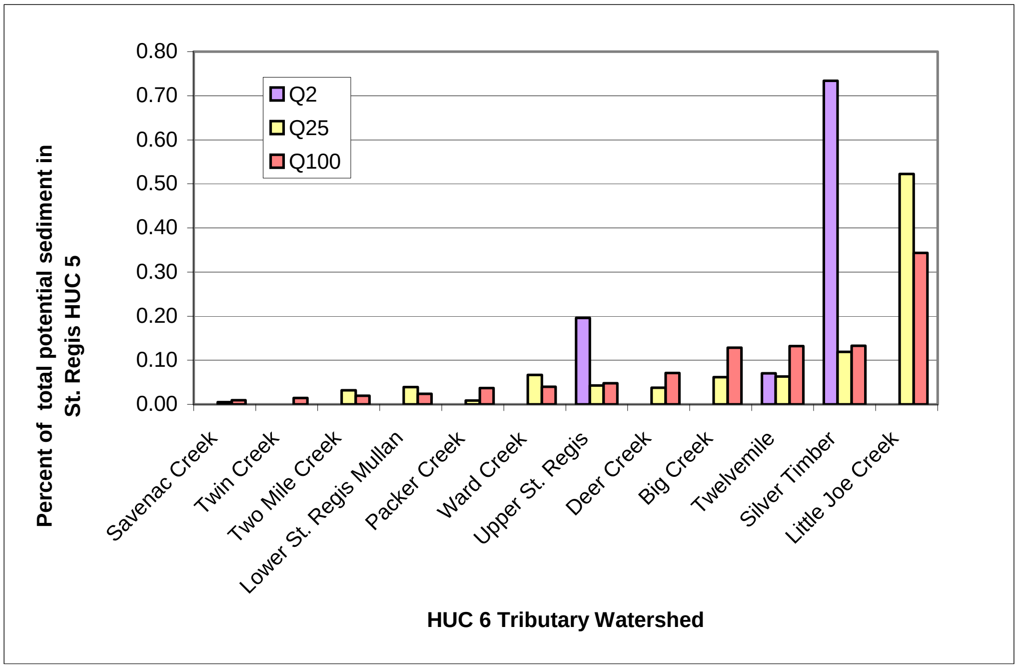

Figure J-6. Summary of Potential Sediment Contribution from Culverts At-Risk Of Failure Under Hw:D 1.0 Condition

Estimating Average Annual Sediment Yield

Estimating potential sediment contribution from the culvert flood event based failure analysis above involved determining how much sediment is produced in a century based on probability of flood recurrence. The watershed wide assessment was extrapolated to a sub-watershed scale using the estimated number of culverts in the sub-watershed and applying an average annual load per crossing from the assessed sites in the St. Regis Watershed. A headwater depth to culvert depth ratio of 1.4 was used in this analysis. Lolo Forest culvert failure documentation over the past few decades indicates culverts that appear to be at risk of failure using this method do not fail at a rate equivalent to the potential failure rate using recurrence probabilities. Therefore, all culverts sized at Q10 or less are assumed to fail 10 times over 100 years for the existing conditions scenario and flood frequency probabilities for Q10 and above are followed (**Table J-5**). Also, all of the fill at an average crossing will likely not fail. An estimated 25% of the road fill was used to represent the average sediment production at an average culvert failure in the St. Regis Watershed.

Culvert failure modeling scenarios were completed to assist in TMDL allocations (**Table J-5**). Two scenarios were completed by upgrading culverts upon failure with culverts sized at Q25 and Q100 designs. Each of these scenarios assumes upgrades after an initial failure that would occur according to flood frequency probability. These scenarios assume the upgrades would fail according to flood frequency probability.

Table J-5. Average Annual Potential Sediment Loads from Culvert Failure and Estimated Load Reductions from Mitigation Practices

	Existing Total Average Annual Sediment Yield Potential (t/Y)	Total Average Annual Yield Potential (t/Y) for Q100 upgrade	% Reduction due to Q100 upgrades
Big Creek	10.8	6.8	37
Deer Creek	3.6	2.3	37
Little Joe Creek	26.4	16.7	37
Lower St. Regis	34.8	22.0	37
Packer Creek	12.0	7.6	37
Savenac Creek	3.9	2.5	37
Silver Timber	13.5	8.6	37
Twelvemile	36.6	23.2	37
Twin Creek	8.4	5.3	37
Two Mile Creek	10.2	6.5	37
Upper St. Regis	21.9	13.9	37
Ward Creek	8.1	5.1	37
St. Regis	186.0	117.8	37

Discussion

Several approaches may be taken to interpret the results of this analysis and determine how to reduce the risk of potential sediment contribution from culvert failure. One approach is to upgrade culverts incapable of passing the most frequent flows. Risk of culvert failure decreases when culverts are capable of passing the most frequent flows. Another approach is to upgrade those undersized culverts with the greatest amount of road fill at risk of becoming sediment in the event of culvert failure. By ensuring that culverts with the greatest amount of road fill are large enough to pass flows, the quantity of potential sediment delivery greatly decreases.

The current sediment load potential from culvert failure will be compared to a road system that can pass 100 year storm events without failure for the allocation approach. This approach is consistent with Forest Service standards (Q100) but should be applied watershed wide, not only on Forest Service lands. See the main document for the allocation approach for sediment due to risk of culvert failure.

Several caveats should be considered when interpreting the results of this analysis. First, the USGS regression equations are subject to large standard errors that at times can substantially over or under predict discharge. Second, the assessment was conducted using a sub-sample of approximately 20% of culverts in the St. Regis watershed. The results of this analysis are based on current conditions and do not factor in potential increased flows after timber harvest or forest fires.

An important factor to consider for restoration is the short-term sediment contribution that results from disturbing the existing roadbed to remove and replace undersized culverts with larger culverts. Based on previous Lolo National Forest Monitoring Reports and other research the short-term sediment pulse is expected to be about 2 tons per culvert during the first 24 hours during and after culvert replacement (USDA, 1999). Most of the sediment increases passes within 24 hours, and decays to near normal levels within one year. Mitigation measures such as diverting live water, using filter cloths, slash filter windrows, and straw bales, and seeding and fertilizing can reduce this sediment increase up to 80 percent (Wasniewski, 1994).

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APPENDIX K
TRACTION SAND ASSESSMENT FOR THE ST. REGIS RIVER TMDL

Prepared by Land and Water Consulting, Inc.

Introduction

Significant sources of sediment in the St. Regis River Watershed are thought to include highway traction sand, cut and fill slope erosion, and an extensive forest road network. Delivery of sediment from these non-point sources was analyzed through aerial photograph assessment, cut and fill slope measurements, and in-stream indicators. This report focuses upon the delivery of traction sand from Interstate 90 into the St. Regis River. Mechanisms for traction sand delivery into the St. Regis River include direct casting, fill slope transport, and culvert transport. The movement of traction sand along roadside ditches at the base of cut slopes was also examined along with cut slope erosion. In addition, this report includes an analysis of sediment delivery at several tributary crossings located on non-National Forest lands.

Methods

Traction Sand Assessment

The input, storage, and transport of traction sand were examined along the St. Regis River. Data pertaining to the annual application of traction sand along Interstate 90 between St. Regis and Lookout Pass were obtained from the Montana Department of Transportation. The storage and transport of traction sand were assessed based on the proximity of the interstate to the stream channel and the movement of traction sand on interstate fill slopes. The routing of traction sand through culverts, as well as the input of traction sand from bridge decks, was also estimated.

Interstate 90 was delineated based on the proximity of the road to the stream channel using 1996 orthophoto quads. Interstate stationing begins at the overpass just east of the Montana-Idaho border and progresses in 0.1-mile increments eastward. Sections were classified as within 100 feet, 200 feet, 300 feet, and greater than 300 feet of the stream channel using GIS software. Measurements were made from the edge of the road shoulder to approximately the center of the stream channel. Thus, distances are generally over-estimated. Sites in which the road is within 100 feet of the stream channel were further classified as between 50 and 100 feet, 25 and 50 feet, and less than 25 feet using aerial photographs along with observations made during field work.

Interstate 90 fill slopes were investigated at cross sections perpendicular to the road at 13 sites between Lookout Pass and Saltese and several intermittent sites between Saltese and St. Regis. These measurements were made to determine traction sand accumulation and transport, though they are not directly related to the mean annual application rate, since traction sand deposits can accumulate over several years. Fill slopes were situated primarily along the eastbound lane of Interstate 90 in this area. The depth of traction sand deposits on fill slopes was measured at five-foot intervals progressing away from the road shoulder. Every five feet a standard shovel, with 0.16-foot (5 cm) delineations drawn on the blade beginning at the tip, was placed into the fill slope perpendicular to the angle of the slope and pressed down once firmly with the boot sole.

This was repeated every five feet until no traction sand was observed. Many of the traction sand deposits were extremely compacted and difficult to dig into; especially those near the road shoulder and on lower angled slopes. Thus, field measurements tended to under-estimate the depth of traction sand in these locations. The angle of the fill slope was measured with a hand-held clinometer.

Culverts were first identified using the “as constructed” highway plans along with the 1996 orthophoto quads. Overall, 184 culverts were identified prior to field work along 33.4 miles of Interstate 90, and 66 of these had the potential to drain into the stream channel. Thirty-nine of the 66 culverts that potentially drain into the stream channel are located at the base of cut slopes. Culverts potentially draining into the stream channel were located in the field, contributing cut slope road length was determined, and delivery to the stream channel was assessed.

Interstate 90 cut slopes drained by culverts were assessed for delivery of cut slope material into the stream channel. Cut slopes were located primarily along the westbound lane of Interstate 90. The horizontal length of cut slopes was measured on the 1996 orthophoto quads with 0.1-mile stationing. The cut slope “face” was measured in the field using Leica LRF 800 Rangemaster binoculars while standing at the base of the cut slope and measuring the distance to the top. This was repeated at several points along each cut slope and an average height was used to determine the area of cut slopes. Cut slope material was visually assessed for erodibility and the amount of surface area covered with bedrock, boulder, cobble, gravel, and sand was determined. Cut slopes identified as potentially draining into the stream channel were walked along their entire length. Cut slopes lacking any culverts draining into the stream channel were considered to not deliver sediment into the stream channel from the abutting lane of interstate.

Stream Crossings
Sediment contribution was assessed from several stream crossings on non-Forest Service lands. The total number of stream crossings on private land was tallied using GIS. A subset of stream crossings was then assessed in the field. Assessed stream crossings were all located in the lower portions of a given tributaries watershed. For each stream crossing the contributing length of road, the tread width, base erosion rate, gravel factor, percent cover, and percent delivery were determined (Washington Forest Practices Manual 1997). A base erosion rate of 30 tons/acre/year was used in this analysis (Washington Forest Practices Manual 1997).

Results and Discussion

Annual Traction Sand Application Rates
Eleven years of data (1997-2007) from the Montana Department of Transportation indicate that an average of 15,282 cubic yards of traction sand are applied over a winter season to Interstate 90 along 33.4 miles extending from mile marker 0 at the Montana-Idaho border at the top of Lookout Pass to mile marker 33.4 at St. Regis (**Table K-1**). Application rates ranged from 10,383 cubic yards to 22,460 cubic yards (measured over the fiscal year, which extends from July 1 through June 30). One cubic yard of slightly damp sand weighs 2,850 pounds (D. Scheck, MDT, pers. comm., 2003). Thus, an average of 21,777 tons of traction sand is applied annually, ranging from a minimum of 14,796 tons to a maximum of 32,006 tons in the period of record. The particle size distribution of the sand is such that one hundred percent of particles pass

through a 3/8-inch sieve (9.5 mm), 40 to 80% pass through a #4 mesh (0.187 inches, 4.75 mm), 0 to 35% pass through a #40 mesh (0.0165 inches, 0.425 mm), and 0 to 10% pass through a # 200 mesh (0.0029 inches, 0.075 mm) (E. Stimson, MDT, pers. comm., 2003).

Table K-1. Amount of Traction Sand Applied to 33.4 Miles of Interstate 90 Over Six Winter Seasons Between the Top of Lookout Pass and St. Regis, Montana*

Year	Cubic Yards	Tons
1996-1997	20,427	29,108
1997-1998	10,383	14,796
1998-1999	17,120	24,396
1999-2000	15,495	22,080
2000-2001	12,505	17,820
2001-2002	22,460	32,006
2002-2003	10,390	14,806
2003-2004	16,256	23,165
2004-2005	10,926	15,570
2005-2006	17,624	25,114
2006-2007	14,517	20,687
Mean Annual Rate	**15,282**	**21,777**

*MDT 2003

In the 2001-2002 winter season, 61% of the traction sand was applied between mile marker 0 and mile marker 10, which is located near the Saltese exit, 18% of the traction sand was applied between mile marker 10 and mile marker 22, which is located near the Twelvemile Creek exit, while the remaining 21% of traction sand was applied between mile marker 22 and mile marker 34, which is near the St. Regis exit (D. Moeller, MDT, pers. comm., 2003). These sections contain 10 miles, 12 miles, and 12 miles of road length respectively. For the purposes of this study the 10 miles between Lookout Pass and Saltese will be considered to receive 60% of the traction sand applied annually, while application rates of 20% will be assumed for the other two sections.

The 60-20-20 percentages were applied to the average annual rate of traction sand application. There are an estimated 9,169 cubic yards of traction sand applied annually between Lookout Pass and Saltese, while 3,056 cubic yards are applied annually to the other two sections (**Table K-2**). It's estimated that 13,066 tons of traction sand are applied annually between Lookout Pass and Saltese, while 4,355 tons are applied to both of the downstream sections. Assuming an average lane width of 12 feet across four lanes of highway, as indicated by the "as constructed" plans, reveals 0.10 feet (3.0 cm) of traction sand are applied over the four lane surface on a mean annual basis between the top of Lookout Pass and Saltese, while 0.03 feet (0.9 cm) of traction sand are applied between Saltese and St. Regis. Application rates are 10.3 pounds per square foot in miles 0 to 10 and 2.9 pounds per square foot elsewhere.

Table K-2. Mean Annual Traction Sand Application Rates along Interstate 90 between Lookout Pass and St. Regis, Montana

Mile Marker	Description	Percent Applied	Cubic Yards	Tons	Pounds per Square Foot	Depth (Feet)
0 to 10	Lookout Pass to Saltese (Reach 7-9)	60	9,169	13,066	10.3	0.10
10 to 22	Saltese to Twelvemile Creek (Reach 4-6)	20	3,056	4,355	2.9	0.03
22 to 34	Twelvemile Creek to St. Regis (Reach 1-3)	20	3,056	4,355	2.9	0.03

Overall, 7.3 miles of Interstate 90 are within 100 feet of the St. Regis River, 12.0 miles are between 100 and 200 feet from the stream channel, 6.0 miles are between 200 and 300 feet of the stream channel and 9.8 miles are farther than 300 feet from the stream channel. In addition, the 7.3 miles of the interstate within 100 feet of the stream channel contain approximately 0.4 miles of bridge crossings. Thus, for this analysis, 6.9 miles of interstate are considered to be within 100 feet of the stream channel and 0.4 miles are made up of bridge crossings. Out of 6.9 miles of interstate within 100 feet of the stream channel, 3.0 miles of the eastbound lane are between 50 and 100 feet of the stream channel, and 2.5 miles are between 25 and 50 feet of the stream channel (**Table K-3**). Along the westbound lane 0.4 miles are between 50 and 100 feet of the stream channel, 0.5 miles are between 25 to 50 feet of the stream channel, and 0.5 miles are within 25 feet of the stream channel.

Table K-3. Length of Interstate 90 within 100 Feet of the St. Regis River

Distance to Stream Channel	Eastbound Lane (Miles)	Westbound Lane (Miles)
50 to 100 Feet	3.0	0.4
25 to 50 Feet	2.5	0.5
Within 25 Feet	0.0	0.5
Total	5.5	1.4

Fill Slope Measurements

The accumulation of traction sand on fill slopes was examined primarily upstream of Saltese. At 13 measured sites, the mean observed extent of traction sand was 33 feet, with a minimum of 25 feet and a maximum distance of 45 feet. Fill slopes averaged a 45% slope and ranged from less than 10% to greater than 60% slopes. The maximum depth of accumulated traction sand deposits was 0.66 feet (20 cm) and it was observed within the first 20 feet from the interstate shoulder. The maximum mean depth of 0.37 feet (11.2 cm) occurred 10 feet from the road shoulder (**Figure K-1**). Lower angled slopes tended to have shallower deposits and shorter dispersal distances, while steeper slopes tended to have deeper deposits and greater dispersal distances. Traction sand deposits on fill slopes downstream of Saltese also followed this pattern, decreasing toward St. Regis as the rate of application decreases.

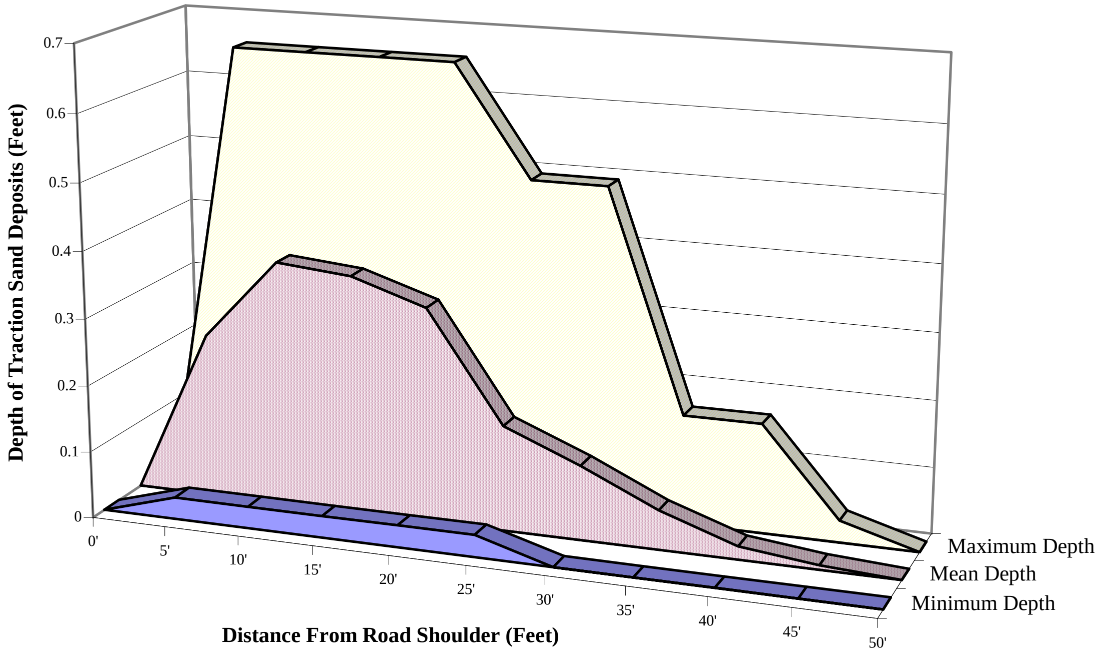

Figure K-1. Depth of Traction Sand on Fill Slopes Measured at 5-Foot Intervals Progressing Away from the Interstate 90 Shoulder

Eighty-eight percent of the mean traction sand deposit was found within the first 25 feet of the road shoulder, while only 12.0% of the mean deposit was found between 25 and 50 feet (**Table K-4**). Traction sand deposits started to taper off at approximately 20 feet from the road shoulder, with 78.4% of the traction sand deposit within 20 feet of the road shoulder. While no traction sand deposits were observed over 45 feet from the road shoulder at the 13 fill slope assessment sites, additional observations of traction sand movement made during the stream channel assessment indicate traction sand is dispersed as far as 112 feet from the road shoulder on steep (>60%) fill slopes.

Table K-4. Percent of Mean Traction Sand Deposit Accumulated on Fill Slopes Measured at 5-Foot Intervals from the Road Shoulder

Distance From Road Shoulder (Feet)	Percent of Mean Deposit	Cumulative Percent of Mean Deposit
0-5	14.9	14.9
5-10	22.3	37.2
10-15	21.7	58.9
15-20	19.5	78.4
20-25	9.6	88.0
25-30	6.8	94.8
30-35	3.6	98.4
35-40	1.2	99.6
40-45	0.4	100
45-50	0	100

Culverts

Overall, 38 culverts were identified in the field. Thirty-two of these culverts provide potential pathways to the stream channel and 8 of these culverts discharge within 30 feet of the stream channel (**Table K-5**). Twenty-one out of 32 culverts providing pathways to the stream channel are associated with cut slopes. Four culverts were identified in Reach 9 (see Table K-2 for reach locations), though only one of them appears to provide a pathway for traction sand to enter the stream channel. Seven culverts were identified in Reach 8, 5 of which provide pathways to the stream channel, while one culvert discharges within 30 feet of the stream channel. Three cut slopes are drained by culverts in Reach 8. Twelve culverts were found in Reach 7, 11 of which lead to the stream channel, and 4 of which discharge within 30 feet of the stream channel. Three cut slopes are drained by culverts in Reach 7. Two culverts drain two cut slopes in Reach 6, while no culverts were identified in Reaches 4 and 5 with only one cut slope identified in each of these two reaches. Seven culverts providing pathways to the river were identified in Reach 3, all of which are associated with cut slopes. Five culverts were identified in Reach 2, all of which are associated with cut slopes, while Reach 1 contains only one culvert that drains a cut slope.

Table K-5. Culverts Draining Interstate 90 with the Potential to Deliver Traction Sand into the St. Regis River

Reach	Culvert	Mile Marker	Drain Cut Slope?	Perennial?	Application Rate(Lbs/SqFt)	
9	1	2.18	No	No	10.3	
8	2	2.95	No	No	10.3	
8	3	3.2	No	No	10.3	
8	4	3.42	Yes	Yes	10.3	
8	5	5.2	Yes	Yes	10.3	
8	6	5.9	Yes	Yes	10.3	
7	7	7.04	Yes	Yes	10.3	
7	8	7.5	No	Yes	10.3	
7	9	7.7	No	Yes	10.3	
7	10	7.95	Yes	No	10.3	
7	11	8.02	No	Yes	10.3	
7	12	8.17	No	No	10.3	
7	13	8.4	No	No	10.3	
7	14	8.53	No	Yes	10.3	
7	15	8.65	Yes	No	10.3	
7	16	9.2	No	Yes	10.3	
7	17	9.85	No	No	10.3	
6	18	12.58	Yes	Yes	2.9	
6	19	13.17	Yes	No	2.9	
3	20	23.8	Yes	No	2.9	
3	21	23.83	Yes	No	2.9	
3	22	24.25	Yes	Yes	2.9	
3	23	24.35	Yes	Yes	2.9	
3	24	24.8	Yes	No	2.9	
3	25	24.95	Yes	Yes	2.9	
3	26	25.8	Yes	No	2.9	
2	27	26.5	Yes	No	2.9	
2	28	27.1	Yes	Yes	2.9	
2	29	27.45	Yes	Yes	2.9	
2	30	27.96	Yes	No	2.9	
2	31	28.58	Yes	No	2.9	
1	32	30.55	Yes	No	2.9	

Cut Slopes

Forty-seven cut slopes were identified along Interstate 90 between St. Regis and Lookout Pass covering a linear roadside distance of 9.7 miles (51,300 feet) and a total area of 180.0 acres (**Table K-6**). The majority of cut slopes are located along Reaches 2, 3, 6, and 7.

Table K-6. Cut slopes associated with Interstate 90 along the St. Regis River

Reach	# of Cut Slopes	Length (Miles)	% of Reach	Area (Acres)
1	2	0.6	13	5.9
2	10	2.6	73	48.0
3	11	2.0	41	32.0
4	1	0.1	2	4.0
5	1	0.2	5	1.6
6	7	1.9	41	48.7

Table K-6. Cut slopes associated with Interstate 90 along the St. Regis River

Reach	# of Cut Slopes	Length (Miles)	% of Reach	Area (Acres)
7	8	1.2	27	23.9
8	3	0.4	13	3.3
9	4	0.7	19	12.6
Total	47	9.7	26	180.0

Erosion rates for cut slopes in which the parent geology is Precambrian Belt series metasedimentary rocks average 30 tons/acre/year (Washington Forest Practices Manual 1997). Field assessment of cut slope material indicated that cut slopes were only partially comprised (35%) of highly erodible materials such as sand and fine gravels. Thus, the erosion rate of 30 tons/acre/year was calculated for 35% of the cut slope area along Interstate 90. Overall, culverts potentially drain 105.5 acres of cut slope surface area. Reaches 1-6 contain 95.9 acres of cut slope associated with culverts leading to the stream channel, while Reaches 7-9 have only 9.5 acres of cut slope associated with culverts leading to the stream channel. However, only 56.9 acres of cut slope in Reaches 1-6 were determined to drain into culverts and 5.5 acres of cut slopes drain into culverts in Reaches 7-9. Best professional judgment was used to determine that 10% of the eroded material at the base of cut slopes was transported to the stream channel on an annual basis, though standard models suggest a higher delivery rate (Washington Forest Practices Manual 1997). Thus, a total of 66 tons are delivered to the St. Regis River annually from cut slopes with a delivery rate of 10% (**Table K-6**).

Input of Traction Sand from Interstate 90

The assessment of traction sand delivery into the St. Regis River was based on the following criteria:

1. Eastbound and westbound lanes were considered separately. Thus, the application rate of traction sand was considered over the linear length of road multiplied by width of 2 lanes of highway (24 feet). Reaches 1-6 have an application rate of 2.9 pounds per square foot, while Reaches 7-9 have an application rate of 10.3 pounds per square foot (**Table K-2**). Contribution rates were determined for only the two adjacent lanes. Thus, fill slope contribution based on the proximity of the road shoulder to the stream channel were determined for the two lanes abutting the stream channel, while the assessment of culvert drainage was also considered for only the pertinent two lanes. Along the St. Regis River, fill slopes were generally found along the eastbound lane and culvert inlets were generally found along the westbound lane.
2. Contribution from stretches of road greater than 100 feet from the stream channel was considered to be zero for the two lanes abutting the stream channel, though culvert contribution from the other two lanes were considered when appropriate. Thus, all the traction sand applied to stretches of road greater than 100 feet from the stream channel and not drained by culverts was considered to be stored.

Fill slope assessments indicate that sediment transport from Interstate 90 into the stream channel is most likely when the road is within 50 feet of the stream channel (**Figure K-1**). Thus, the major input of traction sand occurs along the 2.5 miles of eastbound Interstate 90 and the 1.0 miles of westbound Interstate 90 within 50 feet of the stream channel. Sections of interstate 90 within 50 feet of the stream channel tend to be associated with steep fill slopes that lack dense vegetative cover due to the annual application and accumulation of traction sand. In addition, the

St. Regis River within these areas tends to be channelized with riprap, which limits the development of a buffer strip of riparian vegetation. While some fill slope storage clearly takes place, the transport of traction sand from fill slopes in areas where the interstate is within 50 feet of the stream channel appears to be considerable.

Eighty-eight percent of the traction sand applied is deposited within 25 feet of the road shoulder (**Figure K-1, Table K-4**). The only section of Interstate 90 within 25 feet of the stream channel is located along the westbound lane between mile markers 2.0 and 2.6. This section of Interstate 90 was determined in the field to be within an average of 15 feet of the stream channel. The 19.5% deposited between 15 and 20 feet, the 9.6% deposited between 20 and 25 feet, along with the 12.0% deposited between 25 and 50 feet yield a direct delivery rate of 41.1% (**Table K-4**). This analysis indicates the delivery of traction sand into the St. Regis River from sections of road within 25 feet of the stream channel averages 147 tons annually.

Figure K-1 and **Table K-4** indicate that sections of road between 25 and 50 feet from the stream channel directly receive between 0 and 12.0% of the traction sand applied. A delivery rate using the midpoint value of 6% of the total is used for sections of road between 25 and 50 feet of the stream channel. This analysis indicates delivery of traction sand into the St. Regis River from sections of road between 25 and 50 feet of the stream channel averages 88 tons annually.

Traction sand was not directly observed at distances greater than 50 feet in the fill slope assessment. However, stretches of interstate between 50 and 100 feet from the stream channel likely contribute some sediment. Traction sand was observed as far as 112 feet from the road shoulder during the stream channel assessment. Best professional judgment was used to determine that 3% of the traction sand applied between 50 and 100 feet of the stream channel is delivered on an annual basis. This delivery is likely comprised of the finest portion of the traction sand, such as particles that would pass though a #40 mesh (0 to 35% of the traction sand applied) and a # 200 mesh (0-10% of the traction sand applied). This analysis indicates delivery of traction sand into the St. Regis River from sections of road within 50 to 100 feet of the stream channel averages 23 tons annually.

The amount of road area delivering traction sand to culverts was determined for the lane abutting the culvert, which is generally the westbound lane along Interstate 90 between St. Regis and Lookout Pass. A contribution rate of 10% was determined using best professional judgment. This is the same rate employed in the delivery of cut slope erosion from the base of cut slopes, since many of these areas are overlapping. Drainage pathways leading to culverts occur on relatively low angled slopes that generally lack vegetation. Overall, 32 culverts drain 3.6 miles (18,800 feet) of interstate 90, leading to the input of 118 tons of traction sand into the St. Regis River on an annual basis, with 66 tons delivered from Reaches 7-9 and 51 tons delivered from Reaches 1-6.

There are no barriers to the movement of road sand from bridge decks into the stream channel. However, the Montana Department of Transportation reports that traction sand is removed from bridge decks (D. Moeller, MDT, pers. comm., 2003). A 90% delivery rate was selected to account for bridge deck clean up. There are a total of 14 Interstate 90 crossings of the St. Regis River totaling approximately 2,100 feet in length (0.4) miles. Bridge deck contributions were considered separately from sections of interstate within 25 feet of the stream channel. There were 3 crossings upstream of Saltese, where road sand application was greatest, while the remaining crossings were downstream of Saltese. A road width of 24 feet was assigned for single lane crossings, while 48 feet was used when both lanes crossed the river. Bankfull widths of the St. Regis River measured during TMDL development were used to determine the contributing length of road along delineated reaches. Thus, a bridge crossing near the mouth of the St. Regis River (Reach 1) was considered to have a contributing length of 176.8 feet based on bankfull channel measurements, while a bridge crossing in reach 9 was assigned a contributing length of 27.1 feet based on bankfull channel measurements. This assessment indicates that 88 tons are delivered from bridge decks annually.

The linear length of road capable of contributing traction sand into the stream channel was determined and the amount of traction sand delivered to the St, Regis River on an annual basis was estimated. Various sources were assigned the individual delivery rates described above. This analysis indicates that 486 tons of traction sand are delivered to the St. Regis River during an average winter, which amounts to roughly 2.1% of the annual application rate of 21,777 tons of traction sand (**Table K-7**). Sections of Interstate 90 within 100 feet of the stream channel contribute 258 tons annually, delivery of traction sand through culverts contributes 118 tons annually, and bridge decks contribute 88 tons annually. A detailed assessment of traction sand contributions is presented in **Table K-8**.

Table K-7. Mean Annual Input of Traction Sand into the St. Regis River from Interstate 90

Source	**Tons**	**Percent of Mean Annual Application Rate**
Interstate within 100 feet of the channel	258	1.2%
Contribution through culverts	118	0.5%
Contributions from bridges	88	0.4%
TOTAL	464	2.1%

Table K-8. Estimated Traction Sand Delivery Rates from Contributing Road Segments

		Westbound Lane		Eastbound Lane	
		Reaches 1-6	Reaches 7-9	Reaches 1-6	Reaches 7-9
Traction sand application rate (lbs/sqft)	**Delivery Rate**	**2.9**	**10.3**	**2.9**	**10.3**
Length of road between 50 and 100 feet (feet)		1300	600	15000	1000
Surface area (sqft)		31200	14400	360000	24000
Traction sand delivery (pounds)	0.03	2714	4450	31320	7416
Traction sand delivery (tons)		1.4	2.2	15.7	3.7
Length of road between 25 and 50 feet (feet)		2600	0	3100	10200
Surface area		62400	0	74400	244800
Traction sand delivery (pounds)	0.06	10858	0	12946	151286
Traction sand delivery (tons)		5.4	0.0	6.5	75.7
Length of road within 25 feet (feet)		0	2900	0	0
Surface area		0	69600	0	0
Traction sand delivery (pounds)	0.41	0	293920	0	0
Traction sand delivery (tons)		0.0	147.0	0.0	0.0
TOTALS					
Traction sand delivery (pounds)		13572	298370	44266	158702
Traction sand delivery (tons)		6.8	149.2	22.2	79.4
Bridges				0	0
Surface area (based on # of lanes and bfw)		48,062	4,819	0	0
Traction sand delivery (pounds)	0.9	125442	49636	0	0
Traction sand delivery (tons)		63	25	0	0

The majority of the traction sand entering the stream channel is derived from two stretches of Interstate 90. Traction sand inputs within 25 feet of the stream channel for 2,900 feet (approximately 0.5 miles) from mile marker 2.0 to 2.6 along the westbound lane accounts for 158 tons, which is 34% of the mean annual delivery rate. A 10,200 foot (1.9 mile) stretch of road just upstream of Saltese, in which the interstate is within 50 feet of the stream channel from mile marker 8.0 to mile marker 10.0, contributes 81 tons, which accounts for approximately 17% of the mean annual delivery rate. Thus, direct runoff from Interstate 90 along these two stretches of highway accounts for almost 50% of the total contribution of traction sand, while the other stretches of Intestate 90 within 100 feet of the stream channel account for 29 tons, which is approximately 6% of the mean annual delivery rate. The remaining traction sand is contributed is through culverts (25%) and from bridges decks (19%)(**Table K-9**).

Table K-9. Percent Contribution of Traction Sand to the St. Regis River from Interstate 90

Source	Tons	Percent
Mile markers 2.0-2.6 and 8.0-10.0	229	49%
Other portions of I-90 within 100 feet of the channel	29	6%
Contribution through culverts	118	25%
Contribution from bridges	88	19%

Additional Sites of Concern

There are two sites in Reach 9 in which traction sand drainage may impact the St. Regis River. Erosion from the eastbound lane along the base of a cut slope leads into a ditch and drains approximately 1,000 feet of road surface and empties into the forest at approximately mile marker 2.8 creating a large sediment plume extending into the forest. While this sediment plume does not reach the stream channel, it certainly has an environmental impact within the forest and over time may extend to the stream channel. A drainage ditch along the westbound lane also drains approximately 500 feet of roadway into a ditch at approximately mile marker 2.8 and may discharge in to the stream channel. In addition, a culvert at mile marker 7.7 is almost completely blocking the drainage of a perennial stream, which has led to a channel being formed along the base of the cut slope that leads to the next culvert at mile marker 7.8.

Stream Crossings

A total of approximately 108 stream crossings were identified on private lands in the St. Regis watershed using GIS. Sixteen stream crossings were assessed in the field on Little Joe, Twelvemile, Savenac, Big, Twin, and Packer creeks using a modified Washington Field Assessment Method. Approximately 2.6 tons of sediment are delivered to St. Regis River tributaries on an annual basis from these sixteen stream crossings. This averages 0.16 tons (320 pounds) from each stream crossing annually. Based on the average load per stream crossing, the estimated annual sediment load is 17.3 tons for all 108 stream crossings (**Table K-10**). This assessment was followed up by further monitoring using WEPP Road monitoring and modeling methods that are presented in **Appendix I**. The WEPP modeling results are used for source assessment and allocation. The information provided in this stream crossing section is provided to support that the WEPP Road modeling results are in the same range as this alternative method.

Table K-10. Sediment Contributions from Stream Crossings on Private Lands in the St. Regis Watershed

Sub-watershed	Number of Crossings Assessed	Total Crossings on Private Land	Annual Sediment Contribution (Tons)
Upper St. Regis	0	4	0.6
Packer	4	7	1.1
Silver-Timber	0	14	2.2
Big	3	3	0.5
Savenac	2	6	1.0
Twin	2	23	3.7
Deer	0	1	0.2
Twelvemile	4	20	3.2
Ward	0	0	0.0
Twomile	0	5	0.8
Little Joe	1	3	0.5
Lower St. Regis	0	22	3.5
TOTAL	**16**	**108**	**17.3**

Literature Cited

Washington Forest Practices Board. 1997. Standard Methodology for Conducting Watershed Analysis.

APPENDIX L
WATER YIELD ANALYSIS

Prepared by Lolo National Forest

Methods

Methods for determining the effects of vegetation removal on water yield have been developed for the Lolo National Forest (Pfankuch, 1973), and reviewed and refined for US Forest Service Region One (USDA Forest Service, 1978). The methods were developed for areas with snowmelt-dominated runoff. Equivalent clear-cut area (ECA) analysis is a key component of these methods. The basis of the ECA analysis is that water yield increases when vegetation is removed, whether by natural disturbance such as fire, or by human disturbance. When all of the vegetation from a land unit is removed (100% crown removal), the equivalent clear-cut area is also 100%, in the first year. ECA is not directly related to the proportion of vegetation removed from a land unit, however. For example, if 50% of the crown is removed, the ECA is 40% in the first year. For, crown removal up to 15%, ECA is 0%; for crown removal of 90%, ECA is 95% in the first year.

Water yield increase is greatest immediately following vegetation removal. In years subsequent to vegetation removal, the ECA (and water yield increase) declines, or “recovers”, because of vegetation re-growth. The rate of re-growth and thus ECA recovery is based on evapotranspiration, snowfall accumulation related to patch dynamics, and the relationship between water yield and changes in vegetation interception. This re-growth relationship is expressed as a recovery curve.

Water yield increase over time can be calculated for each land unit. Land unit size (acres) is multiplied by the amount of crown removed (%) to get the initial acres of equivalent clear-cut area. The year of treatment is subtracted from the analysis year to get the time since treatment. Based on the time since treatment, the recovery curve gives the associated percent recovery value. The initial ECA minus the recovery ECA produces the residual or effective ECA in acres for the analysis year. Runoff depth (feet) for the land unit is determined, usually from isoclines of runoff based on precipitation. Runoff depth is multiplied by the effective ECA to get the runoff volume for the unit in acre-feet. The runoff volume is multiplied by a runoff increase factor to get the residual water yield increase for the unit (the runoff increase factor expresses the proportion of runoff increase expected from vegetation removal at a given elevation). Residual water yield increase is then compared to the average annual water yield for the area of interest to determine the relative magnitude of the residual water yield increase, or percent water yield increase.

Results

Equivalent clear-cut area analysis was used to model residual water yield increases in the St. Regis watershed from documented harvest history on National Forest land, and for 1910 fire history data. The Timber Stand Management Recording System (TSMRS) database for the Lolo

National Forest was queried to obtain all records of documented timber harvest. USGS HUC 6 watersheds were used to delineate the tributary watersheds. Note that unlike the other watersheds, “Lower St. Regis” HUC 6 is a complex of drainages that are tributary to the St. Regis River, rather than tributary to a single stream that is tributary to the St. Regis River. For this reason, the results of the analysis for the Lower St. Regis cannot be evenly compared to the other HUC 6 watersheds. Thus, the results for the complete watershed, identified by the St. Regis HUC5, would be more appropriate for evaluating increased water yield on the lower reaches of the St. Regis River.

Timber Harvest on National Forest Land

Documented timber harvest on the National Forest in the St. Regis watershed began in the 1960s. Harvest activity increased in the 1970s, and peaked in the 1980s and early 1990s, and has diminished in the past decade. Harvest before the 1960s is assumed to be limited because of relatively low demand and lack of equipment necessary to harvest on large scales. Undocumented harvest activity prior to the 1960s is unknown, but is assumed to have a negligible effect on water yield increase.

According to ECA analysis results, residual runoff increase for the St. Regis River in 2003 was 11,841 acre-feet (**Table L-1**). Mean annual water yield for the St. Regis River based on USGS data collected at the gaging station in St. Regis, is approximately 430,000 ac-ft/year. ECA-modeled water yield for the St. Regis River is 2.8% greater than the average annual mean water yield due to past harvest activity on National Forest land.

Flow data for the tributary watersheds is very limited. To obtain a water yield value for the tributary watersheds, mean annual water yield for the St. Regis River was distributed among the tributaries on an area-weighted basis. The area-weighted proportions of the St. Regis River mean annual runoff for each tributary watershed was used to calculate the percent water yield increase for each tributary (**Table L-1, Figure L-1**).

Table L-1. Residual Runoff (RO) and Water Yield Increase to the St. Regis River from Timber Harvest on National Forest Land, Analysis Year 2003

Tributary	Effective ECA (ac)	Percent of HUC6	Runoff Depth (ft)	Runoff Volume (ac-ft)	Average Elevation (ft)	Runoff Increase Factor	Runoff Increase (ac-ft)	Mean Annual Runoff (ac-ft/year)	Percent Water Yield Increase
Big	1858	7.6	2.1	17	4708	0.405	1568	50855	3.1
Deer	783	7.2	2.1	15	4951	0.390	637	20106	3.2
Little Joe	2263	8.2	2.1	17	4833	0.400	1886	44942	4.2
Lower St. Regis	1759	7.2	1.9	13	3959	0.440	1483	21288	7.0
Packer	340	3.0	1.9	6	4644	0.400	261	23654	1.1
Savenac	167	1.5	1.2	2	4559	0.420	82	27202	0.3
Silver Timber	549	2.9	1.8	6	4310	0.430	433	70961	0.6
Twelvemile	2721	7.1	1.9	13	4466	0.420	2191	35480	6.2
Twin	301	2.4	1.5	3	4168	0.435	197	48490	0.4
Twomile	1376	12.6	2.1	27	4604	0.410	1175	44942	2.6
Upper St. Regis	579	2.2	2.5	5	4802	0.400	579	20106	2.9
Ward	1402	9.5	2.1	21	4799	0.400	1168	20106	5.8
St. Regis HUC5	14097	6.1	2.0	28194	4567	0.420	11841	429312	2.8

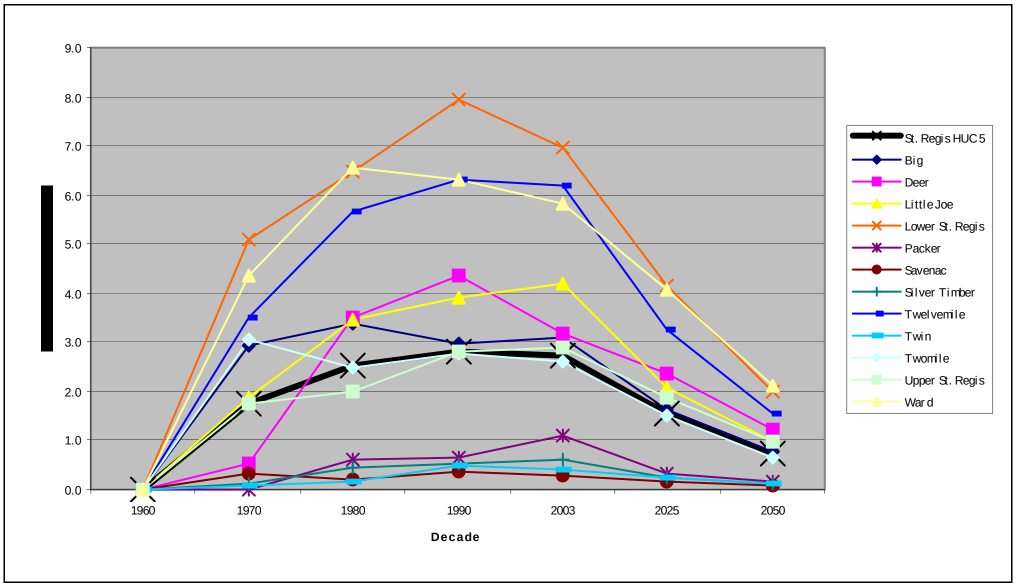

Figure L-1. Water Yield Increase from Timber Harvest on National Forest Land
Note That Unlike The Other Watersheds, "Lower St. Regis" Is A Complex Of Drainages That Are Tributary To The St. Regis River, Rather Than Tributary To A Creek That Is Tributary To The St. Regis River

Road Template

Additional water yield calculations were made to account for water yield increase from the permanent removal of vegetation within the corridor of the road system, the template or "footprint" of the road network. Road width varies, as does width and presence or absence of ditches on one or both sides of road segments. Cut and fill slope area also varies, resulting in changes in clear-cut area along a road corridor. The clear-cut area associated with the road network also changes overtime, primarily increasing as new roads are constructed. Residual clear-cut area also decreases as revegetation occurs on cut and fill slopes and infrequently used or closed roads.

None of the above identified road variables were considered. Instead, ECA and resulting water yield increase from removal of vegetation along the road network was determined assuming 100% residual clear cut area for the year 2003, and average road width of 35 feet (road tread, ditches, cut and fill slopes) for all roads. This resulted in conservatively high water yield calculations.

1910 Fires

The effects of the 1910 fires on water yield were also examined. Fire perimeter data for historic fires on the Lolo National Forest have been interpreted from aerial photos and vegetation mapping. A GIS layer of these fire perimeter data was used to determine the spatial extent of the 1910 fires in the St. Regis watershed (**Figure L-2**). Forty three percent (just less than 100,000 acres) of the St. Regis watershed burned in the 1910 fires (**Table L-2 and Table L-3**). The 1910 fires in this region were primarily high severity, stand replacing fires. For the purpose of this study, we assumed that 90% of the vegetation in the burned area was completely consumed. Ninety percent crown removal is equal to clear cutting 96% of the area. The ECA for the1910 burned area is then 96% of the 43%, or about 95,000 acres. As of 2003 most (97%) of the area burned by the 1910 fires has recovered.

Table L-2. Water Yield Increase from the Clear-Cut Corridor Associated With the Road Network

Assumes 35-foot road width for all roads and 100% residual clear-cut area for model year 2003									
Tributary	Effective ECA (acres)	Percent of HUC 6	Runoff Depth (ft)	Runoff Volume (acre feet)	Average Elevation (feet)	Runoff increase factor	Runoff Increase (acre feet)	Mean Annual Runoff (ac-ft/year)	Percent Water Yield Increase
Big	402	1.7	2.1	844	4708	0.405	342	50855	0.7
Deer	156	1.4	2.1	327	4951	0.390	128	20106	0.6
Little Joe	460	1.7	2.1	967	4833	0.400	387	44942	0.9
Lower St. Regis	585	2.4	1.9	1112	3959	0.440	489	21288	2.3
Packer	131	1.1	1.9	249	4644	0.400	100	23654	0.4
Savenac	77	0.7	1.2	93	4559	0.420	39	27202	0.1
Silver Timber	324	1.7	1.8	582	4310	0.430	250	70961	0.4
Twelvemile	863	2.2	1.9	1639	4466	0.420	688	35480	1.9
Twin	246	1.9	1.5	369	4168	0.435	161	48490	0.3
Twomile	285	2.6	2.1	598	4604	0.410	245	44942	0.5
Upper St. Regis	493	1.9	2.5	1233	4802	0.400	493	20106	2.5
Ward	348	2.4	2.1	731	4799	0.400	293	20106	1.5
St. Regis River	4370	1.9			4567	0.420	3614	429312	0.8

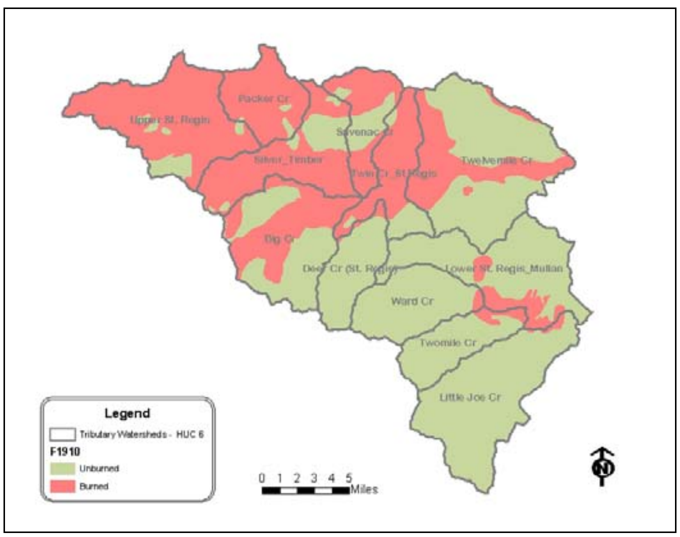

Figure L-2. Mapped Extent of the 1910 Fires in the St. Regis Watershed

Table L-3. Fire History (1910) Statistics for the St. Regis Watershed

	Acres Burned (1910)	Percent Area Burned
Upper St. Regis	23869	90
Packer Creek	11188	96
Silver Timber	15603	80
Big Creek	11955	49
Savenac Creek	7334	69

Table L-3. Fire History (1910) Statistics for the St. Regis Watershed

	Acres Burned (1910)	Percent Area Burned
Deer Creek	573	5
Twin Creek	9835	77
Twelvemile Creek	12515	33
Ward Creek	415	3
Twomile Creek	1108	10
Little Joe Creek	454	2
Lower St. Regis_Mullan	3889	16
St. Regis HUC 5	98739	43

Other fires have occurred in the St. Regis watershed during the 20th century (**Figure L-3**). The next largest fire year occurred in 1919, burning primarily in Big Creek and Lower St. Regis-Mullan. Another large fire burned in Big Creek in 1924. Recurring fires would "re-set" the vegetation recovery and cause an increase in water yield. The magnitude of the increase would depend on the vegetation removed (re-growth from the previous fire) and the intensity and severity of the fire (how much crown is removed). The effects of these fires on water yield were not analyzed.

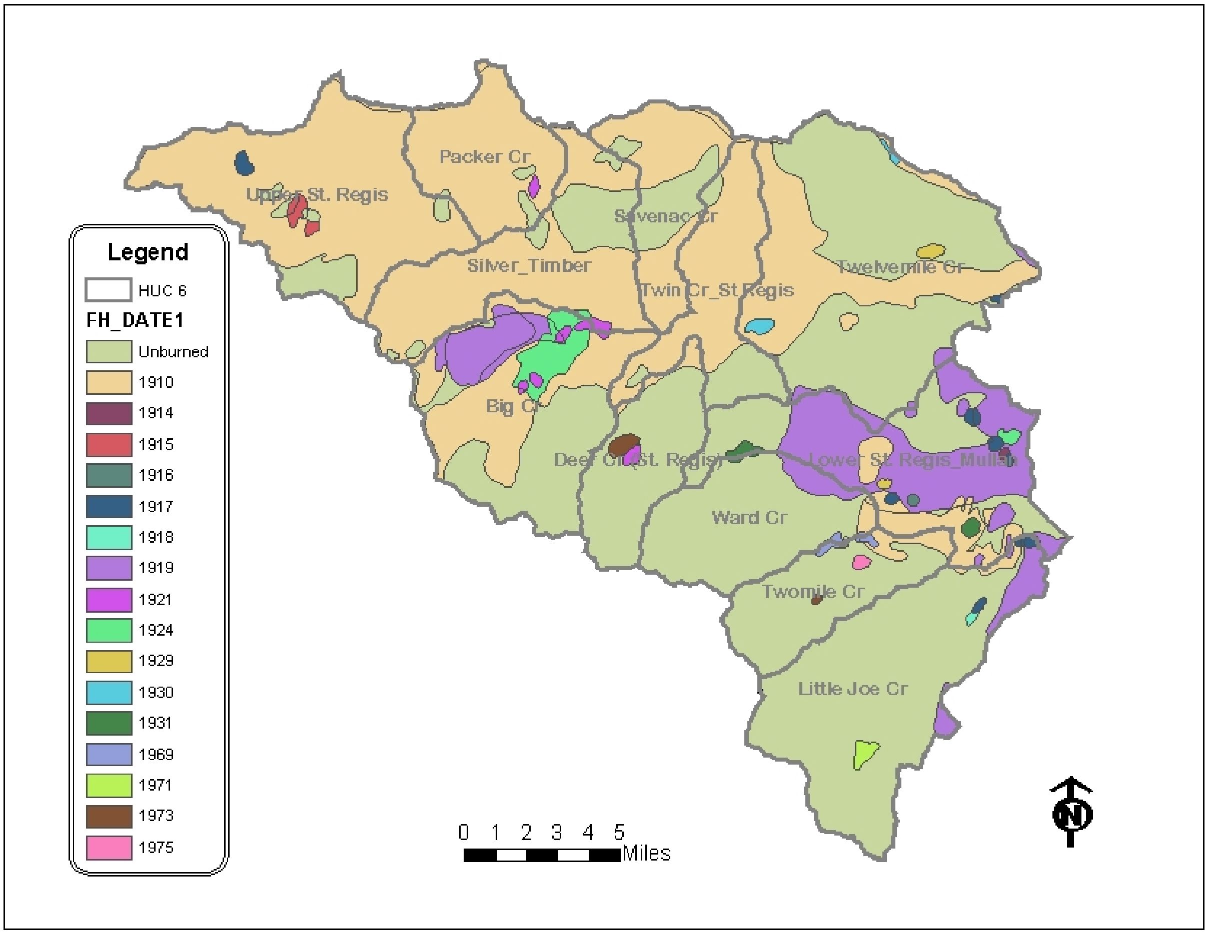

Figure L-3. Twentieth-Century Fires in the St. Regis Watershed
Not all-inclusive.

Discussion

Pfankuch (1973) established the general rule that streams on the Lolo National Forest can, on average, sustain a 10% increase in water yield, in part due to the potential impacts from increased peak flows associated with increased water yields. Pfankuch's water yield increase limit for highly erosive drainages and streams in poor condition is less (~8%) and for drainages with stable soils and geology, and excellent stream conditions, the water yield limit is greater (~10-15%).

Assuming that the St. Regis River and its tributaries in 1910 were not in excellent condition because of the impacts from frontier development including railroad construction, but were also not in poor condition based on the level of development relative to current development. Water yield increase from the fires exceeded the 10% threshold for all tributaries, except for Deer, Ward, Twomile, and Little Joe (**Figure L-4**). For the entire St. Regis River water yield increased by 18.5% immediately after the fires. Not until the 1920's did water yield increase from the fires drop below the 10% increase threshold for the whole St. Regis watershed.

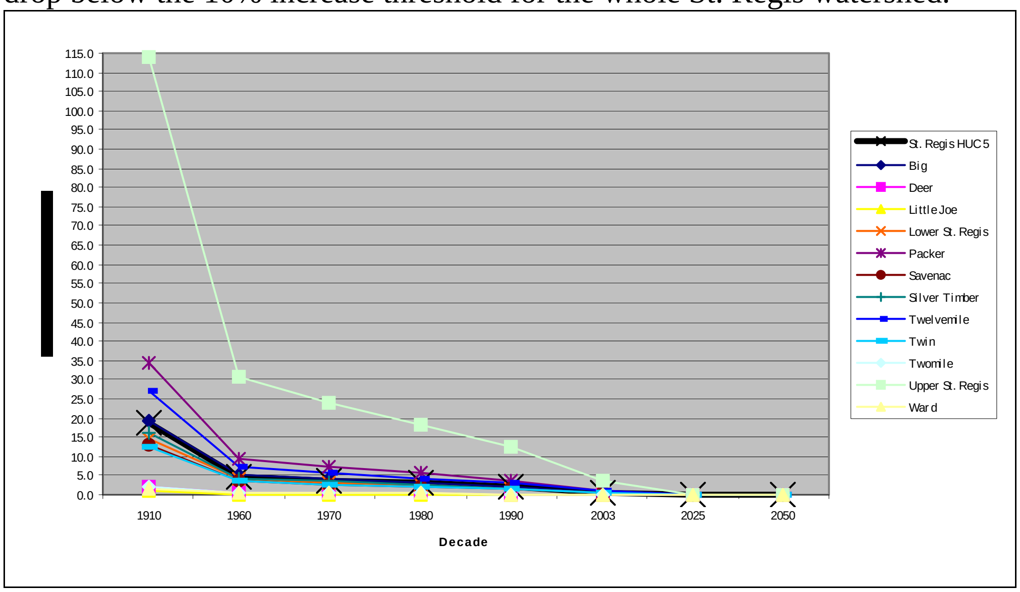

Figure L-4. Water Yield Increase from 1910 Fires

If it were assumed that stream conditions in 1910 were excellent, the water yield effects of the fires in Packer, Twelvemile, Silver-Timber, and Big Creek exceeded the 15% threshold, and exceeded 12% in Lower St. Regis, Savenac, and Twin.

The impacts of vegetation loss on water yield due to the 1910 fires in many of the tributary drainages to the St. Regis River had the potential for tremendous geomorphic effects, more so than the water yield impacts from timber harvest history on the National Forest. Water yield increase from timber harvest on National Forest land has approached the poor stream condition threshold (8%) in one tributary. Lower St. Regis had just less than 8% water yield increase, which peaked in the 1990s. Ward Creek in the 1980s peaked at 6.5% increase and Twelvemile peaked in the 1990s at 6.25% increase. All other tributaries have had water yield increase peaks less than 5% from timber harvest on the National Forest.

Combining effects of documented timber harvest and the 1910 fires, four tributary watersheds had greater than 8-10% water yield increases: Upper St. Regis, Packer, Twelvemile, and Lower St. Regis (**Figure L-5**). Big Creek and Little Joe rose above 5%, Big in the 1970s and Little Joe in the 1980s. All other tributary watersheds remained below 5% water yield increase from the combined impacts of harvest and fire, including the whole St. Regis River. Water yield increase from clear cutting of the road corridor is greater for watersheds with more roads, but small for all watersheds when compared to the effect of harvested stands or burned areas.

Other activities affecting water yield were not analyzed. Clearing for residential subdivision and business development are other likely contributors to increased water yield.

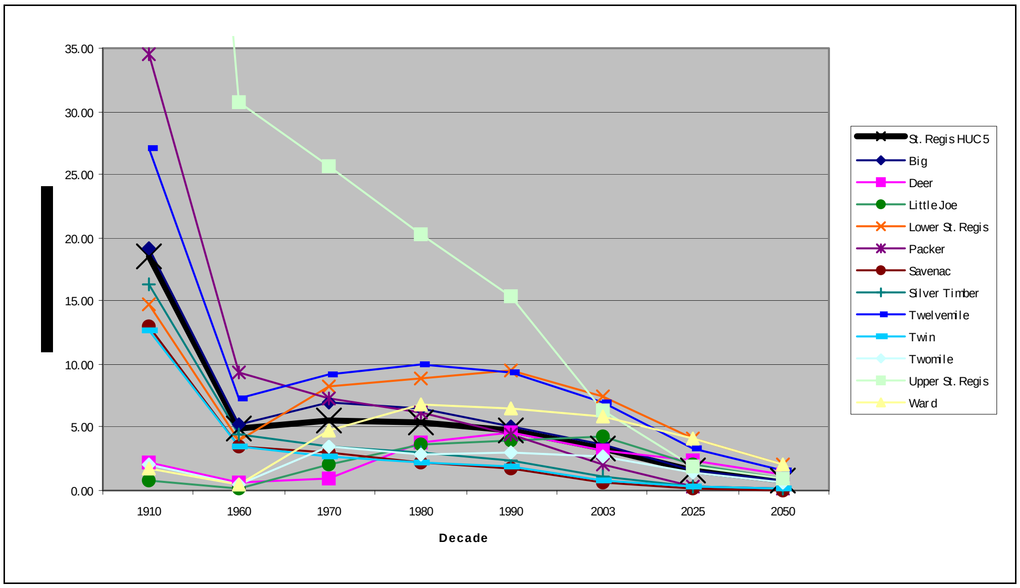

Figure L-5. Combined Water Yield Increase from Timber Harvest and 1910 Fires

Based on this analysis of water yield increases, the effects of National Forest timber harvest activity alone have not likely been detrimental to the St. Regis River or its tributary streams. Stream impacts from water yield increases were likely the result of the 1910 fires. Water yield increases from the 1910 fires in combination with water yield increased due to National Forest harvest activity are not significantly greater than the effects of either activity (harvest or fire) alone because of the temporal disparity of the two activities.

High severity fires such as the 1910 fires in the St. Regis watershed are not unusual or unnatural. Still, streams within heavily burned drainages recover over time; otherwise watershed effects due to a large fire at some period in history would permanently impact most streams. However, the effects of the 1910 and other fires on channel morphology may persist today, in part due to activities that have further reduced and in many cases continue to reduce the stability of vulnerable stream channels attempting to recover from fire-induced water yield impacts. These activities include road encroachment, alteration by development of transportation corridors, and other activities such as timber harvest, particularly timber harvest or other clearing within riparian areas.

Water yield increase values provided in this report are modeled approximations for the increase in runoff volume from vegetation removal. These values do not account for the effect the road system has on routing water and changes to the hydrograph. We do not currently have a way to model these latter effects, although research has shown that such effects are real (Wemple and Jones 2003).

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Pfankuch, D. 1973. Vegetation manipulation guidelines for the Lolo National Forest; a revision and updating of the October 1967 procedures. USDA Forest Service. Lolo National Forest. April, 1973. 69 p.

USDA Forest Service, 1978. Forest hydrology: hydrologic effects of vegetation manipulation, Part II.

Wemple, B.C. and J.A. Jones. 2003. Runoff production on forest roads in a steep, mountain catchment. Water Resources Research 39(8), 1220, doi:10.1029/2002WR001744, 2003.

APPENDIX M
STREAM CHANNELIZATION AND ENCROACHMENT

Prepared by Lolo National Forest

Introduction

Two railroad grades, a local highway, and Interstate 90 confine the St. Regis River along both sides. Construction of these transportation facilities over the last 100 years has established the valley bottom of the St. Regis watershed as a major transportation corridor. The development of the transportation corridor began with the building of a military road between Fort Walla Walla in Washington and Fort Benton in Montana. In his 1863 report, Captain John Mullan chronicles the reconnaissance and construction effort he led to establish this route (Mullan 1863). The historic Mullan Trail today exists in remnant sections in Mullan Creek, East Fork of Twelvemile Creek, and the St. Regis valley bottom and low hillslopes up to Lookout Pass and is not affecting encroachment and channelization of the St. Regis River.

The presence of the Mullan Trail through the St. Regis watershed set the stage for additional transportation routes to follow. The Milwaukee Railroad, also known as the Route of the Hiawatha, was opened in 1909. In the St. Regis watershed, the Milwaukee is located on the south side of the St. Regis River from the town of St. Regis, extending up the watershed low on the southern valley wall and valley bottom, and eventually leaving its proximity to the St. Regis River near Saltese, climbing up to the St. Paul Tunnel from Taft along Rainy Creek. The old Northern Pacific Railroad grade extends up the valley on the north side of the river. At the Taft exit, the old Northern Pacific grade remains close to the river, and continues up the drainage, crossing the mountains near Lookout Pass. Remnant segments of old State Highway 10 can be found adjacent to the St. Regis River. Conversion of State Highway 10 into Interstate Highway 90 began in the 1960’s, and was completed in the1980’s. All major tributaries to the St. Regis River also contain at least one road up their respective valley bottoms.

The development of the St. Regis valley as a major transportation corridor has resulted in shortening, straightening, and overall channelization of the river, loss of floodplain, and destruction of most of the riparian area. Low sinuosity, riffle dominated reaches, and lack of fish habitat quality, quantity, and variety characterize the St. Regis River. Transportation facilities have cut off stream meanders, removed large woody debris, and eliminated large woody debris recruitment resulting in a lack of high quality pools for fish habitat (Hendrickson 2000). Channelization has disconnected the river from its meanders and floodplain, eliminating renewal of the riparian area and the energy dissipating function of the meanders and floodplain. As a result, increased water velocities have caused incision of the stream channel and increased the transport capacity of the stream, increasing the channel substrate particle size. Bank armoring in the form of riprap has been installed along the banks for much of the river length to protect the transportation facilities from the increased velocities of the confined stream.

Three methods were used to quantify the length of stream encroached, length of banks riprapped, and/or length of channel otherwise altered within the Lolo National Forest boundary. These methods include GIS spatial analysis, air photo interpretation, and field measurements.

Methods

GIS Analysis – Roads & Streams
The 2000 Bull Trout baseline Section 7 Consultation study (Hendrickson 2000) examined road-watershed and road-stream relationships by HUC 6 using spatial analysis of GIS data including road and stream layers. Among the parameters evaluated was road density (length of road per area of land). Road density provides a metric for the degree of “roadedness” or development in a watershed. Watersheds with a greater road density have decreased capability of supporting strong populations of key salmonids (USDA Forest Service 1996). Road density for the St. Regis River watershed and its tributary watersheds were evaluated.

Among the other parameters evaluated by Hendrickson, 2000 was the length of stream with roads within 300’ and 125’. Roads within these stream buffers impact sediment delivery potential and large woody debris recruitment potential.

The 300’ buffer was used based on a review of a large body of research on sediment delivery distances (Belt, et al. 1992). The review concluded that sediment within 300’ of a water body has the potential to be delivered to the water body despite the presence of vegetation buffers. Roads are a source of sediment, and when constructed in riparian areas their proximity to a water body increases the likelihood of that sediment being delivered to the water body. Additionally, roads within 300’ of a stream generally hinder the attainment of the INFISH Riparian Management Objective, RMO, which partially delineates the Riparian Habitat Conservation Area (RHCA) with a 300’ buffer from perennial, fish-bearing streams (USDA Forest Service1995).

The 125’ buffer was used based on the average maximum height of the tree species most commonly found in riparian areas on the Lolo National Forest. Potential large woody debris recruitment is considered in terms of site potential tree height. In the region of the Lolo National Forest, mature trees within 125’ of a stream have the potential of falling into the stream, and thus being recruited as large woody debris. Roads within 125’ of streams preclude the growth of trees within the road template (often from top of cut slope to toe of the fill slope), decreasing the density of trees in the riparian area, and thus precluding the number of trees available for large woody debris recruitment.

GIS Analysis – Canopy Cover & Stream Shading
Stream shading and temperature are affected similarly. As roads preclude tree growth and reduce tree density in riparian areas, the ability of the riparian area to shade the stream and buffer stream temperature changes is also diminished. Percent canopy cover estimates were derived from satellite imagery using GIS spatial analysis. Percent canopy cover was broken out into classes: not mapped, low (20-40% cover), moderate (40-70% cover), and high (70-100% cover). Length of bank (including both right and left banks separately) in each canopy cover class was summarized for the St. Regis mainstem and many of its tributaries.

Air Photo Interpretation
Channel alterations and bank riprap were inventoried using year 2000, 1:15,840 scale color aerial photos. Length of apparent channel alterations and of apparent bank riprap was measured using a

digital planimeter. Observations were made for the mainstems of tributaries to the St. Regis River, mostly in the low valley bottoms where canopy cover and topography allow for visual inspection of these parameters from an aerial view at this scale. Observation of channel alteration and riprap in the mid- and upper-elevation valley bottoms is not possible from aerial photos due to dense canopy cover and valley walls. Length of stream bank armored with riprap, and length of altered stream channel were summarized by HUC 6 tributary.

Field Measurements

Field measurements were taken in 2002 to compare the channel bed elevations of the existing St. Regis River and adjacent cut off meanders. A Spectra Precision Laserplane Leveling System was used to acquire relative elevation measurements at three sites near Lolo National Forest stream survey site # 11 above Saltese. Elevation differences between the current channel of the St. Regis River and adjacent cutoff meanders were also collected in this vicinity as part of a relocation and restoration feasibility study which was contracted to a consulting firm by the Lolo National Forest in 1996 (Land & Water Consulting, Inc. 1996). Measured elevation differences from these two studies suggest the degree of incision that has occurred as a result of channel straightening, loss of channel length, and loss of ability to dissipate energy.

Results

GIS Analysis – Roads & Streams

The USDA Forest Service classified road density in examining the characteristics of aquatic/riparian ecosystems in the Columbia River Basin (CRB) (1996, **Table M-1**). Watersheds with greater than 4.7 mi/mi^2 have an "Extremely High" road density. "Very Low" road density is defined by 0.02 to 0.1 mi/mi^2.

The CRB study found that, as road density in a watershed increases, the ability of the watershed to support strong populations of key salmonids is diminished. The effect is more pronounced when all land management types are considered, and less pronounced when only National Forest lands are considered. For all lands, about 8% of watersheds with "High" road density supported strong salmonids populations, whereas, for National Forest lands, 22% of watersheds with "High" road density supported strong salmonids populations (**Figure M-1**).

GIS analysis of road density by HUC 6 (Hendrickson 2000) reveals 90% of the St. Regis watershed has a "High" road density. Only the Savenac Creek HUC 6 has a road density below the "High" classification, with a density of 1.1 mi/mi^2, "Moderate**,"** although most roads in Savenac Creek are concentrated in the lower third of the watershed, while the upper two-thirds are unroaded. Packer Creek is borderline "Moderate-High" with a road density of 1.7 mi/mi^2. Total road density for the entire St. Regis watershed is 2.8 mi/mi^2, "High**."**

Table M-1. Road Density Classification (USDA Forest Service, 1996)

Classification	Road Density (mi/mi^2)
Extremely High	> 4.7
High	1.7 - 4.7
Moderate	0.7 - 1.7
Low	0.1 - 0.7
Very Low	0.02 - 0.1

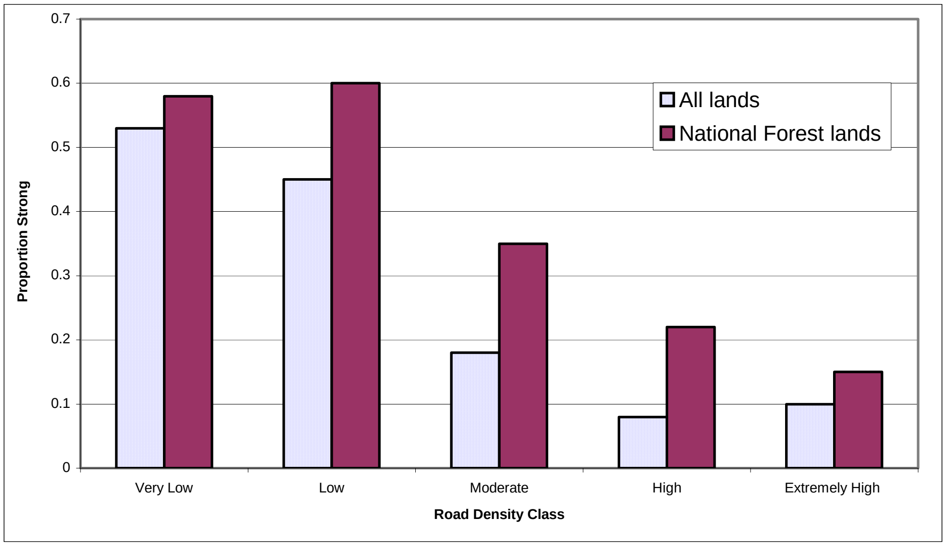

Figure M-1. Relationship between Road Density and Watershed Ability to Support Strong Populations of Key Salmonids (adapted from USDA Forest Service, 1996)

Stream density (length of stream/area of land) was calculated using Hendrickson's results (2000). When comparing stream density to road density, all HUC 6 watersheds, except Savenac and Packer, have more length of road per square mile than length of stream (**Table M-2**).

Another way to examine stream or road density is to calculate and compare the average distance (Ad) between streams and between roads using the equation: **Ad = ½ (1/D)**, where D is density, the length of stream or road/area of land. In Twomile Creek, for example, where Ds (stream density) is 2.3 mi/mi^2, Ad between streams (Ads) is 0.217 miles, and where Dr (road density) is 3.9 mi/mi^2, Ad between roads (Adr) is 0.128 miles:

Ads	= ½ (1/2.3)	Adr	= ½ (1/3.9)
	= ½ (0.435)		= ½ (0.256)
	= 0.217		= 0.128

This means that on average, a raindrop falling on the ground (assuming overland flow conditions) has almost twice as far to travel to get to a stream (1146 feet) as to a road (677 feet).

Research shows that roads interact with surface and subsurface flow of water over hillslopes. This interaction may affect the hydrologic response of a watershed, including the timing and magnitude of the hydrograph. Wemple and Jones (2003) found that depending on the nature of storm events, watershed characteristics, and road segment attributes, storm flow response may be more rapid and have greater peaks because of the interaction roads have on hillslope flow.

Analysis of stream length encroached upon by roads within 300' and 125' shows that 33% of stream lengths in the St. Regis Watershed are encroached by roads within 300' of those streams, and 15% are encroached by roads within 125'. Nine out of twelve of the HUC 6 tributary watersheds to the St. Regis have greater than 30% of their streams' length encroached upon by roads within 300’. Packer and Savenac Creeks have the least length of stream encroached by roads within 300’, 26.2% and 15.2% respectively. Twin Creek is also relatively low (<30%) with 26.9% and 13.5% for 300’ and 125’ buffers respectively.

Table M-2 Road-Stream and Road-Watershed Relationships Characterized in Bull Trout Baseline Section 7 Consultation Study
(Hendrickson 2000). (Table adapted from Hendrickson, 2000).

HUC 6 No.	HUC Name	Area (miles^2)	Stream Length (miles)	Road Density (miles/ mile^2)	% Stream with Road w/in 300' of Stream	% Stream with Road w/in 125'	*Stream density
10	Twomile Cr	17.2	39.3	3.9	32.0	9.5	2.3
12	Lower St. Regis_Mullan +	38.3	100.1	3.6	37.3	19.8	2.6
9	Ward Cr	22.8	36.4	3.6	31.9	12.5	1.6
8	Twelvemile Cr +	59.8	157.6	3.4	34.0	15.6	2.6
7	Twin Cr_St Regis	20.0	45.0	2.9	26.9	13.5	2.3
1	Upper St. Regis +	41.5	81.2	2.8	37.8	20.6	2.0
3	Silver_Timber	30.5	65.4	2.5	30.7	14.6	2.2
11	Little Joe Cr +	43.4	103.5	2.5	36.8	18.9	2.4
4	Big Cr +	37.9	61.6	2.5	36.6	12.8	1.6
6	Deer Cr (St. Regis)	16.7	27.5	2.2	35.2	9.7	1.6
2	Packer Cr	18.2	40.8	1.7	26.2	10.6	2.2
5	Savenac Cr	16.6	41.9	1.1	15.2	6.3	2.5
	Total	363.0	800.0	2.8	265.4	122.1	

*Not part of Hendrickson, 2000 analysis. + On 2002 303(d) list.

Road density alone is not a good indicator of stream condition. Ward Creek and Twomile Creek have very high road densities, but fully support beneficial uses (Montana DEQ 2002). The percent stream length with road within 125’ seems to be a better indicator of stream condition. All of the impaired streams, except Big Creek, have greater than 15% of stream length within 125’. However, only the mainstem of Big Creek is listed as impaired. Considering just this segment, greater than 15% of Big Creek mainstem is within 125’ of road.

GIS Analysis – Canopy Cover & Stream Shading

Canopy cover analysis reveals that in general stream segments on the 2002 303(d) list have the lowest proportion of the “High” percent canopy cover class. These segments with less than 25% of stream length under High percent canopy cover include: Twelvemile, East Fork Big Creek, Big Creek mainstem, Little Joe mainstem, North Fork Little Joe, and St. Regis River. All of these tributaries, except East Fork Big Creek are on the 2002 303 (d) list. Of the stream segments not on the 303(d) list, the proportion of stream with High percent canopy cover class ranges from 31% for West Fork Big Creek to 64% for Deer Creek (**Figure M-2, Table M-3**).

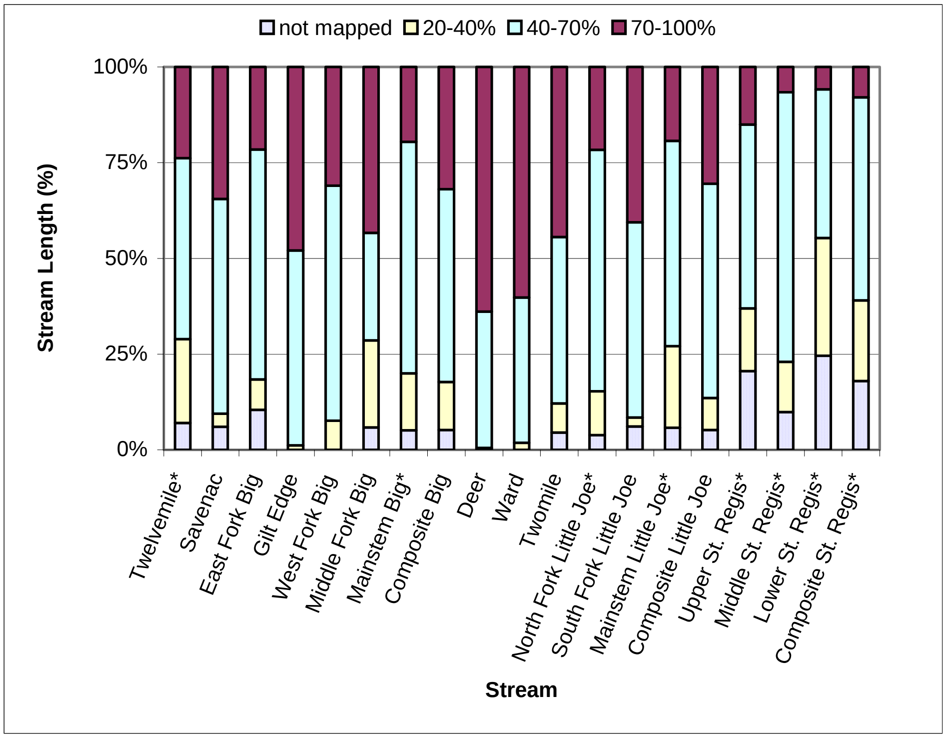

Figure M-2. Percent Canopy Cover for Streams in St. Regis watershed

Table M-3. Percent Canopy Cover for Stream Reaches in the St. Regis Watershed

Stream/Reach	**Percent Canopy Cover**			
	Not Mapped	20-40%	40-70%	70-100%
Twelvemile Creek*				
	7	22	47	24
Savenac Creek				
	6	3	56	35
Big Creek*				
Composite	5	12	50	32
East Fork	10	8	60	22
Gilt Edge	0	1	51	48
West Fork	0	8	61	31
Middle Fork	6	23	28	43
Mainstem*	5	15	61	20
Deer Creek				
	0	1	36	64
WardCreek				
	0	2	38	60
Twomile Creek				
	5	8	43	44
Little Joe Creek				
Composite	5	8	56	30
North Fork*	4	11	63	22
South Fork	6	2	51	41
Mainstem*	6	21	54	19

Table M-3. Percent Canopy Cover for Stream Reaches in the St. Regis Watershed

Stream/Reach	Percent Canopy Cover			
	Not Mapped	20-40%	40-70%	70-100%
St. Regis*				
Composite	18	21	53	8
Upper	21	16	48	15
Middle	10	13	70	7
Lower	25	31	39	6

*Streams on 2006 303(d) list.

Air Photo Interpretation

None of the tributary stream reaches examined are without some type of channel alteration and/or bank riprap. Length of channel affected ranges from 0.78 miles in Twelvemile Creek, followed by 0.44 miles of Big Creek, to between 0.02 and 0.05 miles for the other reaches examined. Most of the riprap sections observed are associated with road encroachment (**Table M-4**).

Table M-4. Length of Riprapped Bank and Altered Channel (feet)

HUC 6 Tributary		Non-FS	FS	Total
Twelvemile Creek				
	Rip Rap	567		567
	Channel Alteration	2752	815	3567
	Total	3319	815	4134
Big Creek Mainstem				
	Rip Rap	1540	410	1950
	Channel Alteration	265	90	355
	Total	1805	500	2305
East Fork Big Creek				
	Rip Rap		80	80
	Channel Alteration		40	40
	Total		120	120
Middle Fork Big Creek				
	Rip Rap		70	70
	Channel Alteration		95	95
	Total		165	165
West Fork Big Creek				
	Rip Rap		200	200
	Channel Alteration		200	200
	Total		200*	200*
Little Joe Creek				
	Rip Rap		236	236
	Channel Alteration			
	Total		236	236
South Fork Little Joe Creek				
	Rip Rap		173	173
	Channel Alteration		1169+	1169+

Table M-4. Length of Riprapped Bank and Altered Channel (feet)

HUC 6 Tributary		Non-FS	FS	Total
	Total		1342	1342
North Fork Little Joe Creek				
	Rip Rap		180	180
	Channel Alteration			
	Total		180	180
Savenac Creek				
	Rip Rap	168	2100	2268
	Channel Alteration		3352	3352
	Total	168	5452	5620
Twomile Creek				
	Rip Rap			
	Channel Alteration		500	500
	Total		500	500

*Single stretch of 200 feet has been both rip rapped and altered. +Little Joe Slide

Field Measurements

Measured differences between bed elevation of cut off meanders and bed elevation of adjacent St. Regis River segments suggest that six to eight feet of channel incision has occurred. This drop in bed elevation is likely the result of increased stream power due to channel shortening and straightening (**Table M-5**).

Table M-5. Difference Between Cutoff Meander Bed Elevation and St. Regis River Bed Elevation

Site	Elevation Difference (feet)
1	7.93
2	7.35
3	6.46

The feasibility study by Land & Water Consulting, Inc. (1996) found incision of the current channel bed ranging from 4-5 feet to 6-12 feet below the elevation of adjacent cutoff meanders. The reach of stream studied was shortened from the original meander pattern to the current straightened channel by approximately 1500 feet, or about 25%.

Discussion

Analyses of stream alterations including channelization, riprap and encroachment by roads using three methods described above, GIS analysis, air photo interpretation and field measurements, support the listing of the St. Regis River and many of its tributaries as 303(d) listed streams. This study found:

- One third of all stream length in the St. Regis River watershed is within sediment contributing distance of roads.
- 15% of stream length has diminished ability to recruit large woody debris because of road proximity.

- Almost all of the St. Regis watershed and its tributary watersheds have a High (1.7-4.7 mi/mi2) road density, and therefore, very likely a diminished ability to support strong populations of key salmonids, the ability to support the Beneficial Use of cold water trout fishery.
- All major tributary stream reaches examined have some length of altered channel and/or riprapped stream bank. Twelvemile Creek and Big Creek have the greatest length of channel/bank altered and/or riprapped bank, with 0.78 and 0.44 miles respectively.
- Current elevation of St. Regis River bed in some sections is 4 -12 feet lower than the bed elevation of the St. Regis River in its meander pattern prior to meander cutoff and channel confinement by transportation development.

Many of these findings are consistent with the identification of habitat and sediment related impairment conditions in this drainage. The location of roads relative to streams and the overall length of riprapped bank and altered channel appear to be good indicators of impairment conditions/lack of beneficial use support. Streams with the least amount of riparian canopy cover, with the greatest extent of channel alterations, and with the largest percent of stream length with a road within 125 feet tend to be impaired. Roads near streams contribute to the loss of canopy cover and overall stream protection, and often promote the need for channel alterations to protect transportation infrastructure. Road density is another factor often considered to be a good indicator of impairment conditions. In the St. Regis watershed however, this does not appear to be the case. For example, Deer Creek, Ward Creek, and lower Savenac Creek have relatively high road densities, but all are identified as supporting water quality standards. It appears that streams in the St. Regis watershed with healthy, mature riparian cover, lack of road encroachment, and few or no channel alterations, are less susceptible to some of the impacts associated with road density.

Water quality planning and TMDL development must account for the impacts roads have on impaired streams. These impacts include increased erosion and transport capacity of the stream as a result of road-related near-stream alterations and other alterations. For example, gross changes in the hydrology of the St. Regis River as a result of confinement, shortening, straightening, and armoring, have increased overall stream gradient and increased its competence and capacity, causing down cutting, incision, and a lowering of the base level. While increased stream capacity has caused accelerated bank erosion in some locations, many other locations have been armored so that sediment supply from natural bank erosion has been eliminated.

Unfortunately, some of the impacts from roads cannot be easily mitigated or the causing factors cannot be significantly removed or reduced (as with the Interstate Highway). Also, road BMP's typically designed to reduce sediment inputs from the surface and cut/fill slopes of roads are not generally adequate to mitigate the types of impacts associated with encroachment and overall confinement caused by roads. Rerouting or total closure of an encroaching road or road segment is one option that can be considered to resolve some of the encroachment impacts from roads, but such efforts may not be practical in all cases.

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APPENDIX N
DAILY SEDIMENT TMDLS

Introduction

Originally, sediment loads for the St. Regis watershed were calculated and applied as average annual sediment yields which is logically sound for this watershed for a few reasons. Because there are no point sources that can alter their load daily and all significant sources are nonpoint source runoff driven, annual loads are appropriate. Also, more importantly, observed affects upon uses are from accumulative, long term sediment loading. Determining a daily allowable sediment load rate is difficult because of naturally dynamic sediment transport conditions in this region. Including daily loads and daily allocations for all TMDLs is a recent requirement by EPA that the original scope of this TMDL project did not consider. This appendix provides an **estimate** of allowable daily sediment loads and allocations. The analysis for providing the daily loads is limited because of project time constraints, the types of sources in the watershed, the validity of using annual load limits to protect the uses, and the **recent** change in EPA requirements.

Methods and Application

The annual sediment loads described in the sediment source assessments (Section 7) are used as a primary basis for determining daily sediment loads for listed streams in the St. Regis TPA. A more detailed daily sediment loading estimate using SWAT model outputs from the Middle Blackfoot TPA is used to divide the estimated yearly sediment loads found in the St. Regis TPA into daily loads. Two comparable subwatersheds in the Middle Blackfoot TPA were used to extrapolate daily loads to the St. Regis watershed. The average SWAT daily loading results from Dunum and Monture Creek Watersheds over a 9 year model run were converted to percent of the average annual load estimated by the SWAT model for a given Julian day (**Figure N-1**). The maximum allowable annual sediment yields and annual allocations from the St. Regis TPA were portioned out into estimated daily loads and allocations using a percentage slightly above daily percentage of the annual sediment budget from the two watersheds in the Blackfoot TPA. Although the daily loads would add up to more than 100% of the annual loading in the main St. Regis TMDL document, the average annual sediment TMDLs should not be exceeded. In essence, loading on any one given day is less of an issue than the long term sediment load in the St. Regis Watershed since uses are affected by long term sediment conditions, not acute conditions.

The allocations are carried evenly as the percent reduction, which is provided in the main document, for every day of the year in these daily allocations. In fact, it may not be a reasonable option to reduce sediment loads during low flow or non-runoff timeframes for many of the human-caused, nonpoint sources. Many of the human caused source categories could make most of their loading reductions during storm or snowmelt runoff. Sediment sources in the St. Regis watershed are contributing sediment production almost exclusively during runoff timeframes. Therefore, do not take these daily loads as an absolute condition that must be met on any one given day since sediment production in a watershed is episodic and sources are also episodic.

The following sections will review the daily loads and daily allocations by sediment listed waterbody. Daily loading and allocation tables are provided in **Attachment N-1** of this appendix.

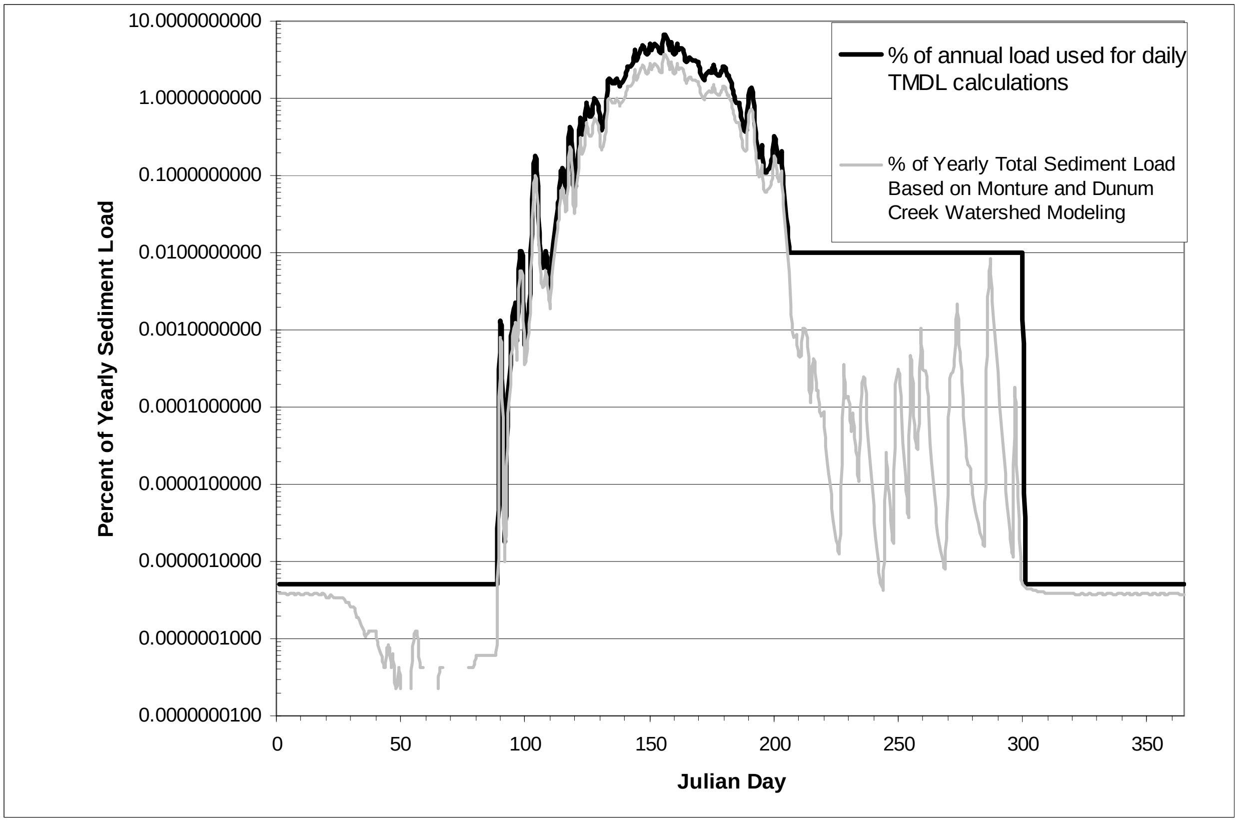

Figure N-1. Percent of Average Annual Sediment Load by Julian Day Used For Deriving Daily Allocations in the St. Regis Watershed

ATTACHMENT N-1. DAILY SEDIMENT LOADS

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
1	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
2	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
3	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
4	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
5	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
6	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
7	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
8	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
9	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
10	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
11	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
12	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
13	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
14	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
15	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
16	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
17	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
18	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
19	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
20	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
21	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
22	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
23	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
24	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
25	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
26	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
27	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
28	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
29	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
30	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
31	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
32	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
33	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
34	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
35	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
36	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
37	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
38	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
39	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
40	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
41	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
42	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
43	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
44	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
45	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
46	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
47	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
48	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
49	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
50	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
51	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
52	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
53	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
54	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
55	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
56	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
57	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
58	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
59	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
60	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
61	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
62	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
63	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
64	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
65	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
66	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
67	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
68	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
69	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
70	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
71	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
72	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
73	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
74	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
75	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
76	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
77	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
78	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
79	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
80	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
81	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
82	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
83	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
84	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
85	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
86	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
87	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
88	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
89	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
90	0.258214	0.208919	0.169013	0.352110	6.408403	7.396659
91	0.009471	0.007663	0.006199	0.012915	0.235044	0.271291
92	0.000388	0.000314	0.000254	0.000529	0.009629	0.011114
93	0.018779	0.015194	0.012292	0.025608	0.466071	0.537946
94	0.105515	0.085371	0.069064	0.143884	2.618683	3.022516

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
95	0.265200	0.214571	0.173586	0.361637	6.581789	7.596783
96	0.486665	0.393756	0.318544	0.663634	12.078130	13.940728
97	0.171309	0.138605	0.112130	0.233603	4.251584	4.907231
98	2.314060	1.872285	1.514657	3.155536	57.430756	66.287294
99	2.005061	1.622276	1.312403	2.734174	49.761958	57.435872
100	0.150183	0.121511	0.098301	0.204795	3.727261	4.302051
101	0.288638	0.233535	0.188927	0.393598	7.163476	8.268174
102	0.927545	0.750468	0.607120	1.264834	23.019977	26.569944
103	6.264496	5.068547	4.100398	8.542495	155.473412	179.449349
104	39.435704	31.907069	25.812461	53.775960	978.722467	1129.653661
105	11.283309	9.129223	7.385439	15.386330	280.031214	323.215514
106	4.040455	3.269095	2.644661	5.509711	100.276738	115.740660
107	1.423159	1.151465	0.931522	1.940672	35.320228	40.767047
108	2.291834	1.854302	1.500110	3.125228	56.879158	65.650633
109	1.955522	1.582195	1.279978	2.666620	48.532490	56.016805
110	0.759137	0.614211	0.496890	1.035187	18.840403	21.745828
111	1.908714	1.544323	1.249340	2.602792	47.370810	54.675978
112	4.079551	3.300728	2.670252	5.563024	101.247043	116.860598
113	8.089830	6.545408	5.295161	11.031586	200.774863	231.736847
114	12.089360	9.781391	7.913036	16.485491	300.035931	346.305208
115	27.213147	22.017910	17.812242	37.108837	675.380835	779.532971
116	13.159037	10.646858	8.613188	17.944142	326.583383	376.946608
117	14.318262	11.584775	9.371953	19.524902	355.353225	410.153118
118	92.278690	74.661849	60.400597	125.834578	2290.189312	2643.365026
119	28.499491	23.058679	18.654212	38.862942	707.305538	816.380861
120	12.627441	10.216748	8.265234	17.219238	313.390133	361.718795
121	36.539898	29.564099	23.917024	49.827134	906.853837	1046.701993
122	124.534068	100.759382	81.513208	169.819183	3090.709136	3567.334977
123	75.187556	60.833568	49.213673	102.528486	1866.018441	2153.781724
124	99.814552	80.759047	65.333161	136.110753	2477.215698	2859.233211
125	191.675291	155.082735	125.460190	261.375396	4757.032210	5490.625822
126	129.385144	104.684343	84.688458	176.434287	3211.104017	3706.296248

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
127	141.015859	114.094650	92.301290	192.294354	3499.757234	4039.463386
128	224.511795	181.650452	146.953175	306.152447	5571.974537	6431.242405
129	188.129429	152.213810	123.139262	256.540130	4669.030366	5389.052998
130	117.259605	94.873681	76.751742	159.899462	2910.170202	3358.954691
131	84.350939	68.247578	55.211524	115.024008	2093.436938	2416.270986
132	114.732794	92.829260	75.097829	156.453810	2847.459336	3286.573029
133	338.508659	273.884278	221.569304	461.602716	8401.169439	9696.734397
134	394.605160	319.271447	258.287014	538.097945	9793.382599	11303.644165
135	352.674573	285.345791	230.841539	480.919872	8752.741672	10102.523446
136	344.942880	279.090148	225.780794	470.376655	8560.855113	9881.045591
137	387.973853	313.906117	253.946522	529.055253	9628.805612	11113.687357
138	318.194445	257.448233	208.272727	433.901515	7897.007582	9114.824502
139	343.002844	277.520483	224.510953	467.731151	8512.706953	9825.472385
140	400.980662	324.429808	262.460069	546.791811	9951.610965	11486.273316
141	566.947785	458.712299	371.093096	773.110617	14070.613221	16240.477019
142	574.915761	465.159116	376.308498	783.976038	14268.363893	16468.723307
143	596.214716	482.391907	390.249632	813.020068	14796.965231	17078.841554
144	951.994165	770.249825	623.123454	1298.173862	23626.764285	27270.305591
145	685.832136	554.900546	448.908307	935.225640	17021.106640	19645.973269
146	836.057255	676.446325	547.237476	1140.078075	20749.420972	23949.240104
147	1084.517381	877.473153	709.865922	1478.887337	26915.749537	31066.493330
148	1041.637929	842.779779	681.799372	1420.415358	25851.559514	29838.191952
149	824.099916	666.771750	539.410854	1123.772613	20452.661550	23606.716683
150	1121.431298	907.339868	734.027759	1529.224497	27831.885854	32123.909276
151	939.236364	759.927604	614.772893	1280.776860	23310.138859	26904.852581
152	1126.089075	911.108434	737.076486	1535.576012	27947.483412	32257.333418
153	1028.520267	832.166398	673.213265	1402.527636	25526.002984	29462.430550
154	945.550552	765.036356	618.905816	1289.387117	23466.845528	27085.725370
155	862.304686	697.682883	564.417613	1175.870027	21400.834491	24701.109700
156	1437.566879	1163.122293	940.952866	1960.318471	35677.796170	41179.756678
157	1339.447614	1083.734888	876.729348	1826.519474	33242.654431	38369.085755
158	928.491269	751.233845	607.739740	1266.124458	23043.465127	26597.054438

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
159	1156.534682	935.741697	757.004519	1577.092748	28703.088012	33129.461658
160	833.177593	674.116416	545.352606	1136.151263	20677.952982	23866.750860
161	1093.994177	885.140743	716.068916	1491.810241	27150.946386	31337.960462
162	947.417904	766.547214	620.128083	1291.933506	23513.189809	27139.216516
163	975.775651	789.491209	638.689517	1330.603161	24216.977522	27951.537059
164	780.929643	631.843075	511.153948	1064.904059	19381.253870	22370.084595
165	635.899043	514.500135	416.224828	867.135059	15781.858069	18215.617133
166	761.405525	616.046288	498.374525	1038.280261	18896.700753	21810.807353
167	672.632110	544.220525	440.268290	917.225605	16693.506006	19267.852537
168	694.938854	562.268709	454.869068	947.643891	17247.118822	19906.839344
169	663.849294	537.114429	434.519538	905.249037	16475.532479	19016.264778
170	650.465906	526.286051	425.759502	886.998963	16143.381121	18632.891543
171	426.953994	345.444595	279.460796	582.209991	10596.221841	12230.291216
172	382.672818	309.617098	250.476754	521.826570	9497.243577	10961.836817
173	454.747331	367.931931	297.652798	620.109996	11286.001933	13026.443990
174	486.258675	393.427474	318.278406	663.080012	12068.056211	13929.100776
175	476.005590	385.131795	311.567295	649.098531	11813.593271	13635.396483
176	602.021916	487.090460	394.050709	820.938977	14941.089380	17245.191441
177	456.478576	369.332666	298.785977	622.470785	11328.968285	13076.036288
178	438.039229	354.413558	286.716586	597.326222	10871.337234	12547.832829
179	480.462331	388.737704	314.484435	655.175906	11924.201486	13763.061861
180	559.888883	453.001005	366.472723	763.484841	13895.424097	16038.271550
181	438.787244	355.018770	287.206196	598.346242	10889.901598	12569.260049
182	436.442495	353.121655	285.671451	595.148856	10831.709182	12502.093638
183	309.749742	250.615701	202.745286	422.386012	7687.425423	8872.922164
184	276.899585	224.036937	181.243365	377.590344	6872.144258	7931.914489
185	195.129038	157.877131	127.720825	266.085052	4842.747955	5589.560002
186	190.973737	154.515115	125.000992	260.418733	4739.620936	5470.529513
187	149.472984	120.937233	97.836862	203.826797	3709.647700	4281.721576
188	85.773753	69.398764	56.142820	116.964209	2128.748603	2457.028149
189	86.854476	70.273167	56.850203	118.437922	2155.570189	2487.985958
190	245.530351	198.656375	160.710775	334.814115	6093.616893	7033.328509

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
191	295.144123	238.798427	193.185244	402.469259	7324.940518	8454.537573
192	143.930895	116.453178	94.209313	196.269402	3572.103111	4122.965898
193	78.064486	63.161266	51.096755	106.451572	1937.418619	2236.192699
194	37.557493	30.387427	24.583087	51.214764	932.108701	1075.851471
195	53.817670	43.543387	35.226111	73.387731	1335.656713	1541.631613
196	26.532504	21.467208	17.366730	36.180687	658.488505	760.035633
197	23.694110	19.170689	15.508872	32.310151	588.044740	678.728563
198	26.669547	21.578088	17.456431	36.367564	661.889657	763.961285
199	30.892002	24.994438	20.220219	42.125457	766.683319	884.915436
200	71.540645	57.882886	46.826604	97.555425	1775.508741	2049.314301
201	64.399329	52.104912	42.152288	87.817267	1598.274264	1844.748061
202	32.689965	26.449154	21.397068	44.577225	811.305499	936.418911
203	44.333223	35.869607	29.018109	60.454395	1100.269981	1269.945315
204	16.865180	13.645464	11.039027	22.997973	418.563106	483.110750
205	6.108705	4.942498	3.998425	8.330053	151.606957	174.986638
206	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
207	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
208	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
209	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
210	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
211	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
212	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
213	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
214	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
215	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
216	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
217	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
218	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
219	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
220	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
221	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
222	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
223	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
224	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
225	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
226	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
227	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
228	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
229	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
230	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
231	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
232	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
233	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
234	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
235	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
236	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
237	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
238	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
239	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
240	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
241	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
242	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
243	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
244	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
245	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
246	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
247	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
248	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
249	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
250	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
251	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
252	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
253	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
254	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
255	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
256	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
257	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
258	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
259	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
260	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
261	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
262	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
263	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
264	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
265	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
266	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
267	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
268	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
269	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
270	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
271	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
272	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
273	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
274	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
275	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
276	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
277	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
278	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
279	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
280	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
281	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
282	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
283	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
284	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
285	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
286	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
287	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
288	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
289	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
290	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
291	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
292	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
293	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
294	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
295	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
296	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
297	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
298	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
299	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
300	2.200000	1.780000	1.440000	3.000000	54.600000	63.020000
301	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
302	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
303	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
304	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
305	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
306	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
307	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
308	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
309	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
310	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
311	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
312	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
313	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
314	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
315	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
316	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
317	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
318	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
319	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
320	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
321	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
322	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
323	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
324	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
325	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
326	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
327	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
328	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
329	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
330	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
331	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
332	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
333	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
334	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
335	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
336	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
337	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
338	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
339	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
340	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
341	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
342	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
343	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
344	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
345	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
346	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
347	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
348	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
349	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
350	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151

Table N-1. Big Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
351	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
352	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
353	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
354	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
355	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
356	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
357	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
358	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
359	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
360	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
361	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
362	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
363	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
364	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151
365	0.000110	0.000089	0.000072	0.000150	0.002730	0.003151

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
1	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
2	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
3	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
4	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
5	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
6	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
7	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
8	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
9	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
10	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
11	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
12	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
13	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
14	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
15	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
16	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
17	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
18	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
19	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
20	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
21	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
22	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
23	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
24	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
25	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
26	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
27	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
28	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
29	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
30	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
31	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
32	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
33	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
34	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
35	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
36	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
37	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
38	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
39	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
40	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
41	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
42	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
43	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
44	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
45	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
46	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
47	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
48	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
49	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
50	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
51	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
52	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
53	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
54	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
55	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
56	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
57	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
58	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
59	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
60	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
61	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
62	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
63	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
64	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
65	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
66	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
67	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
68	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
69	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
70	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
71	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
72	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
73	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
74	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
75	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
76	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
77	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
78	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
79	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
80	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
81	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
82	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
83	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
84	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
85	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
86	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
87	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
88	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
89	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
90	0.532860	0.084506	0.938960	0.469480	7.488208	9.514014

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
91	0.019544	0.003099	0.034439	0.017219	0.274649	0.348951
92	0.000801	0.000127	0.001411	0.000705	0.011252	0.014295
93	0.038754	0.006146	0.068289	0.034144	0.544604	0.691937
94	0.217744	0.034532	0.383690	0.191845	3.059926	3.887737
95	0.547277	0.086793	0.964365	0.482182	7.690809	9.771426
96	1.004299	0.159272	1.769689	0.884845	14.113273	17.931378
97	0.353520	0.056065	0.622943	0.311471	4.967968	6.311966
98	4.775378	0.757329	8.414763	4.207381	67.107733	85.262584
99	4.137716	0.656202	7.291129	3.645565	58.146757	73.877369
100	0.309922	0.049151	0.546119	0.273059	4.355298	5.533549
101	0.595644	0.094463	1.049594	0.524797	8.370509	10.635007
102	1.914115	0.303560	3.372890	1.686445	26.898801	34.175812
103	12.927643	2.050199	22.779987	11.389994	181.670397	230.818220
104	81.380952	12.906230	143.402559	71.701280	1143.635410	1453.026432
105	23.284647	3.692719	41.030214	20.515107	327.215960	415.738648
106	8.338029	1.322331	14.692562	7.346281	117.173185	148.872388
107	2.936883	0.465761	5.175125	2.587562	41.271622	52.436954
108	4.729512	0.750055	8.333943	4.166971	66.463192	84.443673
109	4.035485	0.639989	7.110988	3.555494	56.710126	72.052082
110	1.566583	0.248445	2.760499	1.380249	22.014976	27.970752
111	3.938891	0.624670	6.940778	3.470389	55.352704	70.327433
112	8.418710	1.335126	14.834732	7.417366	118.306985	150.312918
113	16.694467	2.647581	29.417562	14.708781	234.605059	298.073450
114	24.948043	3.956518	43.961309	21.980654	350.591435	445.437959
115	56.158040	8.906121	98.956899	49.478449	789.181269	1002.680778
116	27.155468	4.306594	47.851045	23.925523	381.612085	484.850715
117	29.547686	4.685977	52.066407	26.033203	415.229592	527.562864
118	190.429661	30.200299	335.558874	167.779437	2676.082016	3400.050286
119	58.812585	9.327106	103.634511	51.817256	826.485226	1050.076684
120	26.058447	4.132617	45.917968	22.958984	366.195797	465.263813
121	75.405063	11.958512	132.872357	66.436179	1059.657048	1346.329159
122	256.993031	40.756604	452.851155	226.425578	3611.487964	4588.514332
123	155.159775	24.606837	273.409295	136.704648	2180.439131	2770.319686
124	205.980939	32.666581	362.962007	181.481004	2894.622006	3677.712537
125	395.548099	62.730095	697.001056	348.500528	5558.583425	7062.363204
126	267.003887	42.344229	470.491431	235.245716	3752.169162	4767.254425
127	291.005455	46.150645	512.784943	256.392471	4089.459918	5195.793432
128	463.310703	73.476587	816.406526	408.203263	6510.842042	8272.239121
129	388.230730	61.569631	684.107013	342.053507	5455.753431	6931.714313
130	241.981185	38.375871	426.398564	213.199282	3400.528551	4320.483454
131	174.069665	27.605762	306.730687	153.365343	2446.177228	3107.948684
132	236.766765	37.548914	417.210159	208.605080	3327.251019	4227.381938
133	698.558778	110.784652	1230.940577	615.470289	9816.751103	12472.505398
134	814.321557	129.143507	1434.927853	717.463927	11443.549631	14539.406474
135	727.792073	115.420769	1282.452992	641.226496	10227.562613	12994.454944

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
136	711.836671	112.890397	1254.337746	627.168873	10003.343521	12709.577207
137	800.636950	126.973261	1410.814009	705.407005	11251.241723	14295.072947
138	656.637627	104.136364	1157.070708	578.535354	9227.638896	11724.018948
139	707.833142	112.255476	1247.283070	623.641535	9947.082484	12638.095708
140	827.478274	131.230035	1458.111497	729.055748	11628.439187	14774.314741
141	1169.974066	185.546548	2061.628311	1030.814155	16441.485779	20889.448859
142	1186.417071	188.154249	2090.602768	1045.301384	16672.557077	21183.032549
143	1230.370369	195.124816	2168.053514	1084.026757	17290.226771	21967.802227
144	1964.569778	311.561727	3461.796965	1730.898482	27607.830795	35076.657747
145	1415.308135	224.454153	2493.935039	1246.967519	19889.131935	25269.796781
146	1725.318154	273.618738	3040.208201	1520.104101	24245.660403	30804.909597
147	2238.049504	354.932961	3943.699566	1971.849783	31451.004038	39959.535852
148	2149.561908	340.899686	3787.774288	1893.887144	30207.499945	38379.622971
149	1700.642554	269.705427	2996.726967	1498.363484	23898.897562	30364.335993
150	2314.226406	367.013879	4077.931993	2038.965997	32521.507646	41319.645921
151	1938.242315	307.386446	3415.404961	1707.702481	27237.854565	34606.590768
152	2323.838364	368.538243	4094.869364	2047.434682	32656.583181	41491.263834
153	2122.491823	336.606633	3740.073697	1870.036849	29827.087735	37896.296737
154	1951.272504	309.452908	3438.365645	1719.182823	27420.966020	34839.239899
155	1779.483307	282.208806	3135.653405	1567.826703	25006.835907	31772.008128
156	2966.615286	470.476433	5227.515922	2613.757961	41689.439480	52967.805083
157	2764.132804	438.364674	4870.718598	2435.359299	38843.980818	49352.556193
158	1916.068346	303.869870	3376.331887	1688.165943	26926.246797	34210.682842
159	2386.667025	378.502260	4205.580661	2102.790331	33539.505772	42613.046049
160	1719.375578	272.676303	3029.736701	1514.868350	24162.150188	30698.807120
161	2257.606165	358.034458	3978.160643	1989.080321	31725.831125	40308.712711
162	1955.126039	310.064041	3445.156016	1722.578008	27475.119228	34908.043332
163	2013.646116	319.344759	3548.275095	1774.137547	28297.493881	35952.897398
164	1611.554809	255.576974	2839.744157	1419.872078	22646.959651	28773.707669
165	1312.264389	208.112414	2312.360157	1156.180078	18441.072249	23429.989286
166	1571.264129	249.187263	2768.747363	1384.373682	22080.760221	28054.332657
167	1388.068082	220.134145	2445.934946	1222.967473	19506.331194	24783.435840
168	1434.101089	227.434534	2527.050377	1263.525188	20153.226755	25605.337943
169	1369.943543	217.259769	2413.997433	1206.998716	19251.629527	24459.828989
170	1342.325097	212.879751	2365.330567	1182.665284	18863.511273	23966.711972
171	881.077787	139.730398	1552.559977	776.279988	12381.665814	15731.313964
172	789.697543	125.238377	1391.537520	695.768760	11097.511725	14099.753925
173	938.433128	148.826399	1653.626657	826.813328	13187.672589	16755.372101
174	1003.461084	159.139203	1768.213364	884.106682	14101.501579	17916.421913
175	982.302444	155.783648	1730.929417	865.464709	13804.162101	17538.642318
176	1242.354318	197.025354	2189.170605	1094.585303	17458.635575	22181.771156
177	942.005788	149.392988	1659.922093	829.961047	13237.878692	16819.160608
178	903.953682	143.358293	1592.869924	796.434962	12703.137647	16139.754509
179	991.499537	157.242217	1747.135749	873.567874	13933.407597	17702.852975
180	1155.407059	183.236362	2035.959575	1017.979787	16236.777608	20629.360391

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
181	905.497312	143.603098	1595.589978	797.794989	12724.830072	16167.315449
182	900.658602	142.835725	1587.063616	793.531808	12656.832341	16080.922093
183	639.210832	101.372643	1126.362699	563.181350	8982.742527	11412.870051
184	571.420054	90.621683	1006.907584	503.453792	8030.087979	10202.491090
185	402.675379	63.860413	709.560140	354.780070	5658.742116	7189.618117
186	394.100349	62.500496	694.449954	347.224977	5538.238383	7036.514159
187	308.457886	48.918431	543.538125	271.769062	4334.716543	5507.400047
188	177.005836	28.071410	311.904557	155.952279	2487.438844	3160.372926
189	179.236056	28.425101	315.834460	157.917230	2518.779818	3200.192665
190	506.685361	80.355388	892.837640	446.418820	7120.380179	9046.677387
191	609.070146	96.592622	1073.251358	536.625679	8559.179580	10874.719385
192	297.021028	47.104656	523.385071	261.692536	4173.995943	5303.199234
193	161.096713	25.548377	283.870860	141.935430	2263.870108	2876.321489
194	77.505009	12.291543	136.572703	68.286352	1089.167310	1383.822917
195	111.060100	17.613056	195.700617	97.850309	1560.712423	1982.936505
196	54.753440	8.683365	96.481832	48.240916	769.442612	977.602165
197	48.896028	7.754436	86.160401	43.080201	687.129202	873.020268
198	55.036246	8.728215	96.980169	48.490085	773.416852	982.651567
199	63.749858	10.110110	112.334552	56.167276	895.868054	1138.229851
200	147.633877	23.413302	260.147801	130.073900	2074.678712	2635.947592
201	132.896798	21.076144	234.179379	117.089690	1867.580550	2372.822561
202	67.460201	10.698534	118.872601	59.436300	948.008990	1204.476626
203	91.487650	14.509055	161.211719	80.605859	1285.663457	1633.477741
204	34.803599	5.519513	61.327928	30.663964	489.090223	621.405227
205	12.606146	1.999213	22.213474	11.106737	177.152451	225.078021
206	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
207	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
208	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
209	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
210	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
211	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
212	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
213	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
214	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
215	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
216	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
217	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
218	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
219	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
220	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
221	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
222	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
223	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
224	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
225	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
226	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
227	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
228	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
229	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
230	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
231	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
232	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
233	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
234	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
235	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
236	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
237	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
238	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
239	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
240	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
241	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
242	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
243	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
244	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
245	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
246	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
247	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
248	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
249	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
250	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
251	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
252	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
253	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
254	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
255	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
256	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
257	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
258	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
259	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
260	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
261	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
262	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
263	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
264	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
265	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
266	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
267	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
268	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
269	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
270	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
271	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
272	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
273	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
274	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
275	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
276	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
277	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
278	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
279	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
280	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
281	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
282	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
283	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
284	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
285	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
286	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
287	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
288	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
289	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
290	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
291	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
292	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
293	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
294	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
295	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
296	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
297	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
298	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
299	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
300	4.540000	0.720000	8.000000	4.000000	63.800000	81.060000
301	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
302	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
303	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
304	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
305	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
306	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
307	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
308	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
309	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
310	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
311	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
312	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
313	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
314	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
315	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
316	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
317	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
318	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
319	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
320	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
321	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
322	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
323	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
324	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
325	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
326	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
327	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
328	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
329	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
330	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
331	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
332	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
333	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
334	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
335	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
336	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
337	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
338	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
339	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
340	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
341	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
342	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
343	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
344	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
345	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
346	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
347	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
348	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
349	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
350	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
351	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
352	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
353	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
354	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
355	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
356	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
357	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
358	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
359	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
360	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053

Table N-2. Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
361	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
362	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
363	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
364	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053
365	0.000227	0.000036	0.000400	0.000200	0.003190	0.004053

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
1	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
2	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
3	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
4	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
5	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
6	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
7	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
8	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
9	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
10	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
11	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
12	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
13	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
14	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
15	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
16	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
17	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
18	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
19	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
20	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
21	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
22	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
23	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
24	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
25	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
26	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
27	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
28	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
29	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
30	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
31	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
32	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
33	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
34	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
35	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
36	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
37	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
38	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
39	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
40	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
41	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
42	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
43	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
44	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
45	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
46	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
47	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
48	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
49	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
50	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
51	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
52	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
53	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
54	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
55	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
56	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
57	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
58	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
59	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
60	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
61	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
62	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
63	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
64	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
65	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
66	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
67	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
68	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
69	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
70	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
71	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
72	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
73	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
74	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
75	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
76	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
77	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
78	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
79	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
80	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
81	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
82	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
83	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
84	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
85	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
86	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
87	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
88	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
89	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
90	0.302815	0.049295	0.528165	0.267604	4.272269	5.420148
91	0.011106	0.001808	0.019372	0.009815	0.156696	0.198798
92	0.000455	0.000074	0.000794	0.000402	0.006419	0.008144
93	0.022023	0.003585	0.038412	0.019462	0.310714	0.394197
94	0.123740	0.020144	0.215826	0.109352	1.745789	2.214849
95	0.311008	0.050629	0.542455	0.274844	4.387860	5.566795
96	0.570725	0.092909	0.995450	0.504361	8.052087	10.215532
97	0.200899	0.032704	0.350405	0.177539	2.834389	3.595936
98	2.713761	0.441775	4.733304	2.398207	38.287171	48.574218
99	2.351389	0.382784	4.101260	2.077972	33.174639	42.088044
100	0.176123	0.028671	0.307192	0.155644	2.484841	3.152471
101	0.338494	0.055104	0.590396	0.299134	4.775651	6.058779
102	1.087757	0.177077	1.897251	0.961274	15.346651	19.470010
103	7.346546	1.195949	12.813743	6.492296	103.648942	131.497476
104	46.247325	7.528634	80.663940	40.869729	652.481645	827.791273
105	13.232244	2.154086	23.079496	11.693611	186.687476	236.846913
106	4.738351	0.771360	8.264566	4.187380	66.851159	84.812816
107	1.668978	0.271694	2.911008	1.474911	23.546819	29.873409
108	2.687696	0.437532	4.687843	2.375174	37.919439	48.107683
109	2.293293	0.373327	3.999931	2.026631	32.354994	41.048176
110	0.890261	0.144926	1.552780	0.786742	12.560269	15.934978
111	2.238401	0.364391	3.904188	1.978122	31.580540	40.065641
112	4.784201	0.778823	8.344537	4.227899	67.498029	85.633488
113	9.487164	1.544422	16.547379	8.384005	133.849909	169.812878
114	14.177522	2.307969	24.728236	12.528973	200.023954	253.766653
115	31.913600	5.195237	55.663256	28.202716	450.253890	571.228699
116	15.431962	2.512180	26.916213	13.637548	217.722255	276.220158
117	16.791416	2.733486	29.287354	14.838926	236.902150	300.553332
118	108.217737	17.616841	188.751866	95.634279	1526.792875	1937.013597
119	33.422130	5.440812	58.294413	29.535836	471.537026	598.230215
120	14.808545	2.410693	25.828857	13.086621	208.926756	265.061472
121	42.851335	6.975799	74.740701	37.868622	604.569225	767.005682

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
122	146.044498	23.774686	254.728775	129.062579	2060.472757	2614.083295
123	88.174498	14.353988	153.792729	77.921649	1244.012294	1578.255158
124	117.055247	19.055505	204.166129	103.444172	1651.477132	2095.198186
125	224.782841	36.592555	392.063094	198.645301	3171.354807	4023.438598
126	151.733487	24.700800	264.651430	134.090058	2140.736011	2715.911786
127	165.373144	26.921209	288.441530	146.143709	2333.171489	2960.051082
128	263.291105	42.861343	459.228671	232.675860	3714.649692	4712.706669
129	220.624512	35.915618	384.810195	194.970499	3112.686911	3949.007735
130	137.513537	22.385925	239.849193	121.523591	1940.113468	2461.385713
131	98.920647	16.103361	172.536011	87.418246	1395.624625	1770.602890
132	134.550276	21.903533	234.680715	118.904895	1898.306224	2408.345644
133	396.978336	64.624380	692.404075	350.818064	5600.779626	7105.604482
134	462.764233	75.333712	807.146918	408.954438	6528.921733	8283.121033
135	413.591090	67.328782	721.379808	365.499103	5835.161115	7402.959898
136	404.523923	65.852732	705.564982	357.486257	5707.236742	7240.664636
137	454.987518	74.067735	793.582880	402.081993	6419.203742	8143.923868
138	373.155303	60.746212	650.852273	329.765152	5264.671721	6679.190662
139	402.248790	65.482361	701.596727	355.475675	5675.137969	7199.941522
140	470.240958	76.550854	820.187717	415.561777	6634.407310	8416.948615
141	664.875130	108.235486	1159.665925	587.564069	9380.408814	11900.749424
142	674.219393	109.756645	1175.964057	595.821789	9512.242596	12068.004480
143	699.197258	113.822809	1219.530101	617.895251	9864.643487	12515.088908
144	1116.429521	181.744341	1947.260793	986.612135	15751.176190	19983.222980
145	804.294050	130.931590	1402.838459	710.771486	11347.404427	14396.240012
146	980.467145	159.610931	1710.117113	866.459337	13832.947315	17549.601841
147	1271.843110	207.044227	2218.331006	1123.954376	17943.833025	22765.005744
148	1221.557208	198.858150	2130.623037	1079.515672	17234.373009	21864.927076
149	966.444447	157.328166	1685.658919	854.067186	13635.107700	17298.606417
150	1315.133068	214.091430	2293.836746	1162.210618	18554.590569	23539.862431
151	1101.468100	179.308760	1921.165291	973.390414	15540.092573	19715.425138
152	1320.595370	214.980642	2303.364017	1167.037769	18631.655608	23637.633406
153	1206.173767	196.353869	2103.791455	1065.921004	17017.335322	21589.575417

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
154	1108.872921	180.514196	1934.080675	979.934209	15644.563685	19847.965687
155	1011.248223	164.621804	1763.805040	893.661220	14267.222994	18100.559282
156	1685.873885	274.444586	2940.477706	1489.842038	23785.197446	30175.835661
157	1570.806748	255.712726	2739.779211	1388.154800	22161.769621	28116.223107
158	1088.867033	177.257424	1899.186686	962.254588	15362.310085	19489.875816
159	1356.299763	220.792985	2365.639122	1198.590488	19135.392008	24276.714366
160	977.090086	159.061177	1704.226894	863.474960	13785.301988	17489.155105
161	1282.956807	208.853434	2237.715361	1133.775783	18100.630924	22963.932309
162	1111.062815	180.870691	1937.900259	981.869465	15675.459873	19887.163102
163	1144.318718	186.284442	1995.904741	1011.258402	16144.651681	20482.417985
164	915.817491	149.086568	1597.356088	809.327085	12920.835914	16392.423145
165	745.736150	121.398908	1300.702588	659.022645	10521.238712	13348.099004
166	892.921025	145.359237	1557.420392	789.092998	12597.800502	15982.594154
167	788.814020	128.411585	1375.838407	697.091460	11129.004004	14119.159475
168	814.973747	132.670145	1421.465837	720.209357	11498.079215	14587.398300
169	778.514172	126.734865	1357.873556	687.989268	10983.688320	13934.800181
170	762.819108	124.179855	1330.498444	674.119212	10762.254081	13653.870699
171	500.700592	81.509399	873.314987	442.479593	7064.147894	8962.152465
172	448.770850	73.055720	782.739855	396.588193	6331.495718	8032.650336
173	533.294597	86.815399	930.164995	471.283597	7524.001289	9545.559877
174	570.248810	92.831202	994.620017	503.940809	8045.370807	10207.011645
175	558.224737	90.873794	973.647797	493.314884	7875.728847	9991.790060
176	706.007520	114.931457	1231.408465	623.913622	9960.726253	12636.987318
177	535.324875	87.145910	933.706177	473.077797	7552.645524	9581.900282
178	513.700551	83.625671	895.989332	453.967928	7247.558156	9194.841638
179	563.451279	91.724627	982.763859	497.933688	7949.467657	10085.341110
180	656.596963	106.887878	1145.227261	580.248479	9263.616065	11752.576645
181	514.577768	83.768474	897.519362	454.743144	7259.934398	9210.543146
182	511.828016	83.320840	892.723284	452.313131	7221.139455	9161.324726
183	363.251971	59.134042	633.579018	321.013369	5124.950282	6501.928682
184	324.727696	52.862648	566.385516	286.968661	4581.429505	5812.374026
185	228.833145	37.251907	399.127579	202.224640	3228.498636	4095.935907

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
186	223.960110	36.458623	390.628099	197.918237	3159.747291	4008.712359
187	175.291045	28.535752	305.740195	154.908365	2473.098467	3137.573824
188	100.589220	16.374989	175.446313	88.892799	1419.165735	1800.469056
189	101.856613	16.581309	177.656884	90.012821	1437.046793	1823.154420
190	287.940139	46.873976	502.221172	254.458727	4062.411262	5153.905277
191	346.123563	56.345696	603.703889	305.876637	4883.293679	6195.343464
192	168.791685	27.477716	294.404103	149.164745	2381.402074	3021.240323
193	91.548352	14.903220	159.677359	80.903195	1291.612413	1638.644539
194	44.044697	7.170067	76.822146	38.923220	621.405800	788.365930
195	63.113449	10.274282	110.081597	55.774676	890.437809	1129.681813
196	31.115391	5.065296	54.271031	27.497322	438.992337	556.941377
197	27.786729	4.523421	48.465226	24.555714	392.029827	497.360917
198	31.276105	5.091459	54.551345	27.639348	441.259771	559.818028
199	36.227893	5.897564	63.188186	32.015347	511.122213	648.451203
200	83.897666	13.657760	146.333138	74.142123	1183.672494	1501.703181
201	75.522850	12.294417	131.725901	66.741123	1065.516176	1351.800467
202	38.336414	6.240812	66.865838	33.878691	540.870333	686.192087
203	51.990779	8.463615	90.681592	45.945340	733.513321	930.594647
204	19.778257	3.219716	34.496959	17.478459	279.042071	354.015462
205	7.163845	1.166207	12.495079	6.330840	101.071305	128.227276
206	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
207	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
208	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
209	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
210	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
211	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
212	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
213	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
214	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
215	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
216	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
217	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
218	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
219	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
220	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
221	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
222	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
223	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
224	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
225	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
226	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
227	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
228	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
229	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
230	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
231	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
232	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
233	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
234	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
235	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
236	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
237	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
238	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
239	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
240	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
241	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
242	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
243	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
244	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
245	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
246	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
247	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
248	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
249	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
250	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
251	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
252	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
253	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
254	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
255	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
256	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
257	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
258	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
259	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
260	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
261	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
262	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
263	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
264	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
265	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
266	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
267	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
268	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
269	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
270	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
271	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
272	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
273	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
274	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
275	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
276	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
277	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
278	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
279	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
280	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
281	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
282	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
283	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
284	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
285	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
286	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
287	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
288	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
289	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
290	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
291	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
292	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
293	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
294	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
295	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
296	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
297	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
298	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
299	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
300	2.580000	0.420000	4.500000	2.280000	36.400000	46.180000
301	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
302	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
303	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
304	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
305	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
306	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
307	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
308	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
309	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
310	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
311	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
312	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
313	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
314	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
315	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
316	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
317	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
318	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
319	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
320	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
321	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
322	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
323	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
324	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
325	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
326	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
327	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
328	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
329	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
330	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
331	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
332	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
333	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
334	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
335	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
336	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
337	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
338	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
339	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
340	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
341	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
342	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
343	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
344	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
345	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-3. North Fork Little Joe Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Upland Timber Harvest	Natural Background	TMDL
346	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
347	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
348	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
349	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
350	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
351	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
352	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
353	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
354	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
355	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
356	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
357	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
358	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
359	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
360	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
361	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
362	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
363	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
364	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309
365	0.000129	0.000021	0.000225	0.000114	0.001820	0.002309

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
1	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
2	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
3	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
4	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
5	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
6	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
7	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
8	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
9	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
10	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
11	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
12	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
13	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
14	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
15	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
16	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
17	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
18	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
19	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
20	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
21	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
22	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
23	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
24	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
25	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
26	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
27	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
28	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
29	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
30	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
31	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
32	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
33	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
34	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
35	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
36	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
37	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
38	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
39	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
40	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
41	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
42	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
43	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
44	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
45	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
46	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
47	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
48	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
49	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
50	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
51	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
52	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
53	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
54	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
55	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
56	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
57	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
58	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
59	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
60	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
61	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
62	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
63	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
64	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
65	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
66	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
67	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
68	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
69	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
70	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
71	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
72	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
73	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
74	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
75	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
76	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
77	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
78	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
79	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
80	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
81	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
82	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
83	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
84	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
85	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
86	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
87	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
88	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
89	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
90	0.915486	0.103286	0.187792	0.079812	0.469480	7.323890	9.079745
91	0.033578	0.003788	0.006888	0.002927	0.017219	0.268622	0.333023
92	0.001376	0.000155	0.000282	0.000120	0.000705	0.011005	0.013643
93	0.066582	0.007512	0.013658	0.005805	0.034144	0.532653	0.660353
94	0.374098	0.042206	0.076738	0.032614	0.191845	2.992780	3.710280
95	0.940256	0.106080	0.192873	0.081971	0.482182	7.522045	9.325407
96	1.725447	0.194666	0.353938	0.150424	0.884845	13.803577	17.112896
97	0.607369	0.068524	0.124589	0.052950	0.311471	4.858953	6.023855
98	8.204394	0.925624	1.682953	0.715255	4.207381	65.635150	81.370756
99	7.108851	0.802024	1.458226	0.619746	3.645565	56.870809	70.505221
100	0.532466	0.060073	0.109224	0.046420	0.273059	4.259727	5.280969

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
101	1.023354	0.115455	0.209919	0.089215	0.524797	8.186830	10.149570
102	3.288568	0.371018	0.674578	0.286696	1.686445	26.308545	32.615850
103	22.210487	2.505799	4.555997	1.936299	11.389994	177.683900	220.282476
104	139.817495	15.774282	28.680512	12.189218	71.701280	1118.539962	1386.702748
105	40.004459	4.513324	8.206043	3.487568	20.515107	320.035673	396.762174
106	14.325248	1.616182	2.938512	1.248868	7.346281	114.601987	142.077078
107	5.045747	0.569264	1.035025	0.439886	2.587562	40.365975	50.043459
108	8.125594	0.916734	1.666789	0.708385	4.166971	65.004752	80.589225
109	6.933213	0.782209	1.422198	0.604434	3.555494	55.465703	68.763250
110	2.691486	0.303655	0.552100	0.234642	1.380249	21.531889	26.694021
111	6.767259	0.763486	1.388156	0.589966	3.470389	54.138068	67.117323
112	14.463863	1.631820	2.966946	1.260952	7.417366	115.710907	143.451855
113	28.682123	3.235932	5.883512	2.500493	14.708781	229.456986	284.467828
114	42.862276	4.835744	8.792262	3.736711	21.980654	342.898206	425.105853
115	96.482976	10.885259	19.791380	8.411336	49.478449	771.863811	956.913212
116	46.654769	5.263615	9.570209	4.067339	23.925523	373.238152	462.719606
117	50.764746	5.727305	10.413281	4.425645	26.033203	406.117971	503.482151
118	327.169902	36.911476	67.111775	28.522504	167.779437	2617.359213	3244.854307
119	101.043648	11.399796	20.726902	8.808933	51.817256	808.349187	1002.145723
120	44.770019	5.050977	9.183594	3.903027	22.958984	358.160152	444.026753
121	129.550548	14.615959	26.574471	11.294150	66.436179	1036.404386	1284.875693
122	441.529877	49.813627	90.570231	38.492348	226.425578	3532.239012	4379.070673
123	266.574063	30.075022	54.681859	23.239790	136.704648	2132.592504	2643.867886
124	353.887957	39.925821	72.592401	30.851771	181.481004	2831.103655	3509.842608
125	679.576030	76.670116	139.400211	59.245090	348.500528	5436.608240	6740.000215
126	458.729145	51.754057	94.098286	39.991772	235.245716	3669.833162	4549.652138
127	499.965319	56.406344	102.556989	43.586720	256.392471	3999.722553	4958.630396
128	795.996362	89.804718	163.281305	69.394555	408.203263	6367.970900	7894.651103
129	667.004338	75.251771	136.821403	58.149096	342.053507	5336.034704	6615.314819
130	415.738600	46.903842	85.279713	36.243878	213.199282	3325.908803	4123.274118
131	299.062420	33.740376	61.346137	26.072108	153.365343	2392.499357	2966.085742
132	406.779905	45.893118	83.442032	35.462864	208.605080	3254.239242	4034.422239
133	1200.167063	135.403463	246.188115	104.629949	615.470289	9601.336502	11903.195381
134	1399.054657	157.842064	286.985571	121.968868	717.463927	11192.437256	13875.752342
135	1250.391667	141.069829	256.490598	109.008504	641.226496	10003.133339	12401.320435
136	1222.979302	137.977152	250.867549	106.618708	627.168873	9783.834415	12129.445999
137	1375.543659	155.189541	282.162802	119.919191	705.407005	11004.349271	13642.571468
138	1128.143940	127.277778	231.414142	98.351010	578.535354	9025.151522	11188.873746
139	1216.100993	137.201138	249.456614	106.019061	623.641535	9728.807947	12061.227288
140	1421.658709	160.392265	291.622299	123.939477	729.055748	11373.269675	14099.938174
141	2010.087603	226.779114	412.325662	175.238406	1030.814155	16080.700824	19935.945766
142	2038.337699	229.966305	418.120554	177.701235	1045.301384	16306.701592	20216.128769
143	2113.852176	238.485887	433.610703	184.284549	1084.026757	16910.817407	20965.077477
144	3375.252041	380.797666	692.359393	294.252742	1730.898482	27002.016326	33475.576651

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
145	2431.586663	274.332854	498.787008	211.984478	1246.967519	19452.693303	24116.351826
146	2964.202996	334.422902	608.041640	258.417697	1520.104101	23713.623968	29398.813304
147	3845.107077	433.806952	788.739913	335.214463	1971.849783	30760.856614	38135.574802
148	3693.079931	416.655172	757.554858	321.960814	1893.887144	29544.639444	36627.777363
149	2921.808793	329.639966	599.345393	254.721792	1498.363484	23374.470343	28978.349771
150	3975.983693	448.572519	815.586399	346.624219	2038.965997	31807.869547	39433.602374
151	3330.019837	375.694546	683.080992	290.309422	1707.702481	26640.158696	33026.965974
152	3992.497630	450.435630	818.973873	348.063896	2047.434682	31939.981042	39597.386753
153	3646.571855	411.408107	748.014739	317.906264	1870.036849	29172.574838	36166.512652
154	3352.406504	378.220221	687.673129	292.261080	1719.182823	26819.252032	33248.995789
155	3057.262070	344.921875	627.130681	266.530539	1567.826703	24458.096561	30321.768428
156	5096.828024	575.026751	1045.503184	444.338853	2613.757961	40774.624194	50550.078969
157	4748.950633	535.779046	974.143720	414.011081	2435.359299	37991.605064	47099.848842
158	3291.923590	371.396508	675.266377	286.988210	1688.165943	26335.388716	32649.129345
159	4100.441145	462.613873	841.116132	357.474356	2102.790331	32803.529157	40667.964993
160	2953.993283	333.271037	605.947340	257.527620	1514.868350	23631.946265	29297.553896
161	3878.706627	437.597671	795.632129	338.143655	1989.080321	31029.653012	38468.813414
162	3359.027116	378.967162	689.031203	292.838261	1722.578008	26872.216925	33314.658675
163	3459.568217	390.310260	709.655019	301.603383	1774.137547	27676.545739	34311.820167
164	2768.750553	312.371857	567.948831	241.378253	1419.872078	22150.004423	27460.325997
165	2254.551153	254.359617	462.472031	196.550613	1156.180078	18036.409221	22360.522714
166	2699.528679	304.562210	553.749473	235.343526	1384.373682	21596.229432	26773.787002
167	2384.786572	269.052844	489.186989	207.904470	1222.967473	19078.292578	23652.190927
168	2463.874117	277.975541	505.410075	214.799282	1263.525188	19710.992939	24436.577144
169	2353.647497	265.539718	482.799487	205.189782	1206.998716	18829.179977	23343.355176
170	2306.197303	260.186362	473.066113	201.053098	1182.665284	18449.578424	22872.746584
171	1513.745977	170.781597	310.511995	131.967598	776.279988	12109.967818	15013.254974
172	1356.749082	153.069127	278.307504	118.280689	695.768760	10853.992659	13456.167822
173	1612.285990	181.898932	330.725331	140.558266	826.813328	12898.287924	15990.569772
174	1724.008030	194.503470	353.642673	150.298136	884.106682	13792.064241	17098.623232
175	1687.656182	190.402236	346.185883	147.129000	865.464709	13501.249453	16738.087463
176	2134.441340	240.808767	437.834121	186.079501	1094.585303	17075.530720	21169.279751
177	1618.424041	182.591430	331.984419	141.093378	829.961047	12947.392326	16051.446640
178	1553.048176	175.215692	318.573985	135.393944	796.434962	12424.385410	15403.052169
179	1703.457355	192.184932	349.427150	148.506539	873.567874	13627.658841	16894.802691
180	1985.060585	223.955553	407.191915	173.056564	1017.979787	15880.484683	19687.729088
181	1555.700228	175.514898	319.117996	135.625148	797.794989	12445.601826	15429.355084
182	1547.387026	174.576998	317.412723	134.900407	793.531808	12379.096208	15346.905171
183	1098.203632	123.899897	225.272540	95.740829	563.181350	8785.629055	10891.927302
184	981.734894	110.759834	201.381517	85.587145	503.453792	7853.879152	9736.796333
185	691.821136	78.051615	141.912028	60.312612	354.780070	5534.569091	6861.446553
186	677.088705	76.389495	138.889991	59.028246	347.224977	5416.709641	6715.331055
187	529.949671	59.789194	108.707625	46.200741	271.769062	4239.597371	5256.013664
188	304.106943	34.309501	62.380911	26.511887	155.952279	2432.855546	3016.117068

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
189	307.938598	34.741791	63.166892	26.845929	157.917230	2463.508787	3054.119227
190	870.516699	98.212140	178.567528	75.891199	446.418820	6964.133592	8633.739978
191	1046.420074	118.057649	214.650272	91.226365	536.625679	8371.360592	10378.340632
192	510.300444	57.572358	104.677014	44.487731	261.692536	4082.403555	5061.133638
193	276.774088	31.225795	56.774172	24.129023	141.935430	2214.192708	2745.031216
194	133.158386	15.022997	27.314541	11.608680	68.286352	1065.267087	1320.658042
195	190.808102	21.527068	39.140123	16.634552	97.850309	1526.464815	1892.424969
196	94.069786	10.613002	19.296366	8.200956	48.240916	752.558291	932.979318
197	84.006391	9.477644	17.232080	7.323634	43.080201	672.051131	833.171082
198	94.555665	10.667819	19.396034	8.243314	48.490085	756.445322	937.798239
199	109.526188	12.356801	22.466910	9.548437	56.167276	876.209508	1086.275120
200	253.644106	28.616258	52.029560	22.112563	130.073900	2029.152847	2515.629235
201	228.324895	25.759732	46.835876	19.905247	117.089690	1826.599159	2264.514598
202	115.900786	13.075986	23.774520	10.104171	59.436300	927.206285	1149.498048
203	157.181426	17.733289	32.242344	13.702996	80.605859	1257.451407	1558.917321
204	59.794729	6.746072	12.265586	5.212874	30.663964	478.357836	593.041061
205	21.658137	2.443482	4.442695	1.888145	11.106737	173.265094	214.804289
206	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
207	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
208	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
209	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
210	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
211	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
212	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
213	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
214	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
215	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
216	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
217	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
218	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
219	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
220	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
221	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
222	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
223	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
224	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
225	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
226	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
227	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
228	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
229	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
230	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
231	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
232	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
233	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
234	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
235	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
236	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
237	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
238	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
239	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
240	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
241	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
242	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
243	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
244	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
245	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
246	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
247	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
248	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
249	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
250	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
251	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
252	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
253	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
254	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
255	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
256	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
257	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
258	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
259	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
260	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
261	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
262	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
263	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
264	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
265	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
266	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
267	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
268	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
269	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
270	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
271	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
272	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
273	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
274	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
275	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
276	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
277	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
278	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
279	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
280	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
281	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
282	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
283	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
284	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
285	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
286	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
287	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
288	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
289	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
290	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
291	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
292	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
293	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
294	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
295	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
296	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
297	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
298	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
299	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
300	7.800000	0.880000	1.600000	0.680000	4.000000	62.400000	77.360000
301	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
302	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
303	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
304	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
305	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
306	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
307	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
308	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
309	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
310	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
311	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
312	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
313	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
314	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
315	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
316	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
317	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
318	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
319	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
320	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
321	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
322	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
323	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
324	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
325	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
326	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
327	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
328	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
329	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
330	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
331	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
332	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
333	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
334	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
335	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
336	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
337	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
338	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
339	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
340	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
341	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
342	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
343	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
344	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
345	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
346	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
347	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
348	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
349	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
350	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
351	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
352	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
353	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
354	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
355	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
356	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
357	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
358	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
359	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
360	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
361	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
362	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
363	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868
364	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868

Table N-4. Twelvemile Creek Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Natural Background	TMDL
365	0.000390	0.000044	0.000080	0.000034	0.000200	0.003120	0.003868

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
1	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
2	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
3	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
4	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
5	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
6	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
7	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
8	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
9	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
10	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
11	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
12	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
13	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
14	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
15	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
16	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
17	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
18	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
19	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
20	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
21	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
22	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
23	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
24	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
25	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
26	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
27	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
28	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
29	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
30	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
31	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
32	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
33	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
34	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
35	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
36	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
37	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
38	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
39	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
40	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
41	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
42	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
43	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
44	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
45	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
46	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
47	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
48	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
49	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
50	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
51	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
52	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
53	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
54	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
55	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
56	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
57	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
58	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
59	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
60	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
61	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
62	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
63	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
64	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
65	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
66	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
67	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
68	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
69	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
70	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
71	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
72	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
73	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
74	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
75	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
76	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
77	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
78	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
79	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
80	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
81	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
82	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
83	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
84	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
85	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
86	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
87	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
88	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
89	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
90	3.997623	1.218301	1.697171	0.234740	3.873211	9.866124	1.323934	56.314138	78.525242
91	0.146623	0.044684	0.062248	0.008610	0.142060	0.361865	0.048559	2.065463	2.880112
92	0.006007	0.001831	0.002550	0.000353	0.005820	0.014824	0.001989	0.084616	0.117989
93	0.290740	0.088605	0.123432	0.017072	0.281692	0.717545	0.096287	4.095625	5.710998

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
94	1.633559	0.497838	0.693519	0.095922	1.582720	4.031621	0.541003	23.011796	32.087978
95	4.105783	1.251263	1.743089	0.241091	3.978005	10.133062	1.359754	57.837775	80.649823
96	7.534452	2.296172	3.198714	0.442422	7.299969	18.595011	2.495262	106.137120	147.999122
97	2.652178	0.808268	1.125969	0.155736	2.569638	6.545570	0.878349	37.360985	52.096694
98	35.825853	10.918155	15.209684	2.103691	34.710897	88.418120	11.864816	504.675399	703.726613
99	31.041983	9.460240	13.178716	1.822782	30.075909	76.611542	10.280492	437.285486	609.757152
100	2.325101	0.708589	0.987110	0.136530	2.252740	5.738343	0.770028	32.753476	45.671916
101	4.468645	1.361848	1.897140	0.262398	4.329574	11.028605	1.479927	62.949377	87.777513
102	14.360081	4.376325	6.096499	0.843223	13.913173	35.440646	4.755775	202.289102	282.074825
103	96.985795	29.557033	41.174827	5.694997	93.967447	239.360715	32.119782	1366.229729	1905.090325
104	610.536396	186.064821	259.200126	35.850640	591.535557	1506.802392	202.197609	8600.568492	11992.756032
105	174.686138	53.236703	74.162113	10.257554	169.249635	431.124978	57.852602	2460.787111	3431.356834
106	62.553584	19.063600	26.556807	3.673141	60.606820	154.382099	20.716513	881.186429	1228.738992
107	22.033095	6.714725	9.354038	1.293781	21.347391	54.377626	7.296926	310.378120	432.795702
108	35.481760	10.813290	15.063601	2.083486	34.377513	87.568901	11.750859	499.828205	696.967616
109	30.275030	9.226506	12.853110	1.777747	29.332824	74.718702	10.026493	426.481481	594.691892
110	11.752823	3.581747	4.989601	0.690125	11.387057	29.005939	3.892303	165.560902	230.860496
111	29.550362	9.005659	12.545456	1.735194	28.630709	72.930224	9.786497	416.273158	580.457261
112	63.158870	19.248064	26.813777	3.708683	61.193268	155.875943	20.916972	889.713029	1240.628606
113	125.245272	38.169287	53.172244	7.354391	121.347445	309.105036	41.478763	1764.318299	2460.190736
114	187.165271	57.039798	79.460065	10.990327	181.340398	461.923449	61.985445	2636.579478	3676.484231
115	421.308997	128.396576	178.864595	24.739225	408.197208	1039.789615	139.529227	5934.940010	8275.765453
116	203.725825	62.086731	86.490764	11.962761	197.385561	502.794856	67.469974	2869.866430	4001.782902
117	221.672726	67.556162	94.110030	13.016602	214.773927	547.087767	73.413633	3122.682733	4354.313579
118	1428.641904	435.387638	606.522664	83.889718	1384.180353	3525.884864	473.138012	20125.143439	28062.788592
119	441.223931	134.465778	187.319379	25.908628	427.492358	1088.939626	146.124661	6215.479805	8666.954165
120	195.495750	59.578564	82.996728	11.479492	189.411619	482.483051	64.744335	2753.930146	3840.119685
121	565.704061	172.401883	240.166786	33.218089	548.098473	1396.156293	187.350024	7969.019619	11112.115227
122	1928.013794	587.574374	818.528463	113.212789	1868.011016	4758.333516	638.520129	27159.748046	37871.942127
123	1164.040075	354.748561	494.187301	68.352324	1127.813343	2872.848171	385.507106	16397.722491	22865.219373
124	1545.310745	470.943204	656.053828	90.740502	1497.218279	3813.823289	511.776430	21768.646374	30354.512651

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
125	2967.481998	904.358871	1259.829409	174.250264	2875.129358	7323.738600	982.771489	41802.638356	58290.198345
126	2003.117268	610.462632	850.413262	117.622858	1940.777153	4943.688711	663.392918	28217.723575	39347.198375
127	2183.181894	665.338463	926.858784	128.196236	2115.237889	5388.087786	723.026769	30754.276939	42884.204759
128	3475.850783	1059.287467	1475.654795	204.101631	3367.676918	8578.391568	1151.133201	48963.981373	68276.077737
129	2912.585609	887.628850	1236.523427	171.026753	2821.941430	7188.254443	964.590889	41029.318125	57211.869526
130	1815.391888	553.252137	770.715405	106.599641	1758.894078	4480.382916	601.221976	25573.253903	35659.711945
131	1305.905899	397.983066	554.415716	76.682672	1265.264083	3222.972692	432.490268	18396.172943	25651.887340
132	1776.272253	541.330182	754.107363	104.302540	1720.991907	4383.835747	588.266324	25022.179296	34891.285611
133	5240.729507	1597.145399	2224.925093	307.735144	5077.629881	12934.108115	1735.626214	73825.661115	102943.560468
134	6109.205336	1861.818890	2593.632095	358.731963	5919.077395	15077.504419	2023.248273	86059.798005	120003.016376
135	5460.043614	1663.982757	2318.033783	320.613248	5290.118593	13475.374816	1808.258719	76915.118208	107251.543738
136	5340.342952	1627.503225	2267.215475	313.584436	5174.143200	13179.953861	1768.616221	75228.906289	104900.265660
137	6006.540644	1830.531177	2550.046321	352.703502	5819.607788	14824.128201	1989.247753	84613.570197	117986.375583
138	4926.228539	1501.299244	2091.405305	289.267677	4772.916670	12157.920464	1631.469698	69395.315710	96765.823306
139	5310.307671	1618.349783	2254.464149	311.820768	5145.042664	13105.826859	1758.669129	74805.802130	104310.283153
140	6207.909697	1891.899667	2635.536530	364.527874	6014.709924	15321.106552	2055.937210	87450.237018	121941.864474
141	8777.382533	2674.962733	3726.393172	515.407078	8504.216782	21662.559476	2906.895918	123646.157942	172413.975634
142	8900.741286	2712.557092	3778.764504	522.650692	8623.736419	21967.008587	2947.749903	125383.901026	174837.109508
143	9230.487834	2813.049434	3918.756726	542.013378	8943.220744	22780.822295	3056.955454	130029.009482	181314.315347
144	14738.600578	4491.681562	6257.198014	865.449241	14279.912480	36374.831609	4881.133721	207621.272970	289510.080174
145	10617.928428	3235.880713	4507.787583	623.483760	10287.482035	26205.022421	3516.448405	149573.753957	208567.787302
146	12943.686416	3944.670141	5495.176323	760.052050	12540.858829	31944.987673	4286.693563	182336.486858	254252.611854
147	16790.300902	5116.950187	7128.236965	985.924891	16267.760709	41438.423189	5560.616388	236523.381466	329811.594697
148	16126.449030	4914.637138	6846.402025	946.943572	15624.568937	39800.038329	5340.761746	227171.762908	316771.563685
149	12758.565062	3888.253240	5416.583993	749.181742	12361.498739	31488.108606	4225.385023	179728.699847	250616.276252
150	17361.795461	5291.116761	7370.862078	1019.482998	16821.469472	42848.870419	5749.884110	244573.971292	341037.452591
151	14541.086622	4431.487937	6173.344467	853.851240	14088.545464	35887.367629	4815.720995	204838.912541	285630.316896
152	17433.906319	5313.093000	7401.476376	1023.717341	16891.336128	43026.839846	5773.765804	245589.790128	342453.924942
153	15923.363766	4852.745622	6760.183208	935.018424	15427.804001	39298.824374	5273.503913	224310.919991	312782.363298
154	14638.841734	4461.279425	6214.845904	859.591411	14183.258286	36128.627016	4848.095560	206215.979568	287550.518904
155	13350.044373	4068.510293	5667.693530	783.913351	12934.570296	32947.878155	4421.271301	188060.812978	262234.694278

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
156	22256.149039	6782.701909	9448.735030	1306.878981	21563.503179	54928.123554	7370.797450	313520.267440	437177.156582
157	20737.084431	6319.757381	8803.823866	1217.679649	20091.714216	51179.075668	6867.713223	292121.347911	407338.196345
158	14374.733008	4380.790623	6102.719885	844.082972	13927.369033	35476.807300	4760.627960	202495.504907	282362.635687
159	17905.259665	5456.740908	7601.587045	1051.395165	17348.020227	44190.138797	5929.868732	252229.700150	351712.710689
160	12899.104003	3931.083369	5476.249086	757.434175	12497.663890	31834.958382	4271.928748	181708.458623	253376.880278
161	16937.018936	5161.663434	7190.525361	994.540161	16409.912651	41800.522952	5609.206506	238590.184539	332693.574539
162	14667.751738	4470.089931	6227.119499	861.289004	14211.268566	36199.976838	4857.669983	206623.232059	288118.397618
163	15106.781216	4603.886936	6413.507234	887.068774	14636.634766	37283.500559	5003.067884	212807.798811	296742.246179
164	12090.210748	3684.568043	5132.837563	709.936039	11713.944647	29838.611728	4004.039261	170313.655806	237487.803836
165	9844.873367	3000.287303	4179.590983	578.090039	9538.485646	24297.124345	3260.427821	138683.800390	193382.679894
166	11787.941899	3592.449704	5004.510859	692.186841	11421.082873	29092.612918	3903.933782	166055.623104	231550.341979
167	10413.568032	3173.600592	4421.027415	611.483736	10089.481652	25700.661444	3448.768274	146694.948382	204553.539528
168	10758.916979	3278.847864	4567.643556	631.762594	10424.082804	26552.981835	3563.141031	151559.846351	211337.223015
169	10277.594071	3132.161669	4363.300360	603.499358	9957.739411	25365.078026	3403.736380	144779.496037	201882.605312
170	10070.394890	3069.016411	4275.335000	591.332642	9756.988590	24853.710934	3335.116100	141860.700765	197812.595332
171	6610.024101	2014.446570	2806.252158	388.139994	6404.309904	16313.523955	2189.109567	93114.784600	129840.590848
172	5924.470993	1805.519933	2515.204068	347.884380	5740.092272	14621.580495	1962.067904	83457.462785	116374.282830
173	7040.315492	2145.580587	2988.930182	413.406664	6821.209960	17375.482098	2331.613586	99176.258749	138292.797318
174	7528.168398	2294.256840	3196.045656	442.053341	7293.880127	18579.501924	2493.180844	106048.596517	147875.683647
175	7369.431993	2245.880919	3128.654921	432.732354	7140.083845	18187.740849	2440.610478	103812.491785	144757.627145
176	9320.393851	2840.448860	3956.925869	547.292651	9030.328746	23002.710133	3086.730553	131295.507039	183080.337702
177	7067.118311	2153.748916	3000.309183	414.980523	6847.178634	17441.631393	2340.490151	99553.827533	138819.284645
178	6781.643703	2066.748727	2879.112388	398.217481	6570.588438	16737.080730	2245.946593	95532.373713	133211.711774
179	7438.430451	2266.908634	3157.947866	436.783937	7206.934964	18358.028880	2463.461406	104784.466534	146112.962672
180	8668.097889	2641.657548	3679.996931	508.989894	8398.333246	21392.845231	2870.703000	122106.675494	170267.299234
181	6793.224330	2070.277996	2884.028885	398.897494	6581.808658	16765.661690	2249.781869	95695.508911	133439.189833
182	6756.923347	2059.215042	2868.617487	396.765904	6546.637418	16676.070949	2237.759699	95184.140394	132726.130240
183	4795.489192	1461.455602	2035.900579	281.590675	4646.246135	11835.256063	1588.171406	67553.602892	94197.712544
184	4286.909037	1306.462590	1819.985457	251.726896	4153.493782	10580.081434	1419.739693	60389.282324	84207.681213
185	3020.952296	920.654281	1282.529953	177.390035	2926.935577	7455.703170	1000.479797	42555.869389	59340.514498
186	2956.620679	901.048815	1255.218292	173.612488	2864.606060	7296.932891	979.174435	41649.635990	58076.849652

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
187	2314.113565	705.240717	982.445160	135.884531	2242.094764	5711.226844	766.388756	32598.699019	45456.093355
188	1327.933652	404.696163	563.767487	77.976139	1286.606298	3277.337135	439.785426	18706.475818	26084.578118
189	1344.665213	409.795212	570.870786	78.958615	1302.817147	3318.630588	445.326588	18942.171734	26413.235883
190	3801.256252	1158.456838	1613.804034	223.209410	3682.955265	9381.491502	1258.901072	53547.937457	74668.011830
191	4569.367657	1392.543637	1939.901830	268.312839	4427.161852	11277.188644	1513.284415	64368.250195	89756.011069
192	2228.311941	679.092130	946.018516	130.846268	2158.963419	5499.468635	737.972950	31390.019643	43770.693502
193	1208.580186	368.322441	513.096579	70.967715	1170.967297	2982.773061	400.257913	17025.154826	23740.120019
194	581.458285	177.203083	246.855161	34.143176	563.362402	1435.037681	192.567512	8190.947887	11421.575186
195	833.195378	253.921551	353.728866	48.925154	807.265046	2056.324236	275.937870	11737.144523	16366.442625
196	410.771401	125.185177	174.390912	24.120458	397.987558	1013.782852	136.039383	5786.497888	8068.775630
197	366.827909	111.793121	155.734926	21.540100	355.411656	905.330418	121.486166	5167.470078	7205.594374
198	412.893072	125.831770	175.291656	24.245042	400.043199	1019.019131	136.742039	5816.385665	8110.451574
199	478.264356	145.754082	203.044703	28.083638	463.380028	1180.355308	158.391719	6737.264773	9394.538607
200	1107.579262	337.541772	470.217150	65.036950	1073.109679	2733.503018	366.808399	15602.364358	21756.160588
201	997.018707	303.847745	423.279228	58.544845	965.989940	2460.639828	330.192925	14044.908275	19584.421493
202	506.100097	154.237199	214.862226	29.718150	490.349477	1249.053851	167.610367	7129.384221	9941.315588
203	686.358893	209.172205	291.390182	40.302930	664.998340	1693.932135	227.308524	9668.672835	13482.136044
204	261.103652	79.572986	110.850229	15.331982	252.977702	644.403200	86.472378	3678.142462	5128.854591
205	94.573864	28.821982	40.150853	5.553368	91.630578	233.408073	31.320998	1332.253076	1857.712792
206	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
207	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
208	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
209	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
210	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
211	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
212	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
213	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
214	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
215	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
216	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
217	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
218	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
219	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
220	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
221	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
222	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
223	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
224	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
225	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
226	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
227	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
228	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
229	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
230	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
231	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
232	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
233	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
234	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
235	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
236	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
237	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
238	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
239	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
240	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
241	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
242	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
243	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
244	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
245	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
246	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
247	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
248	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
249	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
250	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
251	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
252	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
253	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
254	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
255	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
256	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
257	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
258	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
259	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
260	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
261	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
262	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
263	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
264	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
265	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
266	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
267	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
268	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
269	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
270	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
271	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
272	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
273	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
274	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
275	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
276	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
277	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
278	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
279	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
280	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
281	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
282	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
283	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
284	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
285	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
286	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
287	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
288	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
289	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
290	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
291	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
292	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
293	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
294	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
295	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
296	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
297	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
298	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
299	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
300	34.060000	10.380000	14.460000	2.000000	33.000000	84.060000	11.280000	479.800000	669.040000
301	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
302	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
303	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
304	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
305	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
306	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
307	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
308	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
309	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
310	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
311	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
312	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
313	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
314	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
315	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
316	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
317	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
318	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
319	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
320	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
321	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
322	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
323	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
324	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
325	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
326	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
327	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
328	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
329	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
330	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
331	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
332	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
333	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
334	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
335	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
336	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
337	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
338	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
339	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
340	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
341	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452

Table N-5. St. Regis River Daily Load Allocations and TMDLs

Julian Day	Forest Roads	Eroding Banks	Culvert Failure	Human Caused Mass Wasting	Upland Timber Harvest	Traction Sand	190 Custslopes	Natural Background	TMDL
342	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
343	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
344	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
345	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
346	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
347	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
348	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
349	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
350	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
351	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
352	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
353	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
354	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
355	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
356	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
357	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
358	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
359	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
360	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
361	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
362	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
363	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
364	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452
365	0.001703	0.000519	0.000723	0.000100	0.001650	0.004203	0.000564	0.023990	0.033452

APPENDIX O
DAILY TMDLS AND INSTANTANEOUS TEMPERATURE LOADS

A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (**Equation O-1**). In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream.

Equation O-1. $TMDL = \Sigma WLA + \Sigma LA + MOS.$

Where:

ΣWLA = Waste Load Allocation = Pollutants from NPDES Point Sources
ΣLA = Load Allocation = Pollutants from Nonpoint Sources + Natural Sources
MOS = Margin of Safety

Total maximum daily loads are based on the loading of a pollutant to a water body. Federal Codes indicate that for each thermally listed water body the total maximum daily thermal load cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters. The following approach for setting numeric temperature TMDLs considers all of the factors listed above.

The numeric daily thermal loads (TMDLs) and instantaneous thermal load (ITLs) presented in this appendix apply to all the temperature impaired waters in the St. Regis watershed including Big Creek, Twelvemile Creek, and the St. Regis River. All waters in the St. Regis watershed are classified as B1. Montana's temperature standard for B1 classified waters is depicted in **Figure O-1**.

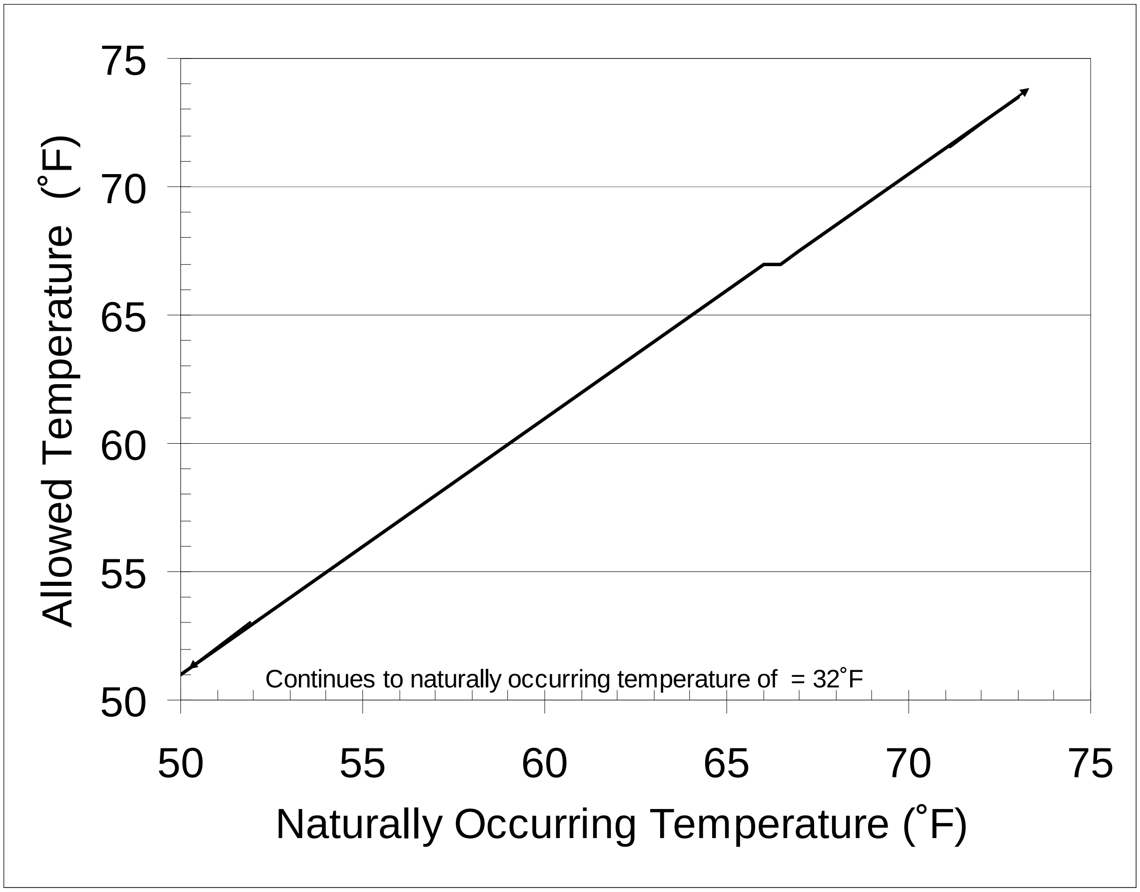

Figure O-1. In-stream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

Daily Thermal Load

The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure O-1**) and using a modeled or estimated naturally occurring daily average temperature. The daily average total maximum load at any location in the water body is provided **Equation O-2**. The daily allowable loading is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kilocalorie increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure O-1**.

Equation O-2

$(\Delta-32)*(Q)*(1.36*10^6) = TMDL$

Where:

Δ = allowed temperatures from **Figure O-1** using daily temperature condition
Q = average daily discharge in cubic feet per second (CFS)

TMDL = daily TMDL in Calories (kilocalories) per day above water's melting point
Conversion factor = 1359209

There are no point sources that increase water temperatures, and therefore, no wasteload allocations in the St. Regis watershed. The TMDL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources without reasonable land, soil and water conservation practices in addition to the naturally occurring loading as defined in state law. See the main document for more information about surrogate allocations, which are more applicable to restoration approaches. The daily numeric TMDL allocation is equal to the load allocation shared by all human-caused sources without reasonable land, soil and water conservation practices plus the load allocated to naturally occurring temperatures as shown in **Equation O-3**.

Equation O-3

Load Allocation = Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios - 32)*(Discharge (CFS))*($1.36*10^6$)

Allowable Human Sources above naturally occurring conditions = (1°F)*($1.36*10^6$)*(Discharge (CFS))

Instantaneous Thermal Load

Because of the dynamic temperature conditions during the course of a day, an instantaneous load is also provided for temperature. For temperature, the daily average thermal conditions are not always an effective indicator of impairment to fisheries. The heat of the day is the usually the most stressful timeframe for salmonids and char. Also, in high altitudes, thermal impacts that heat during the day may produce advanced cooling conditions during the night so that the daily temperature fluctuations increase greatly with potentially significant negative impacts to fish without much impact on daily average temperature conditions. Therefore, Montana provides an instantaneous thermal load to protect during the hottest timeframes in mid to late afternoon when temperatures are most stressful to the fishery, which is the most sensitive use in reference to thermal conditions.

The instantaneous load is computed by the second. The allowed temperature can be calculated using Montana's B1 classification temperature standards (**Figure O-1**) and using a modeled or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the water body is provided **Equation O-4**. The allowable loading over a second is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kCal increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure O-1**.

Equation O-4

$(\Delta - 32)*(Q)*(15.73)$ = Instantaneous Thermal Load (ITL)

Where:

Δ = allowed temperatures from **Figure O-1** using daily temperature condition
Q = instantaneous discharge in CFS
ITL = Allowed thermal load per second in kilocalories per day above water's melting point
Conversion factor = 15.73

There are no point sources that increase water temperatures, and therefore, no wasteload allocations in the St. Regis watershed. The ITL load allocation for each stream is a combination of the 1°F allowable loading shared between the human caused sources without reasonable land, soil and water conservation practices in addition to the naturally occurring loading as defined in state law. See the main document for more information about the allocations. The ITL allocation is equal to the load allocation shared by all human caused sources without reasonable land, soil and water conservation practices plus the load allocated to naturally occurring temperatures as shown in **Equation O-5**.

Equation O-5

Load Allocation = Allowable Human Sources + Naturally Occurring Thermal Loads

Where:

Naturally Occurring Thermal Loads = (Naturally Occurring Temperature (°F) from Modeling Scenarios - 32)*(Discharge (CFS))*(15.73)

Allowable Human Sources above naturally occurring conditions = (1°F)*(15.73)*(Discharge (CFS))

Margins of Safety, Seasonal Variations and Future Sources

See Section 7 of the main document for this discussion.

Example Numeric TMDL Application for Twelvemile Creek

Twelvemile Creek Daily Thermal Load Example Application

A calibrated QUAL2K thermal loading modeling was constructed for Twelvemile Creek. A model scenario used reference riparian shade conditions throughout the watershed to estimate naturally occurring temperatures. The monitoring and modeling effort is described in **Appendix C**. Naturally occurring average daily temperature at Twelvemile Creek's mouth during one of the hottest days of summer 2006 was estimated at 57.7°F. However, calibration of the mean daily temperature in the model was about 0.7°F lower than the existing data at this site, therefore we will raise this modeled estimate by the calibration error to 58.4°F. This temperature is then used to determine the allowable temperature according to **Figure O-1**, Montana's temperature standard. The allowable mean daily temperature is estimated at 59.4°F during the hottest days of the summer. **Equation O-2** from above is used to calculate Twelvemile Creek's TMDL during the hottest days of the summer.

$$(\Delta-32)*(Q)*(1.36*10^6) = \text{TMDL}$$

Where:

Δ = allowed temperatures from **Figure O-1** using daily temperature condition = **59.4°F**
Q = average daily discharge in cubic feet per second (CFS) = **10.3cfs**
TMDL = daily TMDL in Calories (kilocalories) per day above water's melting point = **$3.838*10^8$ kilocal/day**

Twelvemile Creek's load allocation to human caused heat sources not addressed by reasonable land, soil and water conservation practices for the TMDL is $1.36*10^6$ kilocalories per day. The remainder of the TMDL is appropriated to naturally occurring thermal load. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. Currently the daily total maximum daily load is being met.

During the hottest day of 2006, the mean daily temperature of this site was 59.36°F, which equates to a thermal load of $3.832*10^8$ kilocal/day and is just under the state's standard and the TMDL when a daily averaged timeframe is considered. Because this site in Twelvemile Creek is meeting Montana's temperature standard during an average daily condition, it also meets the average daily TMDL. Montana's temperature standard is applied to any timeframe because no duration is provided in the standard. Also, hot stream temperatures over shorter periods than a one day can affect a fishery. Therefore, we will also investigate the instantaneous thermal load. The instantaneous load will consider heating during the warm summer afternoons when the fishery is stressed the most.

Twelvemile Creek Instantaneous Thermal Load

The instantaneous thermal load (ITL) is described as the heat passing a monitoring location per second. The most sensitive timeframe for the fishery occurs during the heat of the day for the hottest period of the year. The same modeling described earlier in this appendix was used to model daily maximum temperatures. The naturally occurring daily maximum temperature at Twelvemile Creek's mouth during one of the hottest days of summer 2006 was estimated at 65.6°F using a QUAL2K model. However, calibration of the maximum temperature in the model was about 2.9°F higher than the existing data at this site; therefore we will lower this modeled estimate by the calibration error to 62.7°F. This temperature is then used to determine the allowable temperature according to **Figure O-1**, Montana's temperature standard. Therefore, the allowable maximum temperature during this timeframe is estimated at 63.7°F during one of the hottest days of the summer. **Equation O-4** from above is used to calculate Twelvemile Creek's ITL during one of the hottest days of the summer.

$(\Delta\text{-}32)*(Q)*(15.73)$ = Instantaneous Thermal Load (ITL)

Where:
Δ = allowed temperatures from **Figure O-1** using instantaneous temperature condition = **63.7°F**
Q = average daily discharge in cubic feet per second (CFS) = **10.3cfs**
ITL = Allowed thermal load per second in kilocalories per day above water's melting point = **5137 kilocal/second**

Twelvemile Creek's load allocation to human caused heat sources not addressed by reasonable land, soil and water conservation practices for the ITL is 162 kilocalories per second. Since there are no NPDES permits that affect water temperature, there is zero waste load allocation. The remainder of the load allocation for the ITL is apportioned to naturally occurring thermal loading.

During the hottest day of 2006, the hottest temperature measured at this site was 67.1°F, which equates to a thermal load of 5687 kilocal/sec. The temperature is above the State's temperature standard and the thermal load is above the allowable instantaneous load when considered during a one second timeframe. Further assessment indicates that the TMDL and the temperature standard are being exceeded during hot summer afternoons. Because this site in Twelvemile Creek is not meeting Montana's temperature standard during a one second timeframe, the thermal load during a one second timeframe is also above the ITL. This scenario would hold true for an hourly time step also. This indicates that Montana's temperature standard at this site is not being met during an important timeframe for the most sensitive use.

A similar analysis could be completed for Big Creek and St. Regis River, but for the sake of brevity is not provided since it is easy to figure if the TMDL and ITL are met by looking at measured temperatures and comparing them to Montana's temperatures standard instead of caloric loads.

APPENDIX P
RESPONSE TO PUBLIC COMMENTS

Executive Summary, Introduction and Standards Review

Comment: Page xi. Table E-1. Pollutant Source Descriptions.
What is the basis of listing "historic and current tree harvest on state land as an agriculture pollutant source in Table E-l? Specifically, what data and data sources were used to identify current timber harvesting on state land as a pollutant source? We are not aware of any sufficient credible data that supports this conclusion.

> **Response:** Sufficient and credible data assessment is identified in Montana's Rules for application to the 303(d) assessment and is not applicable to TMDL source assessment. However, aerial assessment, field reconnaissance, randomized monitoring of sources and watershed modeling and extrapolation of monitoring and modeling results to a watershed scale was used for the sediment TMDL source assessment in the St. Regis Watershed. See appendices relating to sediment source assessments for more information. The language cited in the comment above was edited to consider this comment in the final document.

Targets and Existing Conditions

Comment: The Riffle Stability Index (RSI) is proposed as a water quality target. It is my professional opinion that this Index has not been validated as a tool demonstrating excess watershed-scale sediment loading, and has not been correlated with beneficial use support. Kappesser (2002) merely did a correlative study to show that in his sampling, values for "roaded" and "unroaded" watersheds were different. I believe he should have better demonstrated that his sample watersheds were similar in other respects (channel confinement, geology, etc.), or better yet, had sediment budgets for each one. Additionally, Kappesser notes in his paper that "There are no clear breaks between the numbers, and the following are suggested only as guidelines…." which makes me skeptical that they are appropriate as water quality targets in the TMDL document. Nonetheless, if DEQ elects to utilize RSI, it should be limited to channel types between 2-4% as outlined in Kappesser (2002). Had there been a significant difference for lower gradient "C" channel types, I am sure Kappesser would have reported these as well. Also of note, for the St. Regis RSI dataset in Appendix B, there is no significant difference in RSI values between managed and reference watersheds (p=0.14).

> **Response:** DEQ understands the limitations of the Riffle Stability Index (RSI) as you indicate above. Alternatively, sediment TMDLs need to assess the streams capacity to transport and sort sediment in relation to supporting beneficial uses. This tool provides a linkage between stream channel gradient/sinuosity shifts and sediment transport/sorting. The RSI does not assess increased sediment loads and therefore likely would not show a significant value shift between "roaded" and "unroaded" watersheds. It is a useful tool to indicate if changes in sediment transport and sorting are occurring due to shifts in stream energy from changed channel gradient or sinuosity. This tool is used to assess the

affects of transportation corridors where they have affected stream gradient and sinuosity in the St. Regis Watershed. You are correct in your point that this tool should not be used as an indicator of increased sediment yield. It does provide a link between stream channel changes and sediment sorting and transport. Sediment sorting and transport can affect beneficial uses. Although, in many cases, if stream energy is increased by altering sinuosity or gradient, bank erosion or channel degradation occurs as the stream tries to regain sinuosity and balance gradient along its length. Bank erosion was assessed separately as a sediment source category for this TMDL. Multiple lines of evidence are used to determine if a sediment TMDL is needed. Text concerning this target was edited to reflect caution of its use as a stand alone target.

Comment: The proposed percent fines target of ≤8% is based on the mean value of unmanaged watersheds in the Lolo NF. This implies that half of reference watersheds would fail to the proposed TMDL target. In determining targets some other higher value should be used, such as the 75% percentile (or higher as appropriate – see M. Suplee's latest JAWRA publication on Montana nutrients). This is the approach taken in many other Montana TMDLs.

Response: The original justification for this target was used from Riggers et al, 1998 and a 75th percentile of unmanaged watersheds was not reported in this document. DEQ is coordinating with Lolo National Forest to calculate the 75th percentile for this dataset for use in future reference assessments but this statistic is not available in the timeframe necessary to include into the St. Regis TMDL document. More importantly, almost all sites which met the subsurface % fine targets in the St. Regis watershed also met the 8% surface fine target in the same location. The subsurface percent fine targets are based on more refined reference studies and fry emergence impact assessments. The correlation between surface fines and subsurface fines in the St. Regis Watershed justifies using 8% surface fines in lateral scour pool areas.

Comment: It is unclear how the proposed temperature target for Canopy Density is measured and should be clarified.

Response: The canopy density and effective shade measurement methods are provided inappendices C and F.

Comment: Evaluating temperature in a TMDL or standards context is difficult because biologically optimal conditions for fish are not necessarily physically attainable. I think the TMDL outlines as reasonable approach for evaluating this issue. I do question the 54oF (12.2oC 7DADMT) supplemental indicator for headwater streams (and the Upper St. Regis River). It appears that a primary technical basis for this is Selong et al. (2001), which is appropriate as it is conducted in a controlled laboratory setting. Selong identified 13.2oC as the "optimal" temperature for bull trout growth, but this was determined through regression line fitting. The fact is that Selong's curve is relatively flat at the top, and his study found no decline in growth until temperatures exceeded 16oC. This is also consistent with other research examining formation of heat-shock proteins in bull trout which occurred at levels close to 18oC. All other studies cited by DEQ are simply correlative and do not establish cause-and¬effect related to temperature and bull trout. Lastly, I question the applicability of an optimal bull trout temperature criterion being applied to all headwater streams, whether or not they even have bull trout. Bull trout have very specific habitat requirements (even outside of temperature), and undoubtedly the vast majority of streams in the St. Regis watershed are not bull trout streams (and likely never have been). DEQ should set the supplemental indicator at a temperature closer to 15-16oC as a 7DADMT, and this should apply only to known bull trout streams. Other streams should have a cutthroat standard applied.

> **Response:** The fishery based temperature thresholds are only used as a supplemental indicator for some of the reasons identified in the comment. DEQ is not proposing any fishery based temperature levels as an absolute temperature standard. They do not directly relate to Montana's temperature standard, which identifies an allowable departure from naturally occurring temperature conditions. The fish based thresholds are included because there are bull trout present in the watershed and they are used in guiding an estimate of natural temperatures along with model output. Many headwater streams in the watershed may naturally not meet these temperatures, especially if lakes are present, but a number of the north sloped reference watersheds within the St. Regis watershed do meet the thresholds or come very close to meeting the fishery based thresholds. The bull trout based threshold should not be applied as a stand alone condition that has to be met. Emerging studies about cutthroat trout optimal and growth related temperature thresholds are finding quite similar results to bull trout thresholds you discuss above and could be used when this TMDL is updated during adaptive management process allowed by the state TMDL law when more spatially robust fish presence information becomes available in the St. Regis. DEQ is aware of the threshold differences pointed out in the above comment and did consider a threshold in the range provided in the comment above but EPA and USFWS guidance thresholds were used for endangered species act concerns. Nevertheless, the thresholds are not standards, and text in the document states that they are not to be used as stand alone line of evidence for determining compliance with Montana's temperature standards.

Comment: In section 6.1.8.1, water yield effects on sediment are evaluated. It should be noted that this water yield modeling assumed a fully forested baseline condition, which is not a natural condition in the fire-dominated Northern Rockies ecosystem. Modeling should be re-done using a vegetative condition that the streams historically evolved with, which for the lower Clark Fork area probably was around one-third of the watershed in a stand initiation condition at any one time (see Hessburg et al. in FS General Technical Report PNW-GTR¬458). If modeling is not re-done, the text should clearly state that a false assumption of a fully-forested baseline condition was made.

> **Response:** The modeling will not be re-run at this time. Future modeling should not use the LoloSED model. The document has been updated to reflect the assumptions about modeling from the comment above.

Comment: On page 34 under Anthropogenic Sediment Sources, please define "significant pollutant sources". What or how much is considered "significant"? Is this a qualitative description compared to the quantitative parameters measured with the source assessments and prescribed by the "targets".

Response: Clarification language was added to the document.

Comment: Page 37. Section 4.4.4.2 Reference Riparian Canopy Density
The texts suggest that reference conditions for naturally forested streambanks in steeper streams are 90% riparian canopy density or better. We feel this statement is misleading. We have sampled riparian canopy densities extensively throughout western Montana and found that even under reference conditions a significant portion of the riparian stands across a broader landscape are subject to disturbance regimes such as stand replacement fire, insect and disease and wind events that results in a large range of riparian canopy densities with mean values that are much lower than the figure cited. How extensive was the sample used to derive this figure? Was it representative of the unmanaged landscape within the affected watersheds?

Response: The sample locations used to derive canopy density targets are from non-burned riparian areas. Also, recent tree mortality via insect infestations were not apparent in areas used to derive targets. Tree mortality via insect infestations were not widespread in the St. Regis during the temperature monitoring effort. Recent fires have not significantly affected the St. Regis Watershed, although tree mortality due to insects is limited but continues in the area. Therefore, reference shade conditions used in the TMDL represent current reference conditions in the watershed. If significant portions of the St. Regis watershed are affected by fire or stand replacing insect damage, the targets provided are likely not going to be met due to these natural causes. If these causes of thermal increase do occur, human activities should not exacerbate the heating more than Montana's water quality standards allow. Language was added to the canopy density target section of this document about an adaptive management approach for fire and insect infestations. Discussion about the sample locations used for deriving the TMDL canopy density targets and used for temperature modeling are provided in appendix C.

Significant windfall was not apparent or widespread in the St. Regis Watershed for most riparian areas with adequate buffer zones from clear cuts. Windfall affect was apparent in some riparian zones where trees were not protected from wind due to adjacent upland clearcut areas.

Comment: Page 63.The FS found four bull trout redds in Ward Creek during sampling in 2007, which might be important to note in the document. Page 71, last paragraph. Might want to include bull trout spawning documented in 2007.

Response: The document has been updated to reflect this information.

Source Assessment and Allocations

Paved Roads

Comment: Section 6.1.6, last paragraph, third sentence: Remove "a reduction in plowing speeds," from this sentence. Section 6.6.5.2, page 93, first paragraph, third sentence: Remove "a reduction in plowing speeds," from this sentence.

Response: The document has been updated. MDT provided unofficial, verbal comment at the public meeting that this practice is not a practical BMP because of safety and physical feasibility reasons.

Comment: Section 6.1.7, second paragraph: Quantifying cut-slope erosion and determining a percent reduction (i.e. 10% reduction) would be extremely difficult, if not impossible. Therefore, MDT proposes to replace the first sentence in this paragraph with a sentence similar to the following "MDT will explore alternatives for stabilizing key cut/fill slopes and capturing sediment." Section 6.6.5.2, page 93, second paragraph, first sentence: MDT proposes to replace the first sentence in this paragraph with a sentence similar to the following "MDT will explore alternatives for stabilizing key cut/fill slopes and capturing sediment."

Response: From discussion at the public meeting in St. Regis, it was apparent that MDT could easily meet and exceed the 10% road sanding reduction target. The 10% reduction in sediment entering streams from cut slopes may be problematic to meet. DEQ will combine these two allocations and allow MDT to meet them in combination with the flexibility to reduce sediment loading from either source within their allocation. Sections 6.1.6 and 6.1.7 were combined and the sentence above was used.

Comment: Section 6.6.5.2, page 92, first paragraph, second-to-last sentence: This sentence states that "Sediment loading from potential culvert failure can be reduced by an estimated 91% by upgrading all culverts to safely pass the 100-year flood." MDT currently designs culverts per our hydraulics manual. According to this manual, culverts are designed for the 10-year to 50-year storm events--without over topping the road--based on average daily travel (ADT) and the length of detour in the event of a culvert failure. It is unlikely that MDT will change these design criteria for culverts. Please revise this sentence (and other similar sentences in the document), as necessary. Section 8.4.2, page 105, first paragraph, first sentence: See comment above for Section 6.6.5.2.

Response: The sentence and also section 6.1.4 and 6.6.5.2 were intended to only apply to unpaved roads which MDT usually does not design. This clarification was added to the document.

Comment: Section 8.4.3, first bullet: MDT tried this BMP on Lolo Pass; however, it was discontinued since it was considered unsafe and ineffective. Therefore, this bullet should be removed. It could be replaced with a bullet similar to the following "Utilize a snow blower to directionally place snow and traction sand on cut/fill slopes away from sensitive environments."

Response: The document has been updated.

Comment: Appendix K, Results and Discussion, page K-2, first paragraph: Eleven years of data are presented in Table K-1. Please update this paragraph to reflect all eleven years of data. I also noticed the application rates in Table K-5 are for the old data (i.e. five years of data). Please update this table with the revised application rates. Please double-check all data in Appendix K and verify that all tables, figures, and discussions are related to eleven years of data. Any revisions of the data in Appendix K should also be reflected in the main body of the report.

Response: The document has been updated.

Comment: Appendix K, Results and Discussion, page K-3, first paragraph, last sentence: 0 to 35% pass through a #40 mesh.

Response: The document has been updated.

Comment: Appendix K, Results and Discussion, Table K-1, page K-3: The sand application rates for the 2003 - 2004 and 2005 - 2006 winter seasons are incorrect. The correct applications rates are listed below:
2003 - 2004: 16,256 cy
2005 - 2006: 17,624 cy
Please update this table and revise your sediment loading calculations, as necessary.

Response: The document has been updated.

Comment: Appendix K, Input of Traction Sand from Interstate 90, page K-9, second paragraph: MDT suggests using an average delivery rate of 20.5% for segments of I-90 within 25 feet of the stream channel. This would be consistent with the average delivery rate calculated for segments of I-90 that are located 25 to 50 feet of the stream channel.

Response: The analysis suggests that a delivery rate of 41% is reasonable for stream segments within 25 feet of I-90, and thus its use will continue as the basis of the loading estimates until new study identifies otherwise. We propose working with DEQ to conduct appropriate analysis if changes are necessary.

Comment: Appendix K, Input of Traction Sand from Interstate 90, Table K-8, page K-11: Please update the delivery rates in this table for eleven years of data. Also, the contributions from bridges should have decreased with the revised delivery rates. Please revise these calculations and update the body of Appendix K and the body of the report, as necessary.

Response: The document has been updated.

Unpaved Roads

Comment: The culvert failure analysis is an analysis of the likelihood of risk, the probability of failure. It is not really an actual sediment contribution model like the other modeling components. Many culverts out there are undersized and have been there for years and years with H:D > 1.0 every year and yet have never failed. So to add 800 per year for every year is not supported by what we know does or doesn't happen on the ground.

We know sediment is contributed from road surface erosion every year; we know that I-90 sanding sends sediment to the river every year; we do not know that anywhere near 800 tons from culverts is ever contributed. This might have happened in 1996, but certainly not every year.

The result of the analysis as reported do not stress the limitations and assumptions of the analysis; this needs to be clearly stated so that the resulting values are consider reasonable in relation to the other components of the sediment modeling. (The USGS regression equations alone have standards errors of +/- 50%).

Typically, now we try to replace a failed culvert with something larger and more suitable.

Further, we would like to stress that we feel it is inappropriate to use the results of the road fill sediment volume AT RISK analysis, which was performed by the Lolo National Forest, to extrapolate a daily sediment load allocation from POTENTIAL culvert failures. The analysis portrays sediment AT RISK, is not a known annual contribution, and is not additive, therefore, it should not be accounted for in the same was as actual annual sediment contributions from sediment sources such as road surface erosion and highway sanding. As stated in an email to you on Oct. 9, 2007, the Superior Range District might encounter 1-2 culvert failures per year; in an exceptional year such as 1996 (Q25) there were approximately 6 culvert failures. While we do agree that sediment from failure of undersized culverts is a threat to water quality, this analysis is better used to help prioritize culverts for removal and/or upgrade. A similar analysis was used in the Upper Lolo TMDL as a prioritization mechanism, but was, appropriately, not used to determine an annual load from culvert failures. Furthermore, to our knowledge, as an involved stakeholder in other TMDLs for which the culvert-at-risk-analysis was conducted, the analysis will not be used to extrapolate an annual load for the Prospect and Middle Blackfoot TMDLs. (If the corresponding risk analyses are used for these other TMDLs, the Lolo National Forest will provide the same comment as we have just provided above: essentially that this analysis was not intended to be used to determine an annual sediment load).

I discussed this topic with several transportation folks and engineers.
Typically the Superior District has one, maybe two "culvert failures" per year. In exceptional years we can expect more. With the rain on snow event of 1996 there were probably about 30-40 across the whole Lolo National Forest, around 6 on Superior District. This is a very small portion of all the culverts out there (6/~600 is 1%).

Response: Culvert failure sediment load analysis is being pursued in Prospect, Yaak, and Middle Blackfoot TMDL planning areas. Substantial changes in the culvert failure assessment were enacted because of the comments above. These following changes reduced the estimated sediment yield from culvert failure substantially and provide caveats for the yield identified in the document. They include:

- Fixing errors in the analysis
- Using 25% of the at risk sediment load as a delivery function (a description is provided in Appendix J, Averaging Annual Yields section)
- Using different failure probabilities than stated in the USFS documentation provided to DEQ (a description is provided in Appendix J, Averaging Annual Yields section)

- Using the 1.4 ratio to indicate lower likelihood of failure
- Additional language in the allocation section of the TMDL providing discussion about most of the load from this source derived during large flood events and that it is a very probabilistic analysis.

Using these revised assumptions in the analysis provides a much reduced estimated sediment load from culvert failure that fit into a general range more compatible with Lolo NF estimated culvert failure rates. Existing sediment loading rates from culverts were lowered to about 25% of the original estimate. DEQ agrees with many of the precautions Lolo NF provides about using the load analysis, but with the analytical refinement conducted during the public comment period the analysis can be used to estimate gross load estimates that are useful for comparison to other sediment sources in the watershed.

If future data collection and analysis indicate the culvert failure current loading rates are imprecise, they may be updated during future adaptive management process.

Comment: Culvert failure. From our discussion, it sounds like this part of the TMDL source assessment is being re-done to address some errors identified.

Response: Substantial changes in the culvert failure assessment were completed. See response to the comment directly above.

Comment: Page 76. Section 6.1.2 Sediment Loading due to Timber Harvest
"No new sediment production from road building associated with timber harvest is allowed unless mitigated 2:1 until the road allocations are met. We are concerned that this target is not feasible for landowners with smaller land bases like DNRC. When undertaking smaller timber management projects on an individual parcels that require even moderate levels of new road construction there may not be always be an opportunity to mitigate at 2:1. This may be due to the limited amount of existing road available for offset or due to the economic limitation associated with smaller sized timber harvest. There maybe limited amounts of revenue provided by smaller timber permits that would not be cable of funding the mitigations to existing roads at the 2:1 ratio even if there were available. DNRC would utilize all reasonable soils and water conservation practices to minimize erosion and potential sediment delivery to the extent necessary to meet water quality standards and protect beneficial uses.

Response: If DNRC utilizes all reasonable soil and water conservation practices to minimize erosion and potential sediment delivery, 2-1 mitigation may not be needed. Nevertheless, the mitigation strategy was moved to the restoration section as a "suggested approach" to achieving the TMDLs.

Comment: Page 78 Section 6.1.4 Potential Sediment Risk from Culvert Failures
Table 6-3 Estimated Culvert Failure Sediment Loading summarizes the potential sediment load reductions for upgrading culverts to 50 and 100 year flood events. Typically, DNRC and other private forest landowners design stream crossing on small first and second order stream for 25 and 50 year minimum flood event rather than 100 year events. Montana Forestry BMP require culvert to meet a minimum capacity of a 25 year event. Upgrading culverts to 100 year flood

capacity may be appropriate for larger systems roads, county Roads, USFS and other landowner on larger fish bearing streams. However, this standard is cost prohibitive for DNRC and other small private landowner to adopt broadly across the entire planning area.

> **<u>Response:</u>** The document was clarified. Larger culvert sizes (Q100) should be applied at any fish bearing stream crossings if technically feasible. Twenty five year event sized culverts should be applied in non fish bearing stream crossings. Also, language was added about these sized culverts potentially not being feasible because of local conditions at any given crossing.

<u>Comment:</u> Page 80 Section 6.1.4.2 Bank Erosion
"A 90% reduction in the anthropogenic sediment load from bank erosion is proposed".
A 50 to 75% reduction would be more realistic and possibly achievable considering the proximately of roads and infrastructure near streams that may not be feasible or too cost prohibitive to alter. A contradiction in Section 6.1.7 proposes only a 10% reduction in sediment loading from Highway (I-90) cut slopes and would remain a source of sediment that would aggravate stream channel stability and make it difficult for other source reductions to be effective.

> **<u>Response:</u>** Reducing bank erosion is more feasible than reducing traction sand sediment loading. Safety considerations need to be taken into account during road sanding allocations. Society highly values human life and this came into consideration with the road sanding allocations. Also, alternatives to road sanding such as chemical application also have an environmental impact.
>
> Alternatively, in section 6.1.5.1 the document provides an adaptive management strategy to modify the bank erosion allocation if sediment reductions from this source appear to be unachievable economically.

Shade and Temperature Allocations

<u>Comment:</u> Page 98 Twelvemile Creek Temperature Allocations and Total Maximum Daily Load
We recognize the connection between increased shading and decreased in-stream temperatures, yet question the 89% reference shading for tributaries with tree dominated canopies. Forest stands are a mosaic with varied coverage percentages from full canopy, to patchy tree mortality and canopy loss due to insects and fire. As further insect mortality occurs in Lodgepole pine stands, natural shading may be lower. What is the range of canopy coverage compared to natural conditions and how does the model allocate for fire or natural shade reduction as has happened in the past?

> **<u>Response:</u>** The sample locations used to derive canopy density targets are from non-burned riparian areas. Also, recent tree mortality via insect infestations were not apparent in areas used to derive targets. Tree mortality via insect infestations were not widespread in the St. Regis during the temperature monitoring effort. Recent fires have not significantly affected the St. Regis Watershed, although tree mortality due to insects

is limited but continues in the area. Therefore, reference shade conditions used in the TMDL do represent current reference conditions in the watershed. If significant portions of the St. Regis watershed are affected by fire or shade reducing insect damage, the targets provided are likely not going to be met due to these natural causes. If these causes of thermal increase do occur, human activities should not exacerbate the heating more than Montana's water quality standards allow. Montana's temperature standard allows only a certain amount of human caused heating. Language was added to the canopy density target section of this document about an adaptive management approach for fire and insect infestations. Discussion about the sample locations used for deriving the TMDL canopy density targets and used for temperature modeling are provided in appendix C.

Significant windfall was not apparent or widespread in the St. Regis Watershed for most riparian areas with adequate buffer zones from clear cuts. Windfall affect was apparent in some riparian buffer zones where trees were not protected from wind due to adjacent upland clearcuts. However, most windfall events would fall into the natural source category if they become prevalent, along with fire and bug kill.

Comment: Page 100, Section 7.4 Additional Surrogate Allocation Components for the St Regis Watershed "If activities that reduce shade are absolutely necessary, mitigation on a 2:1 basis should occur if the standard and TMDLs have not been met". Large landowners that have impacted riparian areas have an incentive to a trading system, yet small landowners that have protected their riparian areas may only need a stream crossing site or small treatment on a restoration site in the riparian zone that is difficult to accomplish at 2:1 level of shade mitigation. Any disturbance should require the highest level of prompt shade restoration feasible.

Response: DEQ adds that alternatives to any level of shade disturbance should be thought about thoroughly. Providing mitigation at this level provides incentive to consider alternatives to impact shade. The level of detail provided by the St. Regis TMDL would not support allocations to specific landowners. Similarly, the allocations in this document are for prevalent land use activities within the whole watershed. While DEQ agrees with some of the concepts about difficulties in implementing the mitigation that are presented above but new, unmitigated sources are not appropriate when standards are not currently achieved. Montana has committed to progressing toward implementing TMDLs and trying to meet standards in watersheds with TMDLs. This document identifies that this type of mitigation should occur at a landscape scale within the watershed. Allocation reductions for non point sources in this document are voluntary and not enforceable, although certain state and federal agencies have working objectives that consider implanting the federal clean water act. If there is no way to plan around a future activity which will reduce stream shade or produce mitigation on a land parcel basis, coordination with other local landowners should be considered for restoration on nearby land for mitigation opportunities.

Restoration and Future Monitoring Approaches

Comment: Pg 103 Agency Coordination
Please include DNRC Southwestern Land Office in the Stakeholder Coordination for achieving targets and agency coordination of restoration efforts.

Response: The document has been updated to include this information.

Comment: On page 42 (West Fork Big Creek) and other places throughout the document such as discussions for Twelvemile Creek, please note the known watershed restoration activities for which we have given you information. We have completed a lot of restoration work in the St. Regis River watershed, and that information should be taken into account (especially for Twelvemile, where we did a lot of culvert removals and decommissioning of roads, along with culvert upgrades). In addition to identifying sediment sources which are degrading water quality, it is also important to identify the watershed rehabilitation work that has been implemented which has and will continue to contribute to improved water quality. For example, in Big Creek, the number of crossings has decreased (by 5 or 6).In Twelvemile, the road density has decreased, along with the number of crossings, so those numbers should be reflected as well. Please refer to the list of restoration work emailed to you on Feb. 14, 2007 as well as the email sent to you on Oct. 9, 2007 which reiterates that this type of work should be noted because it speaks to the current conditions discussed in the source assessment as well as to meeting targets and restoration plan implementation. Sediment volumes at risk which have been reduced by this type of already implemented work (culvert upgrades and removals) was reassessed and emailed to you on Oct. 10, 2007.

Response: The restoration section has been updated to include this information.

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Sunset Mine Reclamation Project	In 1991, a bond was obtained to reclaim the Sunset Placer Mine in Sunset Creek, a tributary to South Fork Little Joe Creek. This reclamation would reinforce a weak bank, recontouring of settling ponds, shape and stabilize steep banks, plant alder cuttings, etc. to promote stabilization and growth in the area.	1991	Sunset Creek (South Fork Little Joe Creek)	500 feet streambank stabilization 2 acres placer mine reclamation

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Hendrickson Timber Sale	In 1997, the Superior Ranger District awarded the Hendrickson Timber Sale. The objective of this project was to harvest timber in the Little Joe Creek watershed. As part of the contract, roads #18557 and #4206 would receive level 2 decommissioning.	1997	Little Joe Creek	5.08 miles level 2 decommissioning
Reset Timber Sale	In September of 1997, the Superior Ranger District awarded the Reset Timber Sale. This timber sale would harvest timber in the Two Mile and Little Joe Creek watershed. Five roads under the timber sale contract received scarification and erosion control seeding, which constitutes level 2 closures.	1997	Little Joe Creek Two Mile Creek	2.31 miles level 2 decommissioning
Hiawatha Trail Stabilization	Approximately 5 rock weirs and rootwads will be used to stabilize a 200 foot long, 100 foot high eroding slope that is actively being cut by the St. Regis River into the Hiawatha Trail. Willows will also be planted to aid in bank stabilization. The slope will also be hydro-seeded to ensure revegetation.	1998	St. Regis River	50 feet streambank stabilization 100 feet rootwad, log or boulder placement 5 weirs

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Savenac Creek Stream Restoration Project	The objective of this project was to complete a full stream re-creation around an old mining dam in Savenac Creek. Approximately 550 feet of stream was rerouted and habitat structures were placed in-stream.	1998	Savenac Creek	550 feet stream channel relocation 550 feet rootwad, log or boulder placement
Tujo II Helo Timber Sale	In 1998, the Lolo National Forest, Superior Ranger District awarded the Tujo II Helo Timber Sale. This sale would salvage timber within the Little Joe Creek watershed. As part of the contract, road #16436 would receive level 2 decommissioning.	1998	Two Mile Creek Little Joe Creek	2.57 miles level 2 decommissioning
Ward Creek Flume Removal Project	A watershed monitoring flume was placed in Ward Creek in the early 1960's and is no longer in use. This project proposes to remove the flume from the stream. The removal of this flume allowed for fluvial fish passage approximately 3.0 miles upstream, which has been inaccessible since installation.	1998	Ward Creek	1 fish passage barrier removal 100 feet rootwad, log or boulder placement
2 Joe Road Obliteration Project	One of the objectives of the 2 Joe Road Obliteration Project was to conduct level 3 and 4 road decommissioning on approximately 3 miles of road in the Little Joe and Twomile Creek drainages.	1999	Twomile Creek Little Joe Creek	1.21 miles level 3 decommissioning 1.89 miles level 4 decommissioning 1 culvert removal (0.0 miles accessed)

Project Name	Project Description/Objective	Year Completed	Watershed	Activities
Tarbox Mine Reclamation Project	The objective of the Tarbox Mine Reclamation Project was to reclaim a large area disturbed from past mining by removing much of the waste rock from the area and replacing with topsoil to promote vegetation growth in the area. There were also two stream restoration points associated with this project that will be tracked in this project.	2002	Packer Creek	748 feet stream channel stabilization 2000 feet mine tailing stabilization
Powerswitch Salvage Timber Sale	The objective of this project was to harvest dead and dying timber from a result of mountain pine beetle epidemic in the area. This sale also incorporated the replacement of several fish passage culverts within the project area. One road also received level 3 decommissioning.	2003	Rock Creek	3 culvert replacements (9.62 miles of upstream usable habitat accessed)
Knox Brooks Stewardship Project	This timber stewardship project will harvest up to 2500 acres to remediate the pressures of mountain pine beetle in the area, reconstruct approximately 40 miles of road and decommissioning of approximately 50 miles of road (along with the successive removal of culverts on these roads). Resources enhancement projects designed to enhance riparian and stream channel conditions will also take place.	2004-2005	Twelvemile Creek Rock Creek	39 culvert removals (11.55 miles upstream habitat opened) 7 culvert replacements (29.99 miles upstream habitat opened) 9.67 miles level 3 decommissioning 39.67 miles level 4 decommissioning 0.296 miles level 5 decommissioning

Project Name	**Project Description/Objective**	**Year Completed**	**Watershed**	**Activities**
Middle Fork Big Creek Culvert Removal	The objective of this project was to remove and undersized culvert on the Middle Fork Big Creek on a previously closed road.	2004	Middle Fork Big Creek	1 culvert removal (4.55 miles upstream habitat opened)
West Fork Packer Timber Sale	The objective of this project was to salvage dead and dying trees in the Packer Creek watershed. As part of this project, two roads in the area received level 3 decommissioning, including culvert removals.	2005-2006	Packer Creek	1.66 miles level 3 decommissioning 1 culvert removal (0.77 miles upstream habitat opened)
Big Creek Stream Restoration Project	The objective of this project was to remove several fish passage barriers along Trail 706, along with other culverts that were not fish passage barriers, but were undersized, complete necessary stream restoration work at these sites and at other sites where erosion was occuring, decommission road #18642, change the travel plan designation on Trail 706 from motorized to non-motorized, and exchange easements with Stimson Timber Company.	2005	West Fork Big Creek	8 culvert removals (7.0 miles of upstream habitat opened) 6 streambank stabilization sites 2.38 miles of level 3 decommissioning
Rainy Creek Culvert Replacement	The objective of this project was to replace an undersized culvert that was a fish passage barrier with a culvert that would accomodate passage and high flows. The Idaho Panhandle NF completed this project to haul timber on this road.	2005	Rainy Creek	1 culvert replacement (1.14 miles upstream habitat accessed)

Comment: We also discussed including some language regarding SMZs, RHCAs, BMPs etc, especially a discussion on how they are not equal. Some are optional SMZs are optional for private land owners who are cutting timber but not for a commercial timber sale whereas RHCAs which are required INFISH buffers used by the Forest Service, and which are more stringent than SMZ buffers.

> **Response:** As noted above, the State of Montana's SMZ requirements are a set of minimum Best Management Practices which may or may not be sufficient to achieve (restore) water quality standards, to achieve riparian habitat conservation objectives, or to provide suitable fish habitat. SMZ's generally apply to a minimum of a 50 foot corridor from each stream bank. SMZ's include several types of restoration activities, such as road repair and culvert sizing for modest flood flows. Forestry Best Management Practices are intended to maintain and/or slightly improve upland and streamside watershed conditions to achieve overall watershed health. Montana Forestry BMPs proscribes stream crossing culverts that meet 25 year flood flows, while Forestry BMPs are being developed for fish passage suitability for new culverts. RHCAs include 300 foot riparian buffer zones that provide shade and sediment filtering, exclude road building in riparian zones as much as possible, and routing water off of existing sediment contributing roads. Watershed RCHA practices and reasonable water quality BMPs also include appropriate culvert sizing (50 or 100 year flood flows), fish passage suitable culverts in fish bearing streams, and instream physical habitat characteristics (bank stability, instream fine sediment percentage, pool frequency, pool width/depth ratio, and large woody debris).
>
> Montana's SMZ law and or/ RHCA and INFISH standards are not synonymous with a term used in Montana's water quality rules, "all reasonable land, soil and water conservation practices".
>
> Clarifying language was added to Section 8 of the document to help tie each of these "BMPs" into allocation approaches for sediment or temperature TMDLs.

Comment: Monitoring Section. As mentioned above, major changes have taken place in Twelvemile Creek (road decommisioning, culvert removals and upgrades), it would be good to re-evaluate fine sediment and RSI targets now to see what/if changes have occurred.

> **Response:** DEQ will complete a TMDL review via an adaptive management approach identified in Section 9 of the TMDL document. If feasible, USFS should collect this information after restoration project implementation and it can be used by DEQ during the scheduled TMDL review. Otherwise, DEQ may collect this data during the TMDL review if significant restoration work was completed in the watershed during the time between initial TMDL data collection and the future TMDL review.

Comment: Restoration Section. It is disappointing to see, after all the field work and analysis conducted, that more specific restoration measures were not identified, such as particular stretches of the St. Regis River that could be improved by stream bank revegetation, meander reactivation, habitat enhancement and other more site-specific measures. In general, the restoration section is very generalized and is not very specific to the St. Regis watershed. If possible, we recommend including more specific restoration strategies that can be identified from the data collection, analysis and assessment efforts.

> **Response:** Some of the detail indicated above can be found in respective appendices. DEQ has provided a framework for building a more detailed water quality restoration plan by compiling this document and identifying sources to general land use categories within each of the watersheds in need of a TMDL. DEQ recommends a locally led effort for more detailed restoration planning. This would involve all significant land managers and could include other important restoration efforts such as fishery habitat, local zoning and weed management along with water quality issues. This level of detail would likely require a higher level of local stakeholder input than what was provided in the TMDL planning effort. Funding for further watershed restoration efforts may be supplemented by competitive state and federal grants administered by DEQ and DNRC.

Comment: Page 109. For the SMZ law to have the maximum beneficial effect it should be applied consistently on all lands, therefore we support the inclusion of this statement: "The State of Montana will not consider SMZ law waivers without consulting with DEQ and considering DEQ comments".

> **Response:** Thank you for your comment.