Lower Gallatin Planning Area TMDLs & Framework Water Quality Improvement Plan

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ERRATA SHEET FOR THE LOWER GALLATIN PLANNING AREA TMDLS & FRAMEWORK WATER QUALITY IMPROVEMENT PLAN

This TMDL was approved by EPA on March 28, 2013. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version had minor changes that are explained and corrected on this errata sheet. If you have a bound copy, please note the corrections listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

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

The following table contains corrections to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the Lower Gallatin Planning Area TMDLs & Framework Water Quality Improvement Plan document. The text in error and the correct text are underlined.

Location in the TMDL	Original Text	Corrected Text
Page 11-1, last paragraph, second sentence.	Excerpts from the comment letters and DEQ responses are provided in **Appendix G**.	Excerpts from the comment letters and DEQ responses are provided in **Appendix H.**

Errata Sheet for the "Lower Gallatin Planning Area TMDLs & Framework Water Quality Improvement Plan"

The Environmental Protection Agency (EPA) approved 40 sediment, nutrient, and *E. coli* TMDLs in the Lower Gallatin TMDL planning area addressing 41 impairments on March 28th, 2013. This document included Total Nitrogen (TN) and Total Phosphorus (TP) nutrient TMDLs for all three segments of the East Gallatin River which was determined to be impaired by a variety of point and nonpoint sources. This addition provides the linkage between the nutrient TMDLs developed to address nutrient impairments and existing pH impairment listings on the middle and lower segments of the East Gallatin River.

Listing History

On the 2012 303(d) List and the draft 2014 303(d) List, there are two pH impairment listings on East Gallatin River assessment units which include the middle segment (Bridger Creek to Smith Creek; MT41H003_020) and the lower segment (Smith Creek to Gallatin River; MT41H003_030). Both segments are classified as B-1. At the time the East Gallatin River TMDLs were being developed, DEQ personnel believed that updated assessments would determine that pH was no longer impairing the East Gallatin River based on available data. However, a formal assessment in fall 2013 found that existing data did not clearly indicate that pH was no longer impairing the East Gallatin River. In the middle segment, pH data collected as part of nutrient sampling in 2005 and 2009 ranged from 8.21 to 9.06; the range in the lower segment during the same timeframe was 8.15 to 9.10.

Applicable Water Quality Standards

For B-1 classified streams, the Montana water quality standard for pH (17.30.623(c)) is: induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0. This standard is protective of beneficial uses.

Nutrient TMDL Targets and Linkage to Attainment of pH Water Quality Standards

Impairment from high pH values in a waterbody are a secondary response to excess nutrient pollution and excessive algal growth. Excess nitrogen and phosphorus from human sources can cause excess algal growth, which in turn depletes the supply of dissolved oxygen, killing fish and other aquatic life. Excess nutrient concentrations in surface water create algal blooms, which can alter pH by two different mechanisms. Algal-blooms are caused by a rapid increase in net primary production and photosynthesis when nutrients are available at concentrations greater than naturally occurring levels. The capture of CO_2 by photosynthesis removes carbon from the system raising pH levels (Zheng and Paul, 2014). Conversely, respiration and decomposition processes lower pH by releasing carbon dioxide which forms carbonic acid and hydroxyl ions (Zheng and Paul, 2014). Diel cycling of pH often occurs in streams with low acid neutralizing capacity and has been found to be related to excessive algal growth (Zheng and Paul, 2014). Continuously measured pH is a good indicator which captures heterotrophic and autotrophic responses which are generally sensitive to nutrient stress and provide a clear linkage to aquatic life (United States Environmental Protection Agency, 2014). Therefore, controlling excess nutrient inputs to a waterbody via TMDL development and implementation will also control swings in pH harmful to aquatic life and result in attainment of the pH standard as high pH levels can be toxic to fish and other organisms (Zheng and Paul, 2014).

It should be noted that pH effluent data the city of Bozeman Water Reclamation Facility (WRF) was reviewed to determine if simple mixing was causing an exceedance of the water quality standard in the middle segment of the East Gallatin River. Between 2002 and 2011, pH effluent values ranged from 6.57 to 8.60 with an average value of 7.49 and a median value of 7.54. Simple mixing with known East Gallatin River flows and pH values were not observed to violate the water quality standard. Therefore, simple mixing from the WRF point source is not the source of the pH impairment but rather the availability of excess nutrients paired with diel cycling caused by photosynthesis and respiration in the water column is the most probable cause of the pH impairment.

As described in the Lower Gallatin Planning Area TMDLs and Framework Water Quality Improvement Plan, nutrient targets identified for the East Gallatin River will ensure attainment of all beneficial uses, but particularly of aquatic life support, by limiting algal growth to concentrations that will result in meeting the standard for other response variables such as dissolved oxygen and pH. In addition to pH, the middle and lower segments of the East Gallatin River are impaired by both TN and TP, although larger reductions of TN are needed to achieve the TMDL and restore beneficial. For this reason, the TN TMDLs are used as surrogate TMDLs for the pH impairments on the middle and lower segments of the East Gallatin River. In the Lower Gallatin TMDL document, necessary TN reductions in the East Gallatin River ranged from approximately 75% in the middle segment to 50% in the lower segment.

Nutrient Targets and TN TMDLs for the middle and lower segments of the East Gallatin River

Stream segment	TP target (mg/L)	TN target (mg/L)	TN TMDL (lbs/day)
East Gallatin between Bridger Creek and Hyalite Creek	≤0.030	≤0.300	60.83
East Gallatin between Hyalite Creek and Smith Creek	≤0.060	≤0.290	92.79
East Gallatin between Smith Creek and mouth	≤0.030	≤0.300	234.32

<u>Summary</u>

Based on the linkage between nutrient impairment and pH, this addition clarifies that the TN TMDL for the East Gallatin River (Bridger Creek to Smith Creek) addresses both the nutrient and the pH impairments on assessment unit MT41H003_020. Additionally, the TN TMDL for the East Gallatin River (Smith Creek to Gallatin River) addresses both the Total Nitrogen and the pH impairments on the assessment unit MT41H003_030. Therefore, the Lower Gallatin document contains 40 TMDLs addressing 43 impairments. For your reference, the nutrient targets and TN TMDLs for the aforementioned segments of the East Gallatin River are in the table above but they are described in more detail in **Section 6** of the Lower Gallatin TMDL document.

<u>Literature Cited</u>

United States Environmental Protection Agency. 2014. Experts Workshop Summary: Nutrient Enrichment Indicators in Streams. EPA-822-S-13-001.

Zheng, Lei and Michael J. Paul. 2014. Effects of Eutrophication on Stream Ecosystems.

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple entities for their contributions in the development of the sediment TMDLs contained in this document. The Greater Gallatin Watershed Council (GGWC) and the Gallatin Local Water Quality District (GLWQD) provided support throughout the Lower Gallatin TMDL planning process by providing assistance with the identification of stakeholders and coordinating stakeholder meetings, collecting and reporting water quality data, administering contracts for the completion of source assessments, and via public outreach and education. The GGWC will also be involved in implementing many of the water quality improvement recommendations contained in this document.

Katie Makarowski, the DEQ Monitoring and Assessment project lead in the Lower Gallatin watershed was an invaluable asset for the analyses and determinations of impairment. Steve Cook, a previous water quality planner with DEQ, provided planning support for these TMDLs and was also a vital member of the field crews that collected data for this project. DEQ would like to thank Carrie Greeley, an administrative assistant for the Watershed Management Section of DEQ, for her time and efforts formatting this document.

Multiple consultants provided significant contributions in the development of several appendices and attachments. Atkins (formerly PBS&J) developed **Attachment A**, *Sediment and Habitat Assessment.* Oasis Environmental developed **Attachment B**, 2009 *Lower Gallatin TMDL Planning Area Nutrient, Algae and E. coli Source Assessment*. Water and Environmental Technologies, PC developed **Attachment C**, *Upland Sediment Assessment*, and provided significant contributions to **Appendix C***, Road Sediment Assessment .*

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ACRONYM LIST

Acronym	Definition
AFDW	Ash Free Dry Weight
AFO	Animal Feeding Operation
APO	Area wide Planning Organization
ARM	Administrative Rules of Montana
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (Federal)
BMP	Best Management Practices
CAFO	Concentrated (or Confined) Animal Feed Operations
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DIC	Decrease in Concentration
DMR	Discharge Monitoring Report
DNRC	Department of Natural Resources & Conservation
DO	Dissolved Oxygen
EMC	Event Mean Concentration
DQA	Data Quality Assessment
EMC	Event Mean Concentration
EPA	Environmental Protection Agency (US)
EQIP	Environmental Quality Initiatives Program
FWP	Fish, Wildlife, and Parks (Montana)
GGWC	Greater Gallatin Watershed Council
GIS	Geographic Information System
GLWQD	Gallatin Local Water Quality District
GWIC	Groundwater Information Center
HBI	Hilsenhoff Biotic Index
HDPE	High-Density Polyethylene
HRU	Hydrologic Response Units
HT	Holding Time
IDDE	Illicit Discharge Detection and Elimination
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LWD	Large Woody Debris
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MDT	Montana Department of Transportation
MEANSS	Method for Estimating Attenuation of Nutrients from Septic Systems
MEP	Maximum Extent Practicable
MGD	Million Gallons per Day
MGWPCS	Montana Ground Water Pollution Control System

Acronym	**Definition**
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MS4	Municipal Separate Storm Sewer System
MSU	Montana State University
NBS	Near Bank Stress
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NRDP	Natural Resource Damage Program
NTU	Nephelometric Turbidity Units
NURP	Nationwide Urban Runoff Program
NWIS	National Water Information System
PCB	PolyChlorinated Biphenyls
PIBO	PACFISH/INFISH Biological Opinion
SAP	Sampling and Analysis Plan
SMZ	Streamside Management Zone
STORET	EPA STOrage and RETrieval database
SWAT	Soil & Water Assessment Tool
SWMM	Storm Water Management Model
SWMP	Storm Water Management Program (DEQ)
SWPPP	Storm Water Pollution Prevention Plan
SWTD	Subsurface Wastewater Treatment and Disposal
TIE	TMDL Implementation Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TPN	Total Persulfate Nitrogen
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
UV	Ultraviolet
VFS	Vegetated Filter Strips
WET	Whole Effluent Toxicity
WLA	Wasteload Allocation
WQT	Water Quality Target
WRF	Water Reclamation Facility
WRP	Watershed Restoration Plan
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for 15 impaired tributaries to the Gallatin River (**Figure A-1** in **Appendix A**). A total of 40 individual TMDLs were developed for the identified tributaries.

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

The Lower Gallatin River TMDL Planning Area (TPA) is located in Gallatin, Madison, and Park Counties and includes the lower portion of the Gallatin River and its tributaries. The tributaries originate in the Gallatin Mountains to the south and the Bridger Mountains to the east. The planning area encompasses approximately 997 square miles (638,631 acres) between the headwaters of Hyalite Creek at its southern end, and the confluence of the Gallatin, Madison and Jefferson Rivers at its northern end. Land ownership is divided among federal, state and private landowners.

DEQ determined that 14 tributaries do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with sediment, nutrients and pathogens (see **Table ES-1**).

Sediment TMDLs are provided for 11 waterbody segments in the Lower Gallatin TPA: Bear, Bozeman, Camp, Dry, Godfrey, Jackson, Reese, Rocky, Smith, Stone, and Thompson creeks. Sediment is affecting beneficial uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration goals for sediment were established on the basis of fine sediment levels in fish and macroinvertebrate habitat, channel form, and pool habitat. DEQ believes that once these water quality goals are met, all water uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, roads, and point sources. In many streams, best management practices (BMPs) are in place, but they are still recovering from the effects of historical land management practices. The most significant remaining human sediment sources are roads and degradation of the riparian zone as a result of agriculture and urban development. The Lower Gallatin watershed sediment TMDLs indicate that reductions in sediment loads ranging from 37% to 68% will satisfy the water quality restoration goals.

Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include BMPs for building and maintaining roads, grazing, harvesting timber, and land development. In addition, they includes BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Nutrient TMDLs are provided for 13 waterbody segments in the Lower Gallatin TPA: Bear, Bozeman, Bridger, Camp, Dry, Godfrey, Hyalite, Jackson, Mandeville, Reese, Smith, and Thompson Creeks in addition to the entire length of the East Gallatin River. Nutrients are affecting beneficial uses in these streams by affecting macroinvertebrate populations and increasing net primary production in the water column impacting habitat. If necessary nutrient reductions are achieved then beneficial uses should be restored. Nutrients are impairing the beneficial uses of aquatic life (including coldwater fishery), primary contact recreation and agricultural uses.

Nutrient loads were quantified for all identified sources such as agricultural practices, residential and developed lands impacts, and nutrient point sources as well as natural background. Several stream segments are currently meeting nutrient TMDLs while the more severely impacted waterbodies require >80% reduction in the existing TN or TP load to achieve the TMDL. Major nonpoint nutrient sources include agriculture and residential sources including subsurface wastewater disposal and treatment. The latter becomes more significant in basins with higher septic densities.

Pathogen TMDLs for *E. coli* were developed for Bozeman, Camp, Godfrey, Reese, and Smith Creeks. Loads were quantified from agricultural, anthropogenic and natural background sources. Pathogens affect the beneficial uses of primary contact and recreation as well as aquatic life and the fishery. Necessary reductions range from <5% to 84%. Many of the same BMPs that target sediment and nutrients are also applicable to pathogens.

Implementation of most water quality improvement measures for nonpoint sources described in this plan is based on voluntary actions of watershed stakeholders. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

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

Table ES-1. List of Impaired Waterbodies and their Impaired Uses in the Lower Gallatin TMDL Project Area with Completed Sediment, Nutrient and Pathogens TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
BEAR CREEK, headwaters to mouth (Rocky Creek)	Sediment	Sediment	AQUATIC LIFE COLDWATER FISHERY
	Total Phosphorus	Nutrients	AQUATIC LIFE PRIMARY CONTACT RECREATION
BRIDGER CREEK, headwaters to mouth (East Gallatin River)	Nitrates + Nitrites	Nutrients	AQUATIC LIFE PRIMARY CONTACT RECREATION
CAMP CREEK, headwaters to mouth (Gallatin River)	*Escherichia coli*	Pathogens	PRIMARY CONTACT RECREATION
	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
	Sediment	Sediment	AQUATIC LIFE

Table ES-1. List of Impaired Waterbodies and their Impaired Uses in the Lower Gallatin TMDL Project Area with Completed Sediment, Nutrient and Pathogens TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
DRY CREEK, headwaters to mouth (East Gallatin River)	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
	Sediment	Sediment	AQUATIC LIFE
EAST GALLATIN RIVER, confluence of Rocky and Bear Creeks to Bridger Creek	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
EAST GALLATIN RIVER, Bridger Creek to Smith Creek	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
EAST GALLATIN RIVER, Smith Creek to mouth (Gallatin River)	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
GODFREY CREEK, headwaters to mouth (Moreland Ditch)	*Escherichia coli*	Pathogens	PRIMARY CONTACT RECREATION
	Total Nitrogen	Nutrients	AQUATIC LIFE AGRICULTURAL
	Total Phosphorus	Nutrients	AQUATIC LIFE AGRICULTURAL
	Sediment	Sediment	AQUATIC LIFE AGRICULTURAL
HYALITE CREEK, Bozeman water supply intake to the mouth (East Gallatin River)	Total Nitrogen	Nutrients	AQUATIC LIFE
JACKSON CREEK, headwaters to mouth (Rocky Creek)	Total Phosphorus	Nutrients	AQUATIC LIFE PRIMARY CONTACT RECREATION
	Sediment	Sediment	AQUATIC LIFE
MANDEVILLE CREEK, headwaters to mouth (East Gallatin River)	Total Nitrogen	Nutrients	AQUATIC LIFE
	Total Phosphorus	Nutrients	AQUATIC LIFE
REESE CREEK, headwaters to mouth (Smith Creek)	*Escherichia coli*	Pathogens	PRIMARY CONTACT RECREATION
	Total Nitrogen	Nutrients	AQUATIC LIFE
	Nitrates + Nitrites	Nutrients	AQUATIC LIFE
	Sediment	Sediment	AQUATIC LIFE
ROCKY CREEK, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	Sediment	Sediment	AQUATIC LIFE
SMITH CREEK, confluence of Ross and Reese Creeks to mouth (East Gallatin River)	*Escherichia coli*	Pathogens	PRIMARY CONTACT RECREATION
	Total Nitrogen	Nutrients	AQUATIC LIFE
	Nitrates + Nitrites	Nutrients	AQUATIC LIFE
	Sediment	Sediment	AQUATIC LIFE

Table ES-1. List of Impaired Waterbodies and their Impaired Uses in the Lower Gallatin TMDL Project Area with Completed Sediment, Nutrient and Pathogens TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
SOURDOUGH CREEK (BOZEMAN CREEK)[a], confluence of Limestone Creek and Bozeman Creek to the mouth (East Gallatin River)	*Escherichia coli*	Pathogens	PRIMARY CONTACT RECREATION
	Sediment	Sediment	AQUATIC LIFE
	Total Nitrogen	Nutrients	AQUATIC LIFE PRIMARY CONTACT RECREATION
STONE CREEK, headwaters to mouth (Bridger Creek)	Sediment	Sediment	AQUATIC LIFE
THOMPSON CREEK (Thompson Spring), headwaters to mouth (East Gallatin River)	Total Nitrogen	Nutrients	AQUATIC LIFE PRIMARY CONTACT RECREATION
	Sediment	Sediment	AQUATIC LIFE

[a] Sourdough Creek is identified on the high resolution National Hydrography Dataset (NHD) as Bozeman Creek and will be referred to as Bozeman Creek henceforth.

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment, nutrients and pathogens problems in the Lower Gallatin TMDL project area. This document also presents a general framework for resolving these problems. **Figure A-1**, in **Appendix A**, shows a map of waterbodies in the Lower Gallatin project area with sediment, nutrients and pathogens pollutant listings.

1.1 BACKGROUND

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

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

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

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

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

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

- Quantifying the magnitude of pollutant contribution from their sources
- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

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

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

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists all of the impairment causes from the "2012 Water Quality Integrated Report" that are addressed in this document (also see **Figure A-1**). Each pollutant impairment falls within a TMDL pollutant category (e.g. sediment, nutrients, or pathogens) and this document is organized by those categories.

New data assessed during this project identified new nutrient impairment causes for seven waterbodies. These impairment causes are identified in **Table 1-1** as not being on the 2012 303(d) List (within the integrated report).

TMDLs are completed for each waterbody – pollutant combination, and this document contains TMDLs (**Table 1-1**) addressing 41 pollutant impairment causes. There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 8.0**. **Section 8.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

Table 1-1. Water Quality Impairment Causes for the Lower Gallatin Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR*
BEAR CREEK, headwaters to mouth (Rocky Creek)	MT41H003_081	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Excess Algal Growth	Not a Pollutant	Addressed by TP TMDL in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Solids (Suspended/Bedload)	Sediment	Addressed by sediment TMDL in this document	Yes
BOZEMAN CREEK, confluence of Limestone Creek and Bozeman Creek to the mouth (East Gallatin River)	MT41H003_040	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Chlorophyll-*a*	Not a Pollutant	Addressed by TN TMDL in this document	Yes
		Escherichia coli	Pathogens	*E. coli* TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
BRIDGER CREEK, headwaters to mouth (East Gallatin River)	MT41H003_110	Chlorophyll-*a*	Not a Pollutant	Addressed by N03+N02 TMDL in this document	Yes
		Nitrate+Nitrite	Nutrients	N03+N02 TMDL contained in this document	No
CAMP CREEK, headwaters to mouth (Gallatin River)	MT41H002_010	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Escherichia coli	Pathogens	*E. coli* TMDL contained in this document	Yes
		Low flow alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorous (Total)	Nutrients	TP TMDL contained in this document	No
		Other anthropogenic substrate alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes

Table 1-1. Water Quality Impairment Causes for the Lower Gallatin Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR*
DRY CREEK, headwaters to mouth (East Gallatin River)	MT41H003_100	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
EAST GALLATIN RIVER, confluence of Rocky and Bear Creeks to Bridger Creek	MT41H003_010	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
EAST GALLATIN RIVER, Bridger Creek to Smith Creek	MT41H003_020	Excess Algal Growth	Not a Pollutant	Addressed by nutrient TMDLs in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
EAST GALLATIN RIVER, Smith Creek to mouth (Gallatin River)	MT41H003_030	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
GODFREY CREEK, headwaters to mouth (Moreland Ditch)	MT41H002_020	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Excess Algal Growth	Not a Pollutant	Addressed by nutrient TMDLs in this document	Yes
		Escherichia coli	Pathogens	*E. coli* TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
HYALITE CREEK, Bozeman water supply intake to the mouth (East Gallatin River)	MT41H003_132	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No

Table 1-1. Water Quality Impairment Causes for the Lower Gallatin Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR*
JACKSON CREEK, headwaters to mouth (Rocky Creek)	MT41H003_050	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Chlorophyll-*a*	Not a Pollutant	Addressed by a TP TMDL in this document	Yes
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
MANDEVILLE CREEK, headwaters to mouth (East Gallatin River)	MT41H003_021	Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No
		Phosphorus (Total)	Nutrients	TP TMDL contained in this document	No
REESE CREEK, headwaters to mouth (Smith Creek)	MT41H003_070	*Escherichia coli*	Pathogens	*E. coli* TMDL contained in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	No
		Nitrates	Nutrients	N03+N02 TMDL contained in this document	Yes
		Solids (Suspended/Bedload)	Sediment	Addressed by sediment TMDL in this document	Yes
ROCKY CREEK, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	MT41H003_080	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Other anthropogenic substrate alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
SMITH CREEK, confluence of Ross and Reese Creeks to mouth (East Gallatin River)	MT41H003_060	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Escherichia coli	Pathogens	*E. coli* TMDL contained in this document	Yes
		Total Nitrogen	Nutrients	TN TMDL contained in this document	No
		Nitrates	Nutrients	N03+N02 TMDL contained in this document	Yes
		Physical substrate habitat alterations	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes
STONE CREEK, headwaters to mouth (Bridger Creek)	MT41H003_120	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes

Table 1-1. Water Quality Impairment Causes for the Lower Gallatin Project Area Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2012 IR*
THOMPSON CREEK (Thompson Spring), headwaters to mouth (East Gallatin River)	MT41H003_090	Alteration in streamside or littoral vegetative covers	Not a Pollutant	Addressed by sediment TMDL in this document	Yes
		Chlorophyll-*a*	Not a Pollutant	Addressed by TN TMDL in this document	Yes
		Nitrogen (Total)	Nutrients	TN TMDL contained in this document	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL contained in this document	Yes

* IR refers to the Integrated Report

1.3 Document Layout

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

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

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

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

Sections 5.0 – 7.0 Sediment, Nutrients, and Pathogens TMDL Components:
Each section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 8.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 9.0 Restoration Objectives and Implementation Strategy:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 10.0 Monitoring Strategy:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Lower Gallatin River Watershed Sediment, Nutrients, and Pathogens Assessments and TMDLs".

Section 11.0 Stakeholder and Public Participation:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 Lower Gallatin Watershed Description

This section includes a summary of the physical characteristics and social profile of the Lower Gallatin TMDL planning area (TPA) that has been excerpted from the "Lower Gallatin Watershed Characterization Report" (PBS&J, 2007).

2.1 Physical Characteristics

The following information describes the physical characteristics of the Lower Gallatin watershed.

2.1.1 Location

The Lower Gallatin TPA is located in the south-central portion of the state, includes parts of Gallatin, Park, and Madison Counties, and is within the Gallatin River watershed. The planning area includes streams draining the northern flanks of the Gallatin Range and much of the Bridger Range. Overall, the Lower Gallatin TMDL Planning Area (TPA) covers approximately 997 square miles (638,381 acres) between the headwaters of Hyalite Creek at its southern end, and the confluence of the Gallatin, Madison, and Jefferson rivers at its northern end. The towns of Bozeman and Belgrade occur in the central portion of the planning area, and the town of Manhattan occurs in the northwestern portion of the planning area. The Upper Gallatin TPA occurs south (upstream) of the Lower Gallatin TMDL Planning Area. Water quality issues in the Upper Gallatin TPA were addressed separately from this effort in a TMDL document completed in September 2010.

2.1.2 Climate

The Lower Gallatin TPA has a cold continental climate characterized by warm, dry summers and cold, dry winters. The average annual temperature in Bozeman is 44.6°F. According to the Natural Resource and Conservation Service (NRCS), the typical growing season in Bozeman is 149 days long and begins around May 5th and ends around October 1st.

Precipitation is fairly evenly distributed throughout fall, spring and summer, but is relatively low in winter. Total annual precipitation is variable in the planning area, ranging from 55 inches in the upper portions of the Gallatin and Bridger mountain ranges to 12.3 inches in the western portion of the planning area near Manhattan and Three Forks. Rainfall occurs primarily as high-intensity, convective thunderstorms during spring and fall, while precipitation in winter is in the form of snow. At Montana State University in Bozeman the average annual precipitation is approximately 18.4 inches, Gallatin Gateway is generally slightly wetter (22.6 inches) and Belgrade slightly drier (14.1 inches). The driest time of year is typically November through February and the wettest time of year April through June.

2.1.3 Hydrology

The Gallatin River originates in Yellowstone National Park, flows through the Gallatin Canyon, and finally joins the Madison and Jefferson Rivers to form the Missouri River. The 3 main tributaries to the Gallatin River in the project area are Hyalite Creek, Bridger Creek and the East Gallatin River. Bridger and Hyalite Creeks are tributaries to the East Gallatin River. Streamflows are at their highest between May and June. These are also the months with the greatest amount of precipitation and snowmelt runoff. Streamflows begin to decline in late June or early July, reaching minimum flow levels in September when some streams go dry. About 90,000 acres or 14% of the Gallatin River watershed area (upper and lower) is irrigated. Streamflows begin to rebound in October and November when irrigation has ended and fall storms supplement the base-flow levels. Elevations range from a high of 10,333 feet to a low of approximately 4,030 feet with an average elevation of approximately 5,500 feet. Slope gradients within the watershed vary widely from the gentle slopes in the valleys to steep mountain slopes.

Though variable among monitoring locations, groundwater levels generally fluctuate seasonally and in response to irrigation, with groundwater elevations being highest in the spring through mid-summer and declining for the rest of the year. Hackett et al. (1960) estimated that the average annual discharge of groundwater from the Gallatin Valley as surface flow to be approximately 240,000 acre-feet per year.

The source for the majority of groundwater in the valley is the Gallatin River (Hackett et al., 1960). Recharge to the Gallatin Valley aquifers comes primarily from infiltration of irrigation water and seepage from streams (e.g., Gallatin, East Gallatin, Hyalite), particularly during periods of high runoff (Hackett et al., 1960). Groundwater in the valley flows from the east and southeast to the north-northwest and discharges in the area around Logan at the northwest corner of the valley.

2.1.4 Geology, Soils, and Stream Morphology

The geology of the Lower Gallatin TMDL Planning Area is primarily comprised of sedimentary rock formations and alluvium, though the Gallatin and Madison Ranges at the southern end of the planning area are predominantly volcanic. The streams eroding these mountains have created alluvial fans at the edges of the valleys and have deposited silt, sand, and gravel as alluvial valley fill throughout the area. Modern streams have reworked the valley fill deposits, creating terraces and floodplains at the lower elevations in the valley.

Four soil types comprise approximately 35 percent of the soils in the planning area, with the Whitefish-Gallatin-Helmville soil type being the most dominant and comprising 12 percent of the Lower Gallatin TPA. These soils are generally well-drained loams that formed from alluvium, colluvium and/or eolian sources. There are four hydrologic soil groups: group A soils have a high infiltration rate and a low runoff potential, group B soils have a moderate infiltration rate/ moderate runoff potential, group C soils have a slow infiltration rate and a moderate-high runoff potential, and group D soils have a very slow infiltration rate and a high runoff potential (Natural Resource Conservation Service, 2007). The majority of the planning area is comprised of B soil types, but that there is a relatively consistent band of C type soils that runs along the base of the foothills of the Bridger and Gallatin mountain ranges. The D soil type is prevalent on the mountaintops and north and west of Belgrade in the Horseshoe Hills area.

Many tributary streams in the Lower Gallatin watershed have been historically altered to accommodate a variety of land uses and/or transportation networks. These alterations can significantly affect sediment transport dynamics of streams and may affect streambank stability.

2.1.5 Land Use

From the 2001 National Land Cover Dataset, the Lower Gallatin TPA is relatively rural, with Bozeman and Belgrade containing the majority of urban and suburban development. In fact all of the urban/residential/commercial types of land cover represented only 34,564 acres (5.3 percent) of the entire planning area (**Figure 2-1**). The upper slopes of the Bridger and Gallatin Ranges are predominately evergreen forest and represent approximately 27.5 percent of the planning area. At lower elevations, vegetation types are generally grasslands (23.7 percent), shrublands (13.1 percent), or agricultural in the forms of pasture/hay, cultivated crops (27.9 percent).

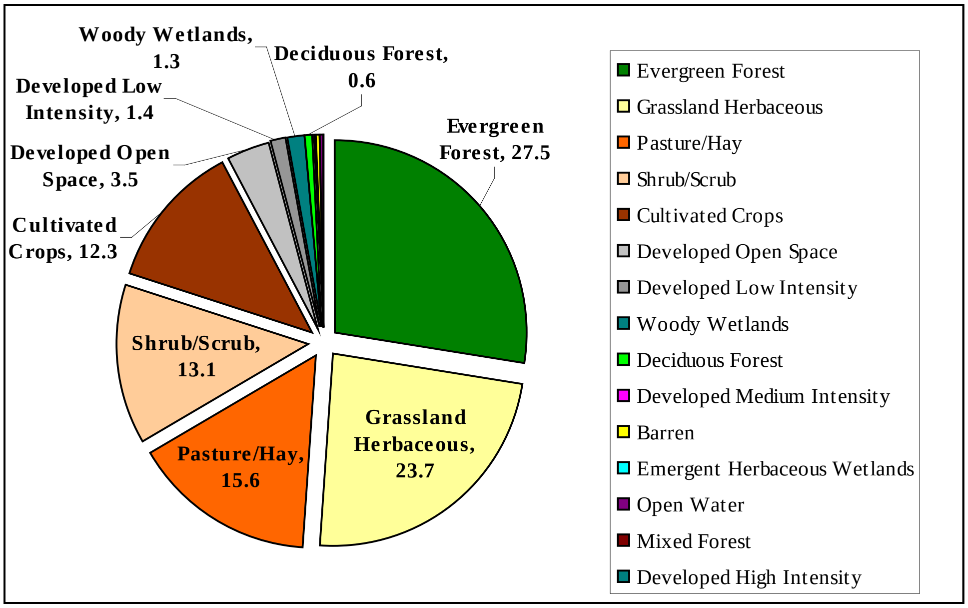

Figure 2-1. Land use categories for the Lower Gallatin TMDL project area, 2003

The dataset used in the Watershed Characterization is now 10 years old and is likely no longer accurate for the TPA. However, it is reported in this document as it is the most recent land use assessment completed in the Lower Gallatin TPA.

2.2 Social Profile

The following information describes the social profile of the Lower Gallatin watershed.

2.2.1 Land Ownership

Private land dominates the Lower Gallatin watershed with 66.3% of the TPA in private ownership. The Gallatin National Forest, U.S. Forest Service is the largest single landowner with 21.2% of the area. Ownership in the remaining 12.5% of the planning area includes Montana State Trust lands (4.1%), Gallatin Valley Land Trust (2.8%), the Nature Conservancy (2.7%), Montana Land Reliance (1.4%), City Government (0.6%), and the Montana University System (0.3%). This data synthesis was completed using 2007 cadastral information.

2.2.2 Population

Population data is not available specific to the Lower Gallatin TPA. However, 97.5% of the TPA is within Gallatin County. While the TPA covers only 38.3% of Gallatin County, nearly all the areas with the highest population densities and incorporated places in the county are within the boundaries of the Lower Gallatin TPA. Therefore, the use of population estimates for the county and the most significant incorporated place in the county is appropriate. The population of Gallatin County increased 24.2% from 67,831 in 2000 to 89,513 in 2010. The city of Bozeman had an observed increase in population of 26.2% from 27,509 in 2000 to 37,280 in 2010. There has been substantial population growth in the TPA since 2000.

3.0 Montana Water Quality Standards

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

Montana's water quality standards include four main parts:

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

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

3.1 Lower Gallatin Watershed Stream Classifications and Designated Beneficial Uses

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. In the Lower Gallatin TPA, 3 assessment units are classified as A-1 which includes the upper and middle segments of Hyalite Creek and Hyalite Reservoir. Twenty assessment units within the watershed are classified as B-1. The difference between A-1 and B-1 classifications is that B-1 may contain impurities not natural to the stream that are removable by conventional treatment.

Streams classified A-1 and B-1 are suitable for:

- Drinking
- culinary and food processing purposes after conventional treatment
- bathing
- swimming
- recreation
- growth and propagation of salmonid fishes and associated aquatic life
- waterfowl
- furbearers
- agricultural water supply
- industrial water supply

While some of the waterbodies might not actually be used for a designated use water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix B**.

Eighteen waterbody segments in the Lower Gallatin watershed are listed in the "2012 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). Waterbody segments that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL. DEQ describes impairment as either partially supporting (P) or not supporting (N), based on assessment results. Not supporting is applied to not meeting a drinking water standard, and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana's use support categories can be found in **Appendix B**. Mandeville Creek in not included in **Table 3-1** as it was not initially assessed until after the 2012 IR report was completed. TMDLs developed for each stream may be found in the appropriate sections for each pollutant group.

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

Waterbody & Location Description	Waterbody ID	Use Class	Aquatic Life	Agriculture	Drinking Water	Recreation
BEAR CREEK, headwaters to mouth (Rocky Creek)	MT41H003_081	B-1	P	F	F	P
BOZEMAN CREEK, confluence of Limestone Creek and Bozeman Creek to the mouth (East Gallatin River)	MT41H003_040	B-1	N	F	F	P
BRIDGER CREEK, headwaters to mouth (East Gallatin River)	MT41H003_110	B-1	P	F	F	P
CAMP CREEK, headwaters to mouth (Gallatin River)	MT41H002_010	B-1	P	F	F	P
DRY CREEK, headwaters to mouth (East Gallatin River)	MT41H003_100	B-1	P	F	F	N
EAST GALLATIN RIVER, confluence of Rocky and Bear Creeks to Bridger Creek	MT41H003_010	B-1	P	F	F	F
EAST GALLATIN RIVER, Bridger Creek to Smith Creek	MT41H003_020	B-1	P	F	F	P
EAST GALLATIN RIVER, Smith Creek to mouth (Gallatin River)	MT41H003_030	B-1	P	F	F	F
GODFREY CREEK, headwaters to mouth (Moreland Ditch)	MT41H002_020	B-1	P	P	F	N
HYALITE CREEK, headwaters to the top of Hyalite Reservoir	MT41H003_129	A-1	P	F	F	P
HYALITE CREEK, Hyalite Reservoir to the Bozeman water supply diversion ditch	MT41H003_130	A-1	P	F	F	P
HYALITE CREEK, Bozeman water supply diversion ditch to mouth (East Gallatin River)	MT41H003_132	B-1	X	X	X	P
JACKSON CREEK, headwaters to mouth (Rocky Creek)	MT41H003_050	B-1	P	F	F	P
REESE CREEK, headwaters to mouth (Smith Creek)	MT41H003_070	B-1	P	F	F	N
ROCKY CREEK, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	MT41H003_080	B-1	P	F	X	F
SMITH CREEK, confluence of Ross and Reese Creeks to mouth (East Gallatin River)	MT41H003_060	B-1	P	F	X	N
STONE CREEK, headwaters to mouth (Bridger Creek)	MT41H003_120	B-1	P	F	F	F
THOMPSON CREEK (Thompson Spring), headwaters to mouth (East Gallatin River)	MT41H003_090	B-1	P	F	F	P

KEY: F = Fully Supporting, P = Partially Supporting, N = Not Supporting, T = Threatened, X = Not Assessed
Note: All Coldwater Fishery and Warm Water Fishery impairments will be combined with Aquatic Life use impairment, starting with the 2012 IR (i.e., only "Aquatic Life" will appear in the IR).

3.2 Lower Gallatin Water Quality Standards

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

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Chronic aquatic life standards prevent long-term, low level exposure to pollutants. Acute aquatic life standards protect from short-term exposure to pollutants.
Narrative standards are developed when there is insufficient information to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant above "naturally occurring" conditions. DEQ uses the naturally occurring condition, called a "reference condition," to determine whether or not narrative standards are being met (**Appendix B**).

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

4.0 Defining TMDLs and Their Components

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

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

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

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

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

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

Development of each TMDL has four major components:

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

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

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

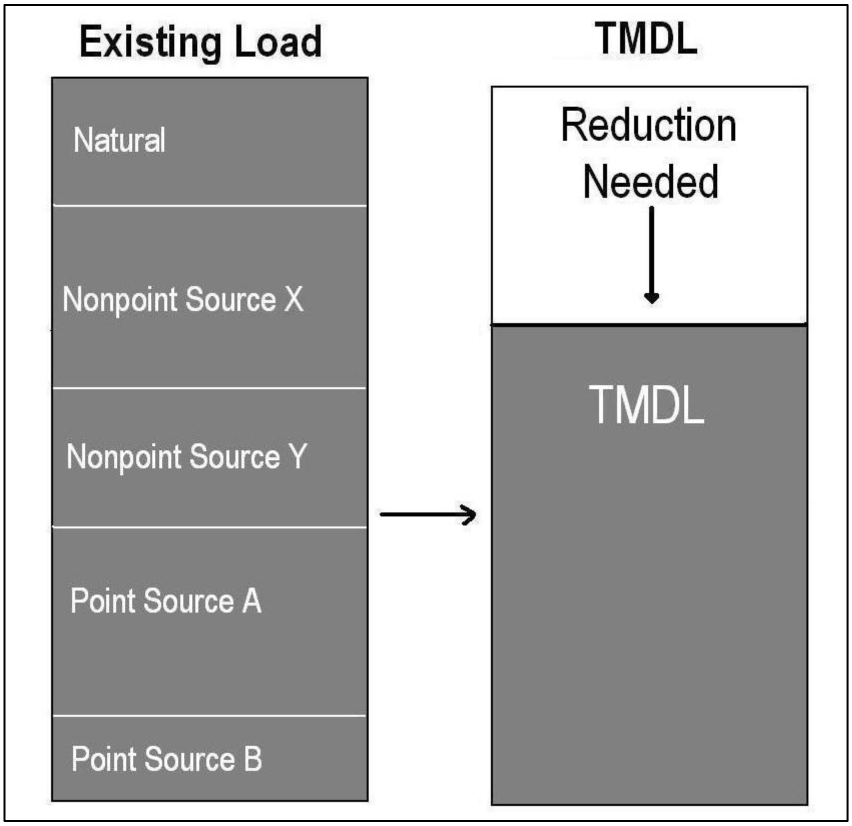

Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

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

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

4.2 Quantifying Pollutant Sources

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

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

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

4.3 Establishing the Total Allowable Load

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

If a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. For *E. coli* water quality criteria exist in rule. This same approach can be applied when a numeric target is developed to interpret a narrative standard such as for TN, TP and NO_3+ NO_2.

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

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

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

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

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

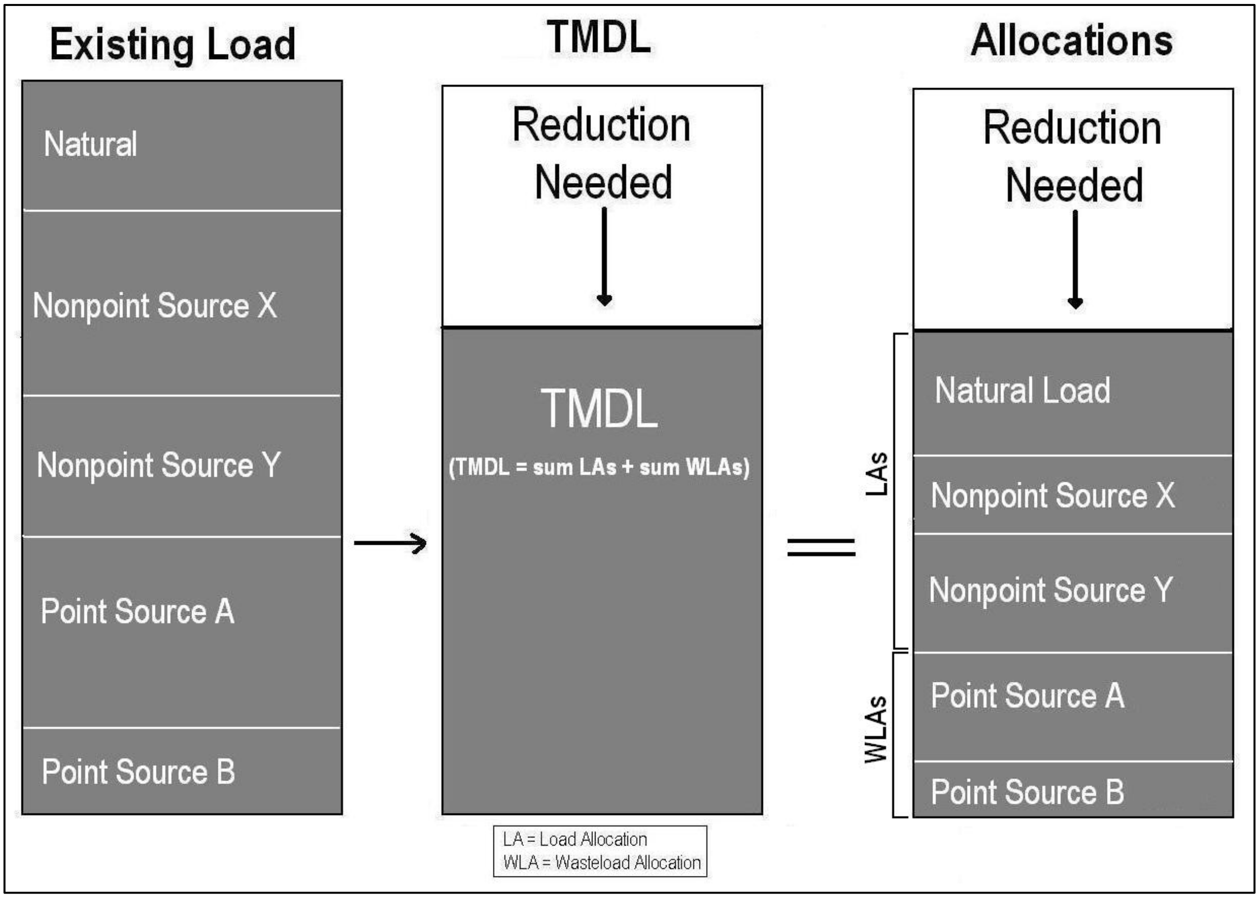

Figure 4-2. Schematic Diagram of a TMDL and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. 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 (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999b; U.S. Environmental Protection Agency, 1999a; United States Environmental Protection Agency, 2001).
The margin of safety is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. For TMDLs in this document where there is a combination of nonpoint sources and one or more permitted point sources discharging into an impaired stream reach, the WLAs are not dependent on implementation of the Las. Instead, DEQ sets the WLAs and LAs at levels necessary to achieve water quality standards throughout the watershed. Under these conditions, the LAs are developed independently of the WLA such that they would satisfy the TMDL target concentration within the stream reach immediately above the point source. In order to ensure that the water quality standard or target concentration is achieved below the point source discharge, the WLA is based on the point source's discharge concentration set equal to the standard or target concentration for each pollutant.

Section 4.5 Implementing TMDL Allocations

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Nonpoint source reductions linked to load allocations are not required by the CWA or Montana statute, and are primarily implemented through voluntary measures. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 9.0** discusses a restoration and implementation strategy by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., grazing, cropland, urban, etc.). **Section 9.5** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site-specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section helps to coordinate nonpoint implementation throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 10.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (see **Section 10.2**). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 Sediment TMDL Components

This section focuses on sediment as a cause of water quality impairment in the Lower Gallatin TMDL Planning Area (TPA). This section: (1) describes how sediment can impair beneficial uses; (2) lists the specific stream segments of concern; (3) discusses the current available data pertaining to sediment impairment in the watershed, including target development and a comparison of existing water quality with targets; 4) describes the approaches used to quantify the various contributing sources of sediment; and 5) identifies and justifies the sediment TMDLs and their allocations.

5.1 The Effects of Excess Sediment on Beneficial Uses

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

More specifically, sediment may block light and reduce primary production, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004). Effects from excess sediment are not limited to suspended or fine sediment; an accumulation of larger sediment (e.g., cobbles) can fill pools, reduce the amount of desirable particle sizes for fish spawning, and overwiden channels, which may lead to additional sediment loading and/or increased temperatures. Larger sediment can also reduce or eliminate flow in some stream reaches where sediment builds up in the channel, causing flow to go subsurface (May and Lee, 2004). Although fish and aquatic life are typically the most sensitive beneficial uses for sediment, excess sediment may also affect other uses. For instance, high concentrations of suspended sediment in streams can also discolor or turn water murky, negatively effecting recreational use. Excessive sediment can also increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 Stream Segments of Concern

A total of 11 waterbody segments in the Lower Gallatin TPA appeared on the 2012 Montana 303(d) List for sediment impairments (**Table 5-1**): Bear, Bozeman, Camp, Dry, Godfrey, Jackson, Reese, Rocky, Smith, Stone, and Thompson Creeks. Most waterbody segments listed for sediment impairment are also impaired for various forms of habitat alterations (**Table 5-1**), which are non-pollutant causes commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

Table 5-1. Waterbody segments in the Lower Gallatin TPA with sediment listings on the 2012 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing	Non-Pollutant Causes of Impairment Potentially Linked to Sediment Impairment
BEAR CREEK, headwaters to the mouth (Rocky Creek MT41H003_080)	MT41H003_081	Sedimentation/Siltation; Solids (Suspended/Bedload)	Alteration in streamside or littoral vegetative covers
BOZEMAN (aka SOURDOUGH) CREEK, Limestone Creek to the mouth (East Gallatin River)	MT41H003_040	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers
CAMP CREEK, headwaters to the mouth (Gallatin River)	MT41H002_010	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations; Other anthropogenic substrate alterations; Low flow alterations
DRY CREEK, headwaters to the mouth (East Gallatin River)	MT41H003_100	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations
GODFREY CREEK, headwaters to White Ditch	MT41H002_020	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers
JACKSON CREEK, headwaters to the mouth (Rocky Creek)	MT41H003_050	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers
REESE CREEK, headwaters to the mouth (Smith Creek)	MT41H003_070	Solids (Suspended/Bedload)	
ROCKY CREEK, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	MT41H003_080	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations; Other anthropogenic substrate alterations
SMITH CREEK, confluence of Ross and Reese Creeks to the mouth (East Gallatin River)	MT41H003_060	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers; Physical substrate habitat alterations
STONE CREEK, headwaters to the mouth (Bridger Creek)	MT41H003_120	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers
THOMPSON CREEK (or Thompson Spring), headwaters to mouth (East Gallatin River)	MT41H003_090	Sedimentation/Siltation	Alteration in streamside or littoral vegetative covers

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed in this section, characterizes overall stream health with a focus on sediment and related water quality conditions. The second category, discussed in **Section 5.6**, quantifies sediment sources in the watershed.

To characterize sediment conditions for TMDL development, sediment data was compiled and additional monitoring took place in 2009. Unless significant changes have occurred in a watershed, data collected within the past 10 years is considered representative of the current condition; data older than 10 years may be discussed to provide historical context for land management practices within a watershed and/or to compare with current conditions. These data sources represent the primary information used to characterize water quality and/or develop TMDL targets:

- DEQ assessment files
- DEQ 2009 sediment and habitat assessments
- PACFISH/INFISH Biological Opinion Effectiveness (PIBO) Monitoring Program reference and non-reference data
- USFS regional reference data
- other monitoring data and reports (e.g., USFS and Greater Gallatin Watershed Council)

5.3.1 DEQ Assessment Files

DEQ assessment files contain information used to make the existing sediment impairment determinations. Many of the impairment listings are based on data and stream condition summaries from the late 1970s compiled as part an EPA-funded Water Quality Management Plan by the Blue Ribbons of the Big Sky Country Areawide Planning Organization (APO)(Blue Ribbons of the Big Sky Country Areawide Planning Organization, 1979; 1977; 1978). In addition to summarizing the information in the APO reports, the DEQ assessment files include a summary of physical, biological, and habitat data collected between 1990 and 2011, as well as other historical information collected or obtained by DEQ. The most common quantitative data that will be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale. Files are available electronically on DEQ's Clean Water Act Information Center website: http://cwaic.mt.gov/.

5.3.2 DEQ 2009 Sediment and Habitat Assessments

To aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected in August 2009 from 23 reaches (**Figure 5-1**). An additional seven reaches were assessed in 2009 to determine the severity of bank erosion and identify the source. These seven reaches are represented by the bank erosion hazard index (BEHI) sites in **Figure 5-1**. Reaches were dispersed among the 11 segments of concern listed in **Section 5.2**, with two full assessment reaches on most streams. Additionally, one reach was evaluated on Bozeman Creek upstream of the listed segment, and two reaches were assessed on South Cottonwood Creek (**Figure 5-1**) to broaden the range of conditions in the sample dataset and serve as potential reference sites. After sampling and closer evaluation of human-induced sediment sources, only one site on South Cottonwood Creek (SCOT25-02) was determined a suitable reference site.

Initially, all streams were assessed aerially to characterize reaches by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These attributes represent main factors influencing stream morphology, which in turn influence sediment transport and deposition.

The next step in the aerial assessment involved identifying near-stream land uses, since land management practices can have a significant influence on stream morphology and sediment characteristics. The result was stratifying streams into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, allowed DEQ to select the above-referenced monitoring reaches. Although ownership is not part of the reach type category (because of the distribution of private and federal land within the watershed), most reach type categories contain predominantly either private or public lands.

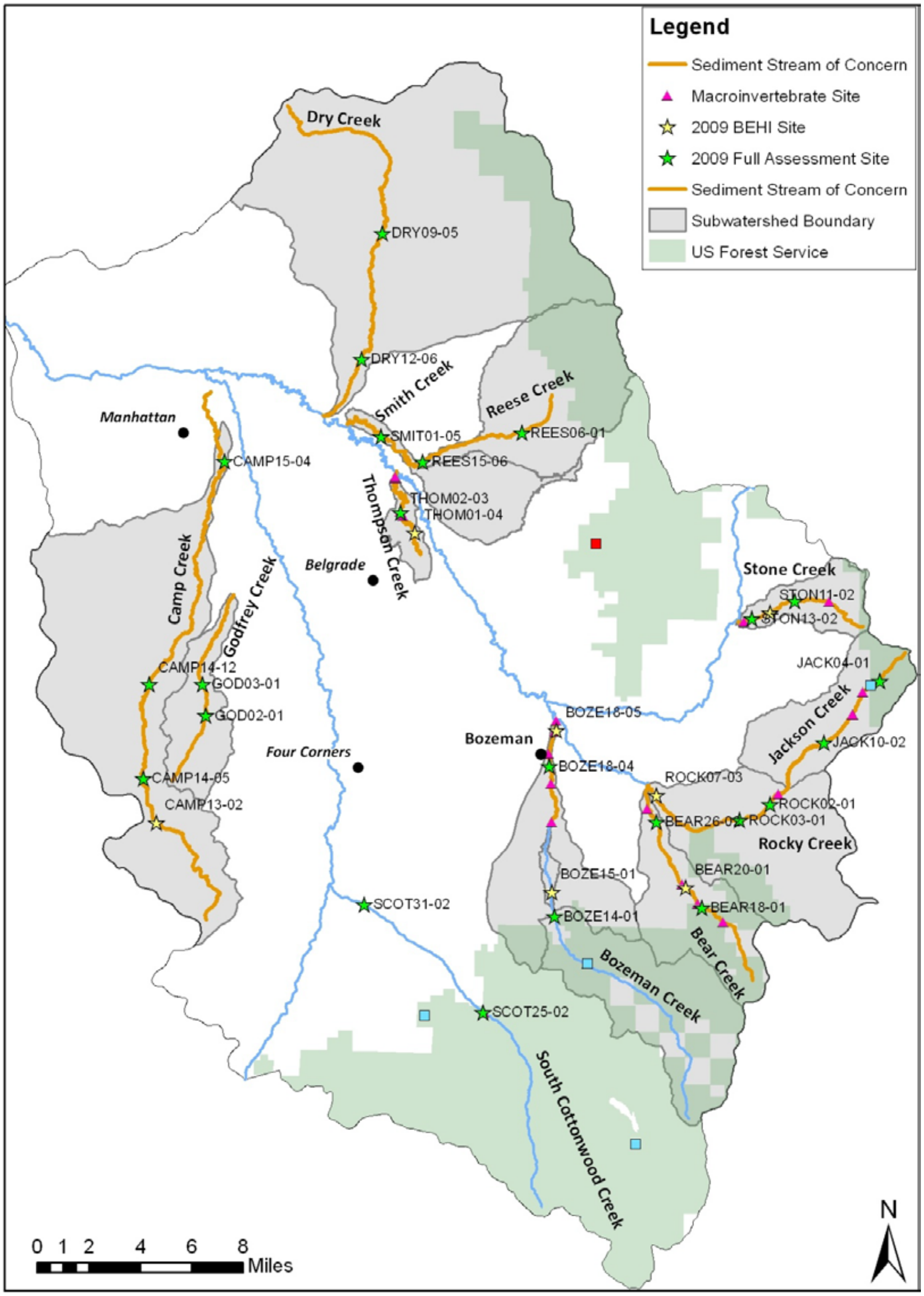

Figure 5-1. Sediment streams of concern and sediment-related sampling sites.

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

Table 5-2. Reach Types and Monitoring Sites

(Type = Ecoregion-Valley Slope-Stream Order-Valley Confinement; MR = Middle Rockies). Sites denoted with an asterisk were streambank erosion sites.

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
MR-0-4-C	1		
MR-2-3-C	1		
MR-4-3-U	1		
MR-10-2-U	1		
MR-0-3-C	2		
MR-2-4-U	2		
MR-10-1-C	3		
MR-0-1-U	4	1	THOM01-04*
MR-2-2-C	4	2	BEAR18-01, STON08-01
MR-2-1-U	5		
MR-4-1-C	5	1	JACK04-01
MR-4-2-C	5		
MR-2-3-U	6	2	SCOT25-02, CAMP13-02*
MR-10-1-U	7		
MR-0-4-U	8	6	CAMP15-04, DRY12-06, REES15-06, ROCK03-01, SMIT01-05, ROCK07-03*
MR-4-1-U	10		
MR-4-2-U	10	1	BEAR20-01
MR-0-3-U	13	9	BEAR26-02, BOZE18-04, CAMP14-05, CAMP14-12, DRY09-05, GOD03-01, ROCK02-01, SCOT31-02, BOZE18-05*
MR-0-2-U	14	5	BOZE14-01, GOD02-01, REES06-01, THOM02-03, BOZE15-01*
MR-2-2-U	19	3	JACK10-02, STON13-02, STON11-02*

The field parameters assessed in 2009 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as “sites” within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 2,000 feet (depending on the channel bankfull width) that were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data and sampling protocols are contained in the 2009 Sediment and Habitat Assessment report (**Attachment A**).

5.3.3 PIBO Data

The PACFISH/INFISH Biological Opinion Effectiveness (PIBO) monitoring program collects data from reference and managed (i.e., non-reference) stream sites on US Forest Service (USFS) and Bureau of Land Management (BLM) land within the Columbia and Upper Missouri River basins. Reference sites are defined as having catchment road densities less than 0.5 km/km^2, riparian road densities less than 0.25 km/km^2, no grazing within 30 years, and no known in-channel mining upstream of the site. Within sediment-impaired watersheds of the Lower Gallatin TPA, data were collected in 2007 at two managed sites in the Gallatin National Forest: Bozeman Creek upstream of the listed segment and Jackson Creek (**Figure 5-1**). There are 15 reference sites in the Gallatin National Forest, including one in the Lower Gallatin TPA (**Figure 5-1**). However, because that is a small dataset for target development, and ecoregion is a primary stratification category, all PIBO reference data from the Middle Rockies ecoregion were used for target development. This consists of all sites in the Gallatin National Forest as well as data from 58 other sites collected between 2001 and 2010.

Data were collected following protocols described in "Effectiveness Monitoring for Streams and Riparian Areas within the Pacific Northwest: Stream Channel Methods for Core Attributes" *(USDA Forest Service, 2006).* Relevant data collected during these assessments include width/depth ratios, residual pool depths, pool frequency, large woody debris frequency, pebble counts, and the percentage of fine sediment in pool tails <6mm via grid toss.

5.3.4 USFS Regional Reference Data

Regional reference data are available from the Beaverhead Deerlodge National Forest (BDNF). BDNF data were collected between 1991 and 2002 from approximately 200 reference sites: 70 of the sites are located in the Greater Yellowstone Area and the remaining sites are in the BDNF, which is also located in southwestern Montana (Bengeyfield, 2004). Reference sites were selected by USFS hydrologists and fish biologists and were defined as representing the current climate and tectonic regime and without having significant human influence. The sites were primarily located in lower-gradient areas where the effects of land management practices are most likely to be seen (Bengeyfield and Hickenbottom, 2005). Applicable reference data from this resource used for TMDL target development are width/depth ratios, entrenchment ratios, and fine sediment <6mm from pebble counts.

5.3.5 Other Monitoring Data and Reports

Additional sources of monitoring data are primarily limited to Bear and Bozeman Creeks. Largely because of concerns related to sediment loading from road and trail conditions, the USFS collected data on Bear Creek in 2003; additional monitoring was conducted in 2011 to evaluate the effectiveness of decommissioning and improvement projects conducted in 2007–2008. Data collection in 2003 included total suspended solids, bedload, and streamflow (Story and Taylor, 2004), as well fish abundance via electroshocking and fish habitat metrics (e.g., percent fine sediment <2mm in pool tails, large wood debris, residual pool depth, pool frequency, and unstable banks) (Barndt and Bay, 2004). Data collection in 2011 was conducted at fewer sites and limited to total suspended solids, bedload, and streamflow (Story and Hancock, 2011).

For Bozeman Creek, the Bozeman Watershed Council (now defunct) conducted a watershed assessment in August 2002 using a modified version of the USFS R1/R4 Habitat Inventory (Overton et al., 1997) that included measurements of pools and riffles, large woody debris, undercut/unstable streambanks, width/depth ratio, visual substrate composition, and percent canopy along the entire stream (Bozeman Watershed Council, 2004). The stream was broken into ten zones, which were subdivided in assessment reaches. For each reach the report includes a summary of land use, geomorphology, channel character, fish habitat, limiting factors, wetlands, and recommendations for improvement. A study was conducted using this data in combination with a GIS analysis of land cover and land use to study the relationship between land use, geomorphology, and aquatic habitat (McIlroy et al., 2008). Additionally, the Greater Gallatin Watershed Council conducted pebble counts and collected macroinvertebrates at two sites on Bozeman Creek in August 2009.

USFS planning documents, including the Gallatin National Forest Travel Plan Final Environmental Impact Statement (U.S. Department of Agriculture, Forest Service, 2006), North Bridgers Grazing Allotment Management Plan Update Environmental Assessment (U.S. Forest Service, 2007), Bangtail Allotment Management Plan Update Environmental Assessment (U.S. Forest Service, 2009), and Bozeman Municipal Watershed Supplemental Environmental Impact Statement (U.S. Department of Agriculture, Forest Service, Gallatin National Forest, 2011) contain information such as descriptions of soil sensitivity to disturbance, intensity and effects of grazing and timber harvest, evaluation of riparian health via a Proper Functioning Condition assessment (Prichard, 1998), and an evaluation of sediment sources, such as roads. Where applicable, this information is incorporated into the existing condition discussion. The planning documents also include estimates of sediment loading under different management scenarios; however, because the estimates were intended to compare relative differences among scenarios, and were conducted at a different scale using different methods than source assessments used for TMDL development, the loads are not presented in this document.

Lastly, as part of the TMDL development effort for nutrient and *E. coli* impairment in the Lower Gallatin TPA, a source assessment was performed in 2009. Because nutrient sources are commonly associated with sediment, the source assessment report (**Attachment B**) was reviewed for information regarding sediment sources. The report contains source assessment information for Bear, Camp, Dry, Godfrey, Jackson, Reese, Smith, Sourdough, and Thompson Spring Creeks.

5.4 Water Quality Targets

The concept of water quality targets was presented in **Section 4.1**. This section provides the rationale for each sediment-related target parameter and discusses the basis of the target values.

In developing targets, natural variation throughout the river must be considered. As discussed in more detail in **Section 3.0** and **Appendix B**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is using reference site data, but modeling, professional judgment, and literature values may also be used. DEQ defines “reference” as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody’s greatest potential for water quality given past and current land use. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets protect all designated beneficial uses because they are based on the reference approach, which strives for the highest achievable condition.

Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations from climate, bedrock, soils, hydrology, and other natural physiochemical differences, yet it allows differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to 2009 DEQ data. As discussed in **Appendix B**, there are several statistical approaches DEQ uses for target development. They include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired (like with fine sediment), and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset is typically used.

If reference data are not available, and the sample streams are predominantly degraded, the 25th percentile of the entire sample dataset is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, how much the representativeness and range of data varies, how severe human disturbance is to streams in the watershed, and the size of the dataset.

In general, stream sediment and habitat conditions within the streams evaluated by DEQ in 2009 reflected a minimal to moderate level of human disturbance (i.e., not severely disturbed). For each target, descriptive statistics were generated relative to any available reference data (e.g., BDNF or PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given to the most protective reference dataset.

Additionally, the target value for some parameters may apply to all streams in the Lower Gallatin watershed, whereas others may be stratified by bankfull width, reach type characteristics (e.g., ecoregion, gradient, stream order, and/or confinement), or by Rosgen stream type, if those factors are determined to be important drivers for certain target parameters. Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit margin of safety (MOS) and that are achievable. MOS is discussed in additional detail in **Section 5.8.2**. Field data from the reference site on South Cottonwood Creek are not discussed within this section but were compared with target values during the target development process to help evaluate the appropriateness and achievability of target values.

5.4.1 Water Quality Target Summary

The sediment water quality targets for the Lower Gallatin watershed are summarized in **Table 5-3** and described in detail in the sections that follow. Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999b), water quality targets for the Lower Gallatin watershed comprise a combination of measurements of instream siltation, channel form, biological health, and habitat characteristics that contribute to loading, storage, and transport of sediment or that demonstrate those effects. Fine sediment targets and biological data, in conjunction with indicators of excess sediment (i.e., fine sediment, residual pool depth, and field observations), are given the most weight.

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

Table 5-3. Sediment Targets for the Lower Gallatin TPA

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of fine surface sediment <6mm and <2mm in riffles via pebble count (reach average)	<6mm: B/C stream types: < 11%, E stream types: < 30% <2mm: B/C stream types: < 9%, E stream types: < 16%
	Percentage of fine surface sediment <6 mm in pool tails via grid toss (reach average)	B/C stream types: ≤ 8% E stream type: ≤ 14%
Channel Form and Stability	Bankfull width/depth ratio (reach average)	B stream types: < 17 C stream types: < 23 E stream types: < 12
	Entrenchment ratio (reach average)	B stream types: > 1.4
		C and E stream types: > 2.2
Instream Habitat	Residual pool depth (reach average)	< 15 ft bankfull width : > 0.7 ft
		> 15 ft bankfull width : > 1.2 ft
	Pools/mile	< 15 ft bankfull width : ≥ 84
		> 15 ft bankfull width : ≥ 52
	LWD/mile	All bankfull widths: 143
Human Sediment Sources	Significant and controllable sediment sources	Presence of significant and controllable man-caused sediment sources throughout the watershed
Biological Index	Macroinvertebrate bioassessment impairment threshold	O/E: ≥ 0.80

5.4.2 Fine Sediment

The percent of surface fines <6 mm and <2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the coldwater fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species (and even age classes within a species), and because the particle size defined as “fine” is variable (and some assessment methods measure surficial sediment while other measures also include subsurface fine sediment), literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10% to 40% fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Bryce et al. (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment <2 mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development; however, because increasing concentrations of fine sediment are known to harm aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B** and consistent with Montana's water quality standard for sediment as described in **Section 3.2.1**.

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

Surface fine sediment measured in riffles by the modified Wolman (1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2009 were performed in three riffles per sampling reach, for a total of at least 300 particles. For DEQ data collected independently of the TMDL development process (i.e., before 2009) and the data collected by the GGWC for Bozeman Creek, pebble counts at each reach were performed from bankfull to bankfull in a single representative riffle, for a total of at least 100 particles.

<u>Less than 6 mm</u>

The BDNF reference dataset is broken out by Rosgen channel type and dominant particle size, but the PIBO reference dataset is not. Because the streams in the Lower Gallatin TPA contain a variety of channel types, including E channels (which tend to have higher levels of fine sediment than other channels), the fine sediment target for particles <6 mm is based on BDNF reference data according to Rosgen channel type.

Although the percentage of fine sediment may vary depending on the dominant particle size in a stream, all gravel- and cobble-dominated B and C channels in the project area had a similar level of fine sediment during sampling in 2009; therefore, the target for riffle substrate fine sediment is expressed as one value for B/C channels and another value for E channels. The target for riffle substrate percent fine sediment <6 mm is set at less than or equal to the median of the reference value based on the BDNF reference dataset (**bold** in **Table 5-4**). The median was chosen instead of the 75th percentile because pebble counts in the BDNF reference dataset were performed using the zigzag method, which includes both riffles and pools and likely results in a higher percentage of fines than a riffle pebble count. The latter was the method used for TMDL-related data collection in the Lower Gallatin watershed.

The 2009 DEQ data are also summarized in **Table 5-4**, and in general, the 75th percentile of the sample dataset is comparable or less than the median of the reference dataset, indicating much of the sample dataset has low percent fines <6 mm in riffles.

Table 5-4. 2009 DEQ Data Summary and BDNF Reference Dataset Median Percent Fine Sediment <6 mm.

Target values are indicated in bold.

Data Source	Parameter	All	B3/C3	B4/C4	B/C	E4
BDNF	Sample Size (n)	129	37	31	68	63
	Median	20	8	21	**11**	**30**
Sample Data	Sample Size (n)	23	4	8	12	12
	Median	10	6	6	6	19
	75th	20	8	9	8	21

Less than 2 mm

For fine sediment <2 mm, PIBO is the only reference data currently available. Like the BDNF data, the PIBO pebble count data are collected from multiple channel types (including E channels) and are also a composite of riffle and pool particles, which are likely to be higher in fines than the DEQ riffle-only pebble count. The median of the PIBO reference dataset is slightly greater than the median of the sample dataset (**Table 5-5**). Because of the tendency of E channels to have a higher percentage of fine sediment than B and C channels, and because the sample dataset is broken out by channel type, the target is based the sample dataset.

As discussed in the target development rationale in **Section 5.4**, the sampled streams ranged from being minimally to moderately disturbed, which indicates the median is likely the most appropriate percentile for target development. Because the median percentile of fine sediment <2mm in riffles of B and C channels (of the sample dataset) is much lower than the most conservative literature values shown to cause harm to fish and aquatic life (i.e., 10-13%) (Bryce et al., 2010), the median value for the entire sample dataset (i.e., 9%) will be set as the riffle fine sediment <2mm target for B and C channels. The median value for E4 streams of 16% from the sample dataset will be applied as the target for E4 channels.

Table 5-5. 2009 DEQ Data Summary and PIBO Reference Dataset Percent Fine Sediment <2 mm.
Target values are indicated in bold.

Data Source	Parameter	All	B3/C3	B4/C4	B/C	E4
PIBO	Sample Size (n)	64	Data not broken out by channel type			
	Median	11				
	75^{th}	21				
Sample Data	Sample Size (n)	23	4	8	12	11
	Median	**9**	4	4	4	**16**
	75^{th}	16	5	7	6	19

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

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

For pool tail grid toss values, PIBO is the only reference data currently available. The 75th percentile of the PIBO reference data for pool tails is 18% and the median is 9% (**Table 5-6**). In the 2009 Lower Gallatin sample dataset, pool tail grid toss values for the 25th percentile of the sample dataset for all sites, as well as B and C channels, was similar to the median of the PIBO dataset. This indicates fine sediment levels in pools within the watershed reflect a more severe level of disturbance than riffles. Therefore, the more conservative 25th percentile of the sample dataset (versus the median) is the most appropriate percentile for pool tail grid toss targets. The pool tail grid toss target is 8% for B/C channels and 14% for E channels and should be assessed based on the reach average grid toss value.

Table 5-6. PIBO Reference and 2009 DEQ Data Percentiles for Percent Fine Sediment <6 mm via Grid Toss in Pool Tails.
Pool tail target values are indicated in bold.

Data Source	Parameter	All	B/C	E
PIBO Pool Tail	Sample Size (n)	70	Data not broken out by channel type	
	Median	9		
	75^{th}	18		
Sample Data Pool Tail	Sample Size (n)	20	11	9
	25^{th}	11	**8**	**14**
	Median	16	14	24
	75^{th}	25	20	29

5.4.3 Channel Form and Stability

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

5.4.3.1 Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio provide a measure of channel stability as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (e.g., riffles, pools, and near-bank zones).

Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess sediment load (MacDonald et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width when the stream attempts to regain a balance between sediment load and transport capacity.

Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios indicate that stream energy is concentrated in-channel during flood events versus having energy dissipate to the floodplain. Accelerated bank erosion and an increased sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Rosgen, 1996; Knighton, 1998; Rowe et al., 2003). Width/depth and entrenchment ratios were calculated for each 2009 assessment reach based on five riffle cross-section measurements.

Width/Depth Ratio Target Development

Although PIBO reference data exists for width/depth ratio, it was not used because Rosgen channel type was not available. Only the BDNF reference dataset was considered for width/depth ratio target development. Because many of the streams in the Lower Gallatin TPA have been historically altered to the extent that reference channel form and floodplain access may not be achievable without extensive channel reconstruction (or the greatest potential may be a combination of channel types), the Rosgen delineative criteria were also used during target development (**Table 5-7**). Width/depth ratios are measured the same way for the reference and sample dataset: in comparing the reference data with the 2009 sample dataset, the 75th percentile of the reference values are similar to the corresponding percentile in the sample dataset for B and C channels but is almost half the 75th percentile ratio for E channels in the sample dataset. This indicates the 75th percentile of reference is an appropriate target for B and C channels but not for E channels. Given that the Rosgen criterion for an E channel is a width/depth ratio less than 12, which is equal to the median of the sample dataset, less than or equal to 12 will be applied as the width/depth ratio target for E streams in the Lower Gallatin TPA. Summary statistics and target values by Rosgen channel type are provided in **Table 5-7**. The target value applies to the average value for each sample reach.

Table 5-7. BDNF Reference and Other Data used for Width/Depth Ratio Targets.
Width/depth ratio target values are indicated in bold.

Data Source	Parameter	B	C	E
BDNF	**Sample Size (n)**	40	30	115
	75^{th}	**17**	**23**	8
Sample Data	**Sample Size (n)**	18	38	46
	25^{th}	11	13	10
	Median	13	16	12
	75^{th}	16	20	15
Rosgen Criteria	**Width/Depth Ratio**	>12	>12	<**12**

<u>Entrenchment Ratio Target Development</u>
The BDNF reference dataset is the only reference data currently available to help develop entrenchment targets. For entrenchment ratio, because it is desirable to have a greater value, the 25th percentile of the BDNF reference dataset was evaluated for target development. For both B and C channels, the median of the sample dataset is comparable to the 25th percentile of the BDNF reference value and in line with the Rosgen delineative criteria (**Table 5-8**). However, for E channels the median of the sample dataset is meeting the Rosgen criteria but well below the 25th percentile of the BDNF reference dataset, indicating the 25th percentile of reference may not be a reasonable target for E channels.

Although having a greater entrenchment value (i.e., more floodplain access) is desirable for C and E channels, because the potential (after implementation of all reasonable land, soil, and water conservation practices) is likely less than the 25th percentile of reference, the Rosgen delineative criteria will be applied as the target for entrenchment ratio (**Table 5-8**). The target value applies to the average value for each sample reach.

Table 5-8. BDNF Reference and Other Data used for Entrenchment Ratio Targets.
Entrenchment ratio target values are indicated in bold.

Data Source	Parameter	B	C	E
BDNF	Sample Size (n)	40	30	115
	25^{th}	1.4	3.2	3.7
Sample Data	Sample Size (n)	18	38	46
	25^{th}	1.4	1.7	1.9
	Median	1.9	3.9	2.5
	75^{th}	2.8	8.0	4.4
Rosgen Criteria	Entrenchment Ratio*	**1.4**-2.2	>**2.2**	>**2.2**

*Values are ± 0.2

5.4.4 Instream Habitat Measures

For all instream habitat measures (i.e., residual pool depth, pool frequency, and large woody debris frequency), PIBO is the only reference data currently available. Because these parameters are largely influenced by stream size, target values will be expressed by bankfull width category. Because all but one reach evaluated by DEQ in 2009 had a mean bankfull width less than 36, and the majority of streams were less than 25 feet wide, instream habitat targets are broken into bankfull width categories of less than and greater than 15 feet.

All of the instream habitat measures are important indicators of sediment input and movement, as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to the effects of sediment. The use of instream habitat measures in evaluating or characterizing impairment must be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

5.4.4.1 Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of pool habitat quality. Deep pools are important resting and hiding habitat for fish, and provide refuge during temperature extremes and high-flow periods (Nielson et al., 1994; Bonneau and Scarnecchia, 1998; Baigun, 2003). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment (fine or coarse), a reduction in channel obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999).

A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also harm fish by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems. During DEQ sampling in 2009, pools were defined as depressions in the streambed bounded by a "head crest" at the upstream end and "tail crest" at the downstream end, with a maximum depth that was 1.5 times the pool-tail depth (Kershner et al., 2004).

The definition of pools for the PIBO protocol is fairly similar to the definition used for the 2009 Lower Gallatin sample dataset: both use the same criterion to calculate the difference between the maximum depth and pool tail depth. However, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth because DEQ's protocol has no minimum pool size requirement, whereas the PIBO protocol only counts pools greater than half the wetted channel.

In comparing the PIBO reference data with the sample data, the PIBO 25th percentile residual pool depth values are all less than the median and similar to the 25th percentile from the sample dataset (**Table 5-9**), indicating the protocol differences likely did not result in smaller residual pool depths in the DEQ dataset. Therefore, the residual pool depth target is equal to or greater than the PIBO 25th percentile value (**bold** in **Table 5-9**).

Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths can indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis, using the data collected in 2009 as a baseline. Future monitoring should document an improving trend (i.e., deeper pools) at sites that fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-9. PIBO Reference and 2009 DEQ Sample Data Percentiles for Residual Pool Depth (ft).
Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data			
	n	25th	Median	n	25th	Median	75th
< 15 ft bankfull width	10	**0.7**	0.9	9	0.7	0.9	1.4
> 15 ft bankfull width	56	**1.2**	1.4	14	1.1	1.3	1.4

5.4.4.2 Pool Frequency

Pool frequency is another indicator of sediment loading that relates to changes in channel geometry and is an important component of a stream's ability to support the fishery beneficial use (Muhlfeld and Bennett, 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, the build-up of larger particles may exceed the stream's capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e., watershed area) increases.

The PIBO 25th percentile pool frequency value for streams with a bankfull width less than 15 feet compare favorably with the median of sample dataset; however, the PIBO 25th percentile value for streams with a bankfull width greater than 15 feet is less than all percentiles for the sample dataset. This indicates that either that protocol differences may have resulted in a greater pool frequency in the DEQ dataset for wider streams, or that wider streams in the Lower Gallatin have a greater pool frequency potential than the 25th percentile of reference (**Table 5-10**). Although the Lower Gallatin TPA is slightly east of the area where the USFS Inland Native Fish (aka INFISH) Riparian Management Objectives apply (west of the Continental Divide), the INFISH values were evaluated in addition to the sample dataset to determine the most appropriate reference percentile for target development (**Table 5-10**).

Although streams with a bankfull width greater than 50 feet have an INFISH value close to the PIBO reference 25th percentile, all but one reach (SMITH01-05) from the Lower Gallatin watershed had a mean bankfull width less than 36 feet. Therefore, the PIBO 25th percentile for streams with a bankfull width greater than 15 feet is much too low to be used as a target value. The pool frequency target for streams with a bankfull width less than 15 feet is set at greater than or equal to the 25th percentile of PIBO reference; the target for streams with a bankfull width greater than 15 feet is set at greater than or equal to the median of PIBO reference (**bold** in **Table 5-10**). Pools per mile should be calculated based on the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-10. PIBO Reference and 2009 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values.
Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data			
	n	Median	25th	n	25th	Median	75th
< 15 ft bankfull width	10	101	**84**	9	74	84	95
> 15 ft bankfull width	56	**52**	22	14	28	55	76
INFISH Riparian Management Objectives	< 20 ft bankfull width: 96-56 25 ft bankfull width: 47			50 ft bankfull width: 26 100 ft bankfull width: 18			

5.4.4.3 Large Woody Debris

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

For DEQ sampling in 2009, wood was counted as LWD if it was greater than 9 feet long, or two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton et al., 1997). The LWD count for PIBO was compiled using a different definition of LWD; if measurements were conducted by DEQ and PIBO protocols within the same reach, the PIBO LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. For streams with a bankfull width of less than 15 feet, the DEQ sample dataset median was equal to the 25th percentile of the PIBO reference data; however, for wider channels, the sample dataset had much lower LWD counts than the PIBO dataset (**Table 5-11**). This difference for larger channel widths may partially be a result of different measurement protocols but is also likely a result of past land conversion and riparian vegetation removal within the wider valley sections of streams. An additional factor is that the typical trend of less LWD in larger streams is not reflected in the PIBO dataset. Given that the 75th percentile of the sample dataset does meet the reference 25th percentile for both bankfull width categories, an appropriate target frequency is likely between the 25th percentile reference values (i.e., 143–239) (**Table 5-11**). The target for all streams will be set at 143 LWD/mile.

Table 5-11. PIBO Reference and 2009 DEQ Sample Data Percentiles for Large Woody Debris Frequency (LWD/mile).
Target value is shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
< 15 ft bankfull width	11	281	**143**	9	143	216
> 15 ft bankfull width	55	343	239	14	53	257

5.4.5 Human Sediment Sources

The presence of human sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified human sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared, since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources; however, the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluating human-caused and natural sediment sources, along with field observations and watershed-scale source assessment information obtained using aerial imagery and GIS data layers.

Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of human-caused sediment sources must consider both current and historical sediment loading as well as historical alterations to channel form and stability because those changes still have the potential to contribute to sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.6**, with additional information in **Appendix C** and **Attachments A**, **B**, and **C.**

5.4.6 Biological Index

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

DEQ uses the Observed/Expected Model (O/E) to assess macroinvertebrate communities. The rationale and methodology for the index is presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). The O/E Model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled. It is expressed as a ratio of the Observed/Expected taxa (O/E value). The O/E community shift point toward a more sediment-tolerant taxa for all Montana streams is any O/E value <0.80. Therefore, an O/E score of ≥0.80 is established as a sediment target in the Lower Gallatin TPA.

Unless noted otherwise, macroinvertebrate samples discussed in this document were collected according to DEQ protocols. DEQ protocols have changed some within the last 10 years. All available data collected within that time are presented in this document; however, the current protocol, MAC-R-500, which is a reach-wide composite from both riffles and pools, is considered the most reliable for use with the O/E model. USFS data were collected according to the PIBO protocol, which is done with a kick net in two sections of the first four riffles/runs within a reach (Heitke et al., 2010); it is comparable to the MAC-R-500 method (personal communication, Dave Feldman, 2012).

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

5.5 Existing Condition and Comparison to Water Quality Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream segment of concern in the Lower Gallatin watershed (**Section 5.2**). The TMDL development determination is whether or not recent data supports the impairment listing and whether a TMDL will or will not be completed, but it is not a formal impairment assessment. All waterbodies reviewed in this section are listed for sediment impairment on the 2012 303(d) List. Although inclusion on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts.

5.5.1 Bear Creek (MT41H003_081)

Bear Creek (MT41H003_081) is listed for sedimentation/siltation and solids (suspended/bedload) on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Bear Creek was initially listed for sediment impairment in 2006 based on data collected in 2003 indicating the watershed has naturally erosive soil but that the sediment supply was elevated from disturbances associated with livestock and unpaved recreational vehicle trails/roads. Additionally, a water quality report from 1978 (APO) indicated residential development could be a factor, since home construction in the canyon had decreased bank vegetation and driveway culverts were undersized. Bear Creek flows 10.2 miles from its headwaters to its mouth at Rocky Creek.

Physical Condition and Sediment Sources

During data collection in 2003, the Gallatin National Forest coordinated with the Gallatin Local Water Quality District, DEQ, and the Montana Water Center to collect measurements of bedload, turbidity, suspended sediment, channel form, riffle fine sediment (via pebble count), macroinvertebrates, and stream discharge. Concurrently, the Gallatin National Forest conducted a fish habitat and abundance study that included percent fines <2mm (via visual estimate with a grid), pool and large woody debris frequency, residual pool depth, and identification of unstable streambanks.

There were eight turbidity/suspended sediment/bedload sites, four channel form/pebble count/macroinvertebrate sites, and four fish sites that captured a range of potential human effects. The uppermost site was upstream of most trails, another site was downstream of two trail fords and a landslide area, and the most downstream extent was downstream of the USFS boundary in an agricultural area near the Bozeman Trail Road. The monitoring conclusions are discussed here, and results were reviewed in comparison with the 2009 DEQ data. However, no data are presented because conditions from 2003 are no longer representative of conditions within the watershed: in 2007 and 2008 the most erosive section of trail was relocated and extensive rehabilitation work was conducted (**Figure 5-2**), drainage was improved, and new trail bridges were installed. In total, the USFS decommissioned approximately 5 miles of road in the watershed in 2007–2008.

Figure 5-2. 2007–2008 photos of obliterated section of trail (courtesy of Gallatin National Forest).

During the sampling in 2003, pool habitat quality was variable, but both quality and abundance were lowest at sites that were downstream of the most erosive sections of trail. Unstable streambanks were common at all sites; causes were cited as natural geology, varying degrees of cattle access on federal and private land, trail crossings, and channel readjustment resulting from an old lumber mill. Fine sediment was elevated at all sites, including those with a minimal level of upstream disturbance. Soils were noticeably destabilized by even the single pass of a cow (Barndt and Bay, 2004).

Fish abundance was high, but the report noted observations were limited to a single year and emphasized the reduced quantity of fish rearing habitat, high levels of fine sediment, and sensitivity of soils to disturbance. Evaluation of trail-related effects to turbidity were limited by a lack of runoff. Elevated fine sediment was noted during periods of active stream fording and in association with irrigation return flows and near-channel grazing, but much sediment was also attributed to the natural instability of the system and fine soil texture.

The Gallatin National Forest followed up with sediment sampling in 2011 at four of the sites from 2003. The sampling locations ranged from just upstream of the former trail ford area to the same downstream extent used in 2003, which represents agricultural land downstream of the USFS boundary. Runoff in 2011 was above average, and sediment and turbidity levels were the highest measured since monitoring was initiated in 1989, making a comparison with 2003 difficult. The 2011 data indicated the trail relocation and improvement efforts eliminated a sediment hotspot; however, similar to the 2003 data, the monitoring results did not allow for separation of the natural versus human contribution to elevated fine sediment (Story and Hancock, 2011). Although conditions at the most downstream site were somewhat improved in 2011 from the bare eroding streambanks observed in 2003, grazing along the stream and irrigation return flows were cited as remaining significant sediment sources from human activity.

In 2009 DEQ assessed sediment and habitat on two sites on Bear Creek (**Figure 5-1**). The uppermost site (BEAR18-01) was on USFS-administered land upstream of the Bear Canyon trailhead and overlapped with part of the trail section that was rehabilitated in 2007. It appeared that the relocation and rehabilitation work mitigated direct sediment inputs from the trail network, but some localized streambank erosion was attributed to the former trail network, particularly near historic stream crossings. Evidence of past riparian logging was observed along the channel, but the reach was lined with dense riparian shrubs that limited bank erosion. Pools were primarily at the outside of meander bends, the substrate was embedded, and there was silt along the channel margin.

The other assessment site (BEAR26-02) was in the lower portion of the segment, where the stream meanders through a broad valley with a mix of agriculture and rural residential development. A fence bordering a hayfield along the reach was falling into the channel, indicating active bank erosion. The channel was overwidened in sections, especially downstream of large eroding banks. Pools were primarily formed by woody debris from riparian shrubs, which were dense on the inside of meander bends. Vegetation on the outside of meander bends was primarily limited to grasses, and bank erosion was attributed to encroachment by cropland.

In 2009 DEQ evaluated one additional site for streambank erosion (BEAR20-01). The site was a confined section of stream located upstream of the Bear Canyon trailhead and had a limited amount of rural residential development. Bank erosion was primarily limited to sections where the stream was eroding away at the base of the hillslope, and all erosion at this site was attributed to natural sources.

Streambanks at all sites corresponded with observations from the USFS reports in that they were primarily composed of highly erodible fine sediment.

During reconnaissance work for the sediment and habitat assessments in July 2009, a storm event occurred and a gully was observed at the edge of the road that started above the trailhead parking lot and continued to pick up sediment until it discharged near a culvert into New World Gulch, a tributary to Bear Creek (**Figure 5-3**).

Figure 5-3. Road erosion and associated sediment loading to Bear Creek observed in 2009.

The nutrient source assessment report (**Attachment B**) corresponds with observations from the 2009 sediment and habitat assessments as well as observations from the USFS sampling: riparian vegetation was typically dense and sediment sources were from naturally erosive soils, streambank and trail erosion, unpaved road crossings, and grazing on public and private land.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Bear Creek are summarized in **Table 5-12**. The macroinvertebrate bioassessment data are located in **Table 5-13**. Four macroinvertebrate samples were collected in 2003 but are not included in **Table 5-13** because of the extensive trail rehabilitation work conducted in 2007 and 2008. All 2003 samples met the target. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-12. Existing sediment-related data for Bear Creek relative to targets.

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
BEAR18-01	2009	15.5	C4b/E4b/B4	B4/C4b	4	2	**23**	12.7	5.6	1.4	58	143
BEAR26-02	2009	22.1	B4c/C4	C4	6	4	**21**	19.5	3.0	1.2	79	**69**

Table 5-13. Macroinvertebrate bioassessment data for Bear Creek.
Values that do not meet the target threshold (0.80) are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
M05BEARC05	0.2 mile downstream of USFS boundary	8/22/2011	MAC-R-500	1.08

Summary and TMDL Development Determination

Both sites met the riffle fine sediment targets but both failed to meet the pool tail grid toss target. Although some localized channel overwidening was observed, both sites met channel form targets. Additionally, pool frequency and residual pool depth targets were met. Likely as a result of past harvest practices in the forest and the valley, the lower site was well below the LWD target. The macroinvertebrate sample met the target.

Although field methods varied slightly between sampling events in 2003 and 2009, general comparisons were made to help evaluate instream changes resulting from the trail rehabilitation project. In 2009 fine sediment values were less, channel form measurements and residual pool depths were similar, pool frequency was greater in the valley portion of the segment, and LWD was greater but still very limited in the valley portion of the segment. Recent data and field observations, along with data collected before the trail rehabilitation project, indicate the work conducted in 2007–2008 addressed a substantial human source of sediment to Bear Creek and that the system is recovering. Although the silt observed at the channel margins and substrate embeddedness at the upper site may be partially to entirely natural, the elevated fine sediment in pool tails, in combination with remaining human sources and the sensitivity of the watershed to disturbance, support the listing. A sediment TMDL will be developed for Bear Creek.

5.5.2 Bozeman Creek (aka Sourdough Creek) (MT41H003_040)

Bozeman Creek (MT41H003_040) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Bozeman Creek was initially listed for sediment impairment in 1990 based on reports from the late 1970s documenting sedimentation associated with agricultural and urban runoff as well as logging. Bozeman Creek forms within the Gallatin National Forest, but the listed segment extends 4.9 miles from the confluence of Limestone Creek to its mouth at the East Gallatin River. The portion of Bozeman Creek from its headwaters to the water supply intake for Bozeman near the USFS boundary is designated as A-Closed. It is commonly called Sourdough Creek upstream of the USFS boundary and Bozeman Creek downstream of the USFS boundary; as explained in the **Table ES-1** of the Executive Summary, the stream will be referred to as Bozeman Creek throughout this document.

Physical Condition and Sediment Sources

In addition to past sediment inputs from logging and associated roads, one potential sediment source to Bozeman Creek from the upper watershed is from the breach of the Mystic Lake Dam, which was conducted during low flow in 1985. After the breach, sediment within the reservoir was left undisturbed, and restoration work was conducted in a 100-meter segment of stream channel and riparian downstream of the dam. Although sediment from the reservoir has likely been flushed downstream since the breach, a study of the ecological response of the dam removal concluded the nature of the dam operation and removal resulted in no noticeable downstream geomorphologic or riparian changes (Schmitz et al., 2008).

In 2002 the Bozeman Watershed Council (now defunct) conducted an assessment of watershed health that involved collecting sediment and habitat data along the entire stream. The stream was broken into 10 zones, which were then broken into sampling reaches. Zones 8 through 10 roughly correspond to the segment of Bozeman Creek listed for sediment impairment; zone 8 was indicated as the area where urban influences become more concentrated.

The assessment concluded that the upper watershed lacked LWD, had steep slopes and highly erodible soils (which are prone to landslides), and contained limited spawning habitat. It cited roads and upland erosion near the city's water supply intake as potential sediment sources within the upper watershed. Sediment inputs in the upper watershed were estimated to be near the pre-logging level, and although erosion from a severe fire was noted as a risk, the predominant issues were nonpoint sources associated with urbanization in the lower watershed. Reaches within zones 8 through 10 were the only sections identified as having low habitat integrity. Limiting factors were noted as channelization and entrenchment, sediment accumulation from streambank erosion and low flow, unstable streambanks, barriers and riprap, and lack of riparian vegetation and LWD.

Increased streamflow velocity from riprap, lack of riparian vegetation, and the orientation of a residential stormwater drain were cited as sources of streambank erosion. In addition to these limitations, the USFS fisheries biologist, Scott Barndt, noted that pool habitat was lacking and there were high levels of fine sediment. At the assessment reaches within zones 8 through 10, fine sediment was estimated at 30% and 40%, respectively, LWD frequency ranged from 2 to 52 pieces per mile, and pool frequency ranged from 3 to 39 pools per mile.

The data from 2002 were used in a study that evaluated the differences in geomorphology and habitat among different land-use classes (McIlroy et al., 2008). The study area started near the USFS boundary at the city's diversion dam and contained five land use classes: agriculture, forest, industrial, high density, and low density (which had a municipal park broken out for the analysis). Channel sinuosity was significantly different between high density and agricultural, low density, and park classes. The agricultural class had more undercut and unstable streambanks and the greatest pool length and pocket pool abundance. Pocket pool abundance was lowest, and the percentage of silt/clay was greatest, in the high density areas. The percentage of sand and gravel were similar across land-use categories. Overall, the study concluded that LWD abundance was low; values ranged from 0 to 264 pieces per mile, with an average of 54 pieces per mile and a median of 83 pieces per mile. Intentional wood removal was determined to be a factor, and the importance of public education and outreach was emphasized.

In 2004 DEQ conducted an assessment at two sites. The upper site (M05SOURC01) was located at the top of the listed segment. The substrate was gravel and cobble, and fine sediment deposition was observed in pools. There were some actively eroding streambanks, particularly where the channel abutted a pasture/hayfield. LWD was abundant at the site. Most of the riparian vegetation was contained within a city-owned recreational trail and was well conserved. The other site (M05SOURC02) was approximately 0.25 mile upstream of the mouth. The stream was channelized and incised but typically had a healthy riparian zone with regenerating willows. The streambanks were frequently armored, and the site was lacking pools because of the channelization. Accumulations of fine sediment were mostly limited to the channel margin.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Bozeman Creek (**Figure 5-1**). The upper site (BOZE14-01) was upstream of the listed segment but was evaluated as part of the source assessment and to assess instream conditions upstream of the listed segment. The site was just upstream of the Sourdough Canyon trailhead (the trail was formerly a road, and there was occasional riprap along the channel where the stream abutted the trail). Riparian vegetation was dense at the site and included alders, red-osier dogwoods, and willows in the understory, with cottonwoods in the overstory. The substrate was mostly small cobble and coarse gravel, and the majority of the site was riffle habitat. Pools were formed by lateral scour and LWD aggregates; one large LWD jam was observed. Spawning potential was estimated to be limited because of the large substrate. Some fine sediment accumulations were observed along the channel margin, and the substrate in pool tails was embedded. Streambank erosion was fairly limited but was observed in a couple places where the trail encroached on the channel. It appeared silt fencing had been used to limit trail sediment inputs to the stream but was inadequately maintained because fencing was tangled with LWD in the channel at this site and the next site downstream (BOZE15-01). On a side note, the Gallatin Valley Land Trust completed an improvement project in October 2011 that included moving the trail access road farther from the stream to reduce sedimentation (Flandro, 2011).

The lower site (BOZE18-04) was in a channelized section of stream near downtown Bozeman and is bordered by houses on the left and Bogert Park on the right. There were a few small pocket pools with spawning sized gravels along the channel margin, but habitat was mostly riffle. The left side of the channel was hardened in many places by retaining walls and riprap; the right side was mostly lined with a narrow band of large deciduous trees. One large eroding streambank was associated with recreational access from the park. Although there was a fair amount of bare ground along the channel, streambank erosion was typically limited because of stabilization by roots from the trees and the extensive use of riprap.

In 2009 DEQ evaluated two additional sites for streambank erosion. The upper site (BOZE15-01) was well upstream of the listed segment approximately 1 mile downstream of BOZE14-01 and near the Nash Road crossing. Some old riprap was observed, but surrounding land-use practices appeared to have minimal effects on the site. Bank erosion was limited as a result of cobbles armoring the streambanks and roots from cottonwood trees in the riparian zone. All erosion was attributed to natural sources. The other site (BOZE18-05) was located near the downstream end of the segment in an industrial area north of I-90 and just upstream of M05SOURC02, which DEQ sampled in 2004. Streambank erosion was limited as a result of extensive riprap that had been strategically placed along meander bends. A component of the bank erosion was attributed to natural sources but the majority was attributed to urban development. Riparian vegetation consisted of a dense band of willows and alders along the channel margin with some cottonwoods in the overstory.

The nutrient source assessment report (**Attachment B**) noted minimal sources within the Gallatin National Forest associated with recreational trails but increasing sources in a downstream direction as residential and urban development intensifies. Downstream of the forest boundary, riparian buffers along pastureland were typically dense and wide. In residential areas upstream of Bogert Park, riparian vegetation was predominantly dense and healthy, and bank erosion was limited to areas of pasture and lawn encroachment. Riparian quality was much lower and streambank trampling and erosion much more common in residential and industrial areas downstream of Bogert Park. However, streambank erosion was limited along many residences because of extensive riprap. Riparian quality improved and bank erosion was much lower near the bottom of the segment downstream of Tamarack Street; however, fine sediment accumulations were observed in areas with slower moving water. Recreational trails and roads were noted as a minor source, but stormwater was identified as a potentially significant source.

The USFS has recently identified Bozeman Creek as a priority watershed for restoration. Some sediment-related items identified as key issues in the restoration action plan include five splash dams that were in the channel between 1878 and 1910, which caused considerable damage to the channel, as well as road density and deferred road/trail maintenance (U.S. Forest Service, 2011). Additionally, approximately 50 feet of road/trail slumpage occurred near the Mystic Lake rental cabin in 2011. The USFS estimates that sediment yields are barely over a pristine baseline (3.4%); however, the action plan includes projects aimed to reduce sediment inputs to the creek, such as repairing the road slump and storm-proofing the road and trail system. Also, because of the estimated risk of a large-scale wildfire and associated resulting ash and fine sediment loads that would end up in Bozeman Creek (and the city's water supply intake), the USFS will be conducting a harvesting and thinning project. The project is not anticipated to affect water yield and will not involve any harvesting within the riparian zone. Further, the USFS estimates it will increase the short-term sediment yield by 1.3% (for a total of 4.7% over pristine) (U.S. Department of Agriculture, Forest Service, Gallatin National Forest, 2011).

Comparison with Water Quality Targets

The existing data in comparison with the targets for Bozeman Creek are summarized in **Table 5-14**. The macroinvertebrate bioassessment data for Bozeman Creek is in **Table 5-15**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-14. Existing sediment-related data for Bozeman Creek relative to targets.

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
M05SOURC 01	2004		C4	--	8	7	--	16.8	2.7	--	**--**	**--**
M05SOURC 02	2004	22	G4/F4	--	14	8	--	15.7	1.6	--	**--**	**--**
PIBO2316*	2007	19.7	--	--	6	3	3	16.9	--	1.0	**49**	264
BOZE14-01*	2009	22.3	C3/C4/E3	C3	8	4	**10**	14.2	5.5	1.3	53	158
BOZE18-04	2009	23.8	B4c/F4/G4c	B4c	10	8	**14**	12.8	1.4	1.3	**11**	**37**

*Upstream of listed segment

Table 5-15. Macroinvertebrate bioassessment data for Bozeman Creek.
Values that do not meet the target threshold (0.80) are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
BOZMC02	E. Lincoln St. below storm outfall	7/24/2008	MAC-R-500	1.14
		7/19/2009	MAC-R-500	1.01
		7/12/2010	MAC-R-500	1.14
		8/20/2011	MAC-R-500	1.27
BOZMC01	1.4 miles upstream of mouth near the old library	7/24/2008	MAC-R-500	1.14
		7/19/2009	MAC-R-500	0.89
		7/12/2010	MAC-R-500	0.89
		8/20/2011	MAC-R-500	1.14
M05BOZMC01	At the mouth	8/30/2005	KICK	1.14
M05SOURC02	0.25 mile upstream of the mouth	8/2/2004	KICK	1.26
M05SOURC01	Upper end of segment just downstream of confluence with Limestone Creek	8/2/2004	KICK	1.15

Summary and TMDL Development Determination

All sites met the target for fine sediment in riffles. Although BOZE14-01 is upstream of the listed segment and had less fine sediment in riffles and pools than BOZE18-04, both DEQ sites from 2009 exceeded the pool tail grid toss target for fine sediment. The sediment assessment procedure performed for the 2002 watershed assessment varied from the more recent assessment procedures; however, in 2002 excess fine sediment was noted as a widespread problem throughout the segment.

Both channel form targets were met at all sites; however, the channel was more entrenched within the listed segment, which corresponds with observations from the assessments performed in 2002 and 2004. The residual pool depth target was met at all sites, but the PIBO site was just short of the pool frequency target, and BOZE18-04 was well below the pool frequency target. Both sites upstream of the listed segment met the LWD frequency target; however, BOZE18-04 was well below the target. Although all macroinvertebrate samples met the target value, fine sediment and habitat parameters, as well as observations about the effects of urbanization, are consistent with the 2002 watershed assessment and sampling conducted in 2004. This information supports the 303(d) listing; a sediment TMDL will be developed for Bozeman Creek.

5.5.3 Camp Creek (MT41H002_010)

Camp Creek (MT41H002_010) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, physical substrate habitat alterations, other anthropogenic substrate alterations, and low-flow alterations, which are non-pollutant listings commonly linked to sediment impairment. Camp Creek was initially listed for sediment impairment in 1988 based on reports going back to the late 1970s documenting sedimentation and limitation of the fishery associated with channel changes, realignment due to road construction, irrigation runoff, bank erosion and removal of riparian vegetation associated with cattle grazing, and increased flow from irrigation returns. Camp Creek flows 29.6 miles from its headwaters to the mouth at the Gallatin River.

Physical Condition and Sediment Sources

In 2001 DEQ assessed two sites on Camp Creek: one was about a mile upstream of Anceney and the other was approximately 1 mile upstream of the confluence with Baker Creek. The site near Anceney had all sizes of rock and gravel but was choked by sand and silt. The site had been heavily grazed for generations, resulting in over-browsed riparian vegetation and an overwidened channel. Undercut streambanks and overhanging willows were providing some good pools and cover for fish.

The lower site near Baker Creek had been formerly overgrazed but had recently changed ownership, and conditions appeared to be improving. Large accumulations of sand, silt, and clay were prevalent and noted to be filling pools and reducing fish habitat. LWD was rare, and an altered flow regime was causing lateral downcutting and channel incisement. Soils at both sites were noted as naturally erosive, but loading was being increased by grazing and dryland agriculture.

In 2009 DEQ assessed sediment and habitat on three sites on Camp Creek. The uppermost site (CAMP14-05) was highly entrenched with large eroding streambanks where the stream meandered into the valley wall. The channel entrenchment, as well as much of the streambank erosion, was attributed to past vegetation removal and agricultural practices. Other human sources of bank erosion were riparian grazing and cropland. The site was used for livestock grazing and had a hayfield along the right side of the channel. The channel margin contained wetland vegetation, grasses, and periodic shrubs, with junipers and rose growing beyond the bankfull zone. The streambanks and streambed were composed of sand and silt. The channel contained dense aquatic vegetation, and fine sediment in pool tails was likely limiting spawning potential. Camp Creek conveys irrigation water drawn from the Gallatin River, and it appeared that streamflows increased between this site and the next downstream site (CAMP14-12).

CAMP14-12 was very similar in character to the upper site in that it was highly entrenched with large eroding streambanks composed of sand and silt. The stream was fairly close to the road on the right side and had a hayfield on the other side that extended to the valley terrace. The upstream addition of irrigation return flows were apparent, since the channel was near bankfull in late August; the landowner commented that the high flows appeared to be accelerating streambank erosion. Additionally, the landowner said that the stream was historically in the center of the hayfield but was relocated. Streambank erosion was primarily attributed to past irrigation water management but also to cropland management. Wetland vegetation lined much of the channel, which was narrow and deep, but the upper end of the site had a wider and shallower channel lined with large willows and grasses. The streambed was primarily fine sediment and likely limits the spawning potential. Although pools were numerous, the elevated flows in the narrow channel and easily disturbed fine grain sediment prevented the field crew from performing pool tail grid toss measurements.

The most downstream site (CAMP15-04) was just downstream of I-90 in a section that resembles a spring creek. This section of stream is within the floodplain of the Gallatin River and receives numerous groundwater and spring inputs. The channel was wide with low streambanks that contained much less silt than the other assessment sites. Streambank erosion was limited to places historically used for livestock access. During the assessment, the site appeared to be used lightly for grazing, but cattle were observed there in December, indicating it may be used as a winter pasture. The reach was primarily a riffle but contained large deep pools with poorly defined tails at the outside of meander bends. There was little shrub cover, and riparian vegetation was primarily wetland vegetation and grasses.

In 2009 DEQ evaluated one additional site for streambank erosion (CAMP13-02). The site was near the Anceney site from 2001 in an area used for grazing, but a portion of the stream was partially fenced off. Streambank erosion at the site was primarily attributed to natural sources, and the erosion rate was limited by dense riparian shrubs.

The nutrient source assessment report (**Attachment B**) documented extensive agricultural sources downstream of Norris Road, which is just upstream of CAMP14-05. Sources included bank erosion associated with overgrazing and pasture encroachment on the stream channel, livestock confinement areas near the stream, and unpaved road crossings.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Camp Creek are summarized in **Table 5-16.** No macroinvertebrate data are available for Camp Creek. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-16. Existing sediment-related data for Camp Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
CAMP14-05	2009	12.3	E4/B4c/5c	E4	**61**	**36**	**83**	11.1	**1.7**	1.1	95	216
CAMP14-12	2009	17.1	B4c	E4	14	10	No Data	**14.0**	**2.1**	**1.1**	90	**26**
CAMP15-04	2009	36.6	C3/C4	C4/E4	9	9	**24**	22.2	6.4	1.9	**16**	**26**

Summary and TMDL Development Determination

The upper site was well over the riffle pebble count targets, and both sites with grid toss data exceeded the target. Reflecting the entrenched nature of the channel at the middle and upper site, both sites failed to meet the entrenchment ratio target. The middle site exceeded the target for width/depth ratio, which is likely a factor of irrigation water management and prolonged elevated flows. The middle site was just below the target for residual pool depth. Although the most downstream site had deep pools, it was well below the target for pool frequency. Both the middle and most downstream site were well below the target for LWD. Soils in the Camp Creek watershed are sensitive to disturbance, and based on the recent data, excess sediment loading associated with channel realignment, overgrazing, and irrigation continue to overwhelm the system's sediment transport capacity. This information supports the 303(d) listing; a sediment TMDL will be developed for Camp Creek.

5.5.4 Dry Creek (MT41H003_100)

Dry Creek (MT41H003_100) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers and physical substrate habitat alterations, which are non-pollutant listings commonly linked to sediment impairment. Dry Creek was initially listed for sediment impairment in 1992 based on data from the late 1970s noting channel realignment associated with transportation, as well as a 1991 DEQ assessment that documented reduced riparian vegetation and siltation and streambank failure associated with agriculture. Dry Creek flows 20.1 miles from its headwaters to the mouth at the East Gallatin River.

Physical Condition and Sediment Sources

A small portion of the upper watershed containing tributary headwaters is on land administered by the USFS and contains a grazing allotment (**Figure 5-1**). In an evaluation for the North Bridgers Allotment Management Plan Update Environmental Impact Statement (U.S. Forest Service, 2007), the riparian vegetation for all sites within the allotment was rated as in proper functioning condition (Prichard, 1998). No potential grazing-related effects to water quality were noted for this allotment.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Dry Creek (**Figure 5-1**). The upper site (DRY09-05) was near the Menard Road crossing in an entrenched section of stream, with large eroding streambanks at the outside of meander bends, and was surrounded by grazing pasture. Streambanks were composed almost entirely of sand/silt, and bank erosion was attributed to grazing. A meander scar was observed on the abandoned floodplain, indicating the stream was not historically entrenched. Woody shrubs were sparse, but the channel appeared to be recovering: it was establishing a new floodplain within the entrenched valley and had wetland vegetation stabilizing the inside of meander bends. Pools predominantly occurred at the outside of meander bends and were deep. Fine sediment deposition was observed in some pool tails.

The lower site (DRY12-06) was approximately 3 miles upstream from the mouth. The stream was entrenched at the upper end of the site but had better floodplain access at the lower end of the site; the source of entrenchment was unclear. The streambanks had some coarse and fine gravel but were predominantly sand/silt. Bank erosion was attributed to past agriculture and vegetation removal. The landowner identified several areas of active bank retreat. Willows, wetland vegetation, and other streambank-stabilizing plants were colonizing the newly forming floodplain at the lower end of the site, indicating the site is recovering. However, most of the streambanks were lined with reed canary grass (which has deep roots but tends to out-compete native vegetation). Riffles were predominantly cobbles, but fine sediment accumulations were noted at the bottom of deep pools under eroding streambanks. Because of turbidity, no grid tosses were performed in pool tails (potential spawning locations could not be identified).

The nutrient source assessment report (**Attachment B**) documented healthy riparian vegetation and stable streambanks throughout most of Dry Creek but did note several areas with large eroding banks because of either grazing or encroachment of pastureland onto the channel. Unpaved road crossings, particularly where gravel was accumulating on bridge decking, were also noted as a potential sediment source.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Dry Creek are summarized in **Table 5-17**. No macroinvertebrate data are available for Dry Creek. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-17. Existing sediment-related data for Dry Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
DRY09-05	2009	14.3	B4c/G4c	E4	22	**19**	**17**	**11.3**	**1.4**	1.6	**74**	**79**
DRY12-06	2009	17.1	C4/B4c	E4	15	11	No Data	**13.9**	3.5	1.5	**37**	**0**

Summary and TMDL Development Determination

The upper site failed to meet the riffle pebble count target for fine sediment <2mm and also the pool tail grid toss target. At the lower site, fine sediment accumulation was not an issue in riffles, and although no grid tosses were performed, field observations indicate excess fine sediment from eroding streambanks is accumulating in pools. The stream appeared to be recovering and narrowing at both sites but is still overwidened and failed to meet the target for width/depth ratio. Pools were quite deep at both sites but failed to meet the target for pool frequency. Also, both sites failed to meet the target for LWD, with the lower site having none. The recovery occurring at the assessment sites corresponds with observations from the nutrient source assessment: much of Dry Creek is either in good condition or in recovery. However, the source assessment and field observations also document the increase in bank erosion and downcutting that can occur when land management practices remove riparian vegetation. This information supports the 303(d) listing; a sediment TMDL will be developed for Dry Creek.

5.5.5 Godfrey Creek (MT41H002_020)

Godfrey Creek (MT41H002_020) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Godfrey Creek was initially listed for sediment impairment in 1996 based on reports from the late 1970s as well as the early 1990s documenting upland erosion from cropland, overgrazing on rangeland and along the stream, lack of riparian vegetation, streambank erosion, channel manipulation, and sediment from irrigation returns. Godfrey Creek is located just east of Camp Creek and flows 9 miles from its headwaters to mouth at Moreland Ditch.

Physical Condition and Sediment Sources

An extensive Section 319 (i.e., nonpoint source) project was undertaken in the early to mid-1990s to improve management practices in the watershed. Many landowners were involved in projects, including adding riparian fencing, improving grazing and manure management, and improving irrigation water management. DEQ conducted several assessments in the mid-1990s that noted minimal improvement but cited inadequate information to fully evaluate changes. The 1996 Section 319 project report mentioned roads as a source and noted that improvements may be limited by three irrigation canals crossing the watershed.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Godfrey Creek (**Figure 5-1**). The upper site (GOD02-01) was in a channelized section of stream along Churchill Road. The streambed was silty, with frequent pools and extensive macrophyte growth. The channel was lined with wetland vegetation and grass, and the limited amount of streambank erosion was attributed to channelization from the road. The lower site (GOD03-01) was located in a pasture used for grazing. The channel was sinuous, with fine substrate and compound pools at meander bends. Spawning-size gravels were observed in the pool tails. Riparian shrubs were lacking, but wetland vegetation was present along the channel margin. Streambank erosion was primarily observed at the outside of meander bends and was attributed to hoof shear and the lack of woody vegetation.

The nutrient source assessment report (**Attachment B**) identified agricultural sediment sources scattered throughout most of Godfrey Creek; however, the most significant sources were observed in a 3-mile section starting at the confluence of the east and west forks (just downstream of GOD02-01 but including GOD03-01). Sources were encroachment by pastureland, streambank erosion caused by overgrazing of riparian vegetation, the presence of near-channel livestock confinement areas, and direct disturbance of the channel by livestock. Sections of the stream that had better implementation of BMPs and dense riparian grasses had very limited bank erosion.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Godfrey Creek are summarized in **Table 5-18**. No macroinvertebrate data are available for Godfrey Creek**.** All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-18. Existing sediment-related data for Godfrey Creek relative to targets.

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
GOD02-01	2009	7.9	B4c/C4/E4	E4	**34**	**27**	**45**	10.5	2.4	**0.6**	180	**0**
GOD03-01	2009	10.8	B4c/C4	E4	22	16	**29**	**13.5**	2.9	0.8	95	**11**

Summary and TMDL Development Determination

Riffle pebble count targets were exceeded at the upper site, and both sites exceeded the target for pool tail grid toss. As a result of overgrazing, the lower site was overwidened and failed to meet the target for width/depth ratio. The upper site was slightly below the target for residual pool depth but was more than double the target for pool frequency. Both sites were lacking LWD and fell short of the LWD target. Observations from the nutrient source assessment and sediment/habitat assessment sites indicate many of the significant sediment sources identified in the 1990s remain, and excess sediment continues to overwhelm the transport capacity of Godfrey Creek. This information supports the 303(d) listing; a sediment TMDL will be developed for Godfrey Creek.

5.5.6 Jackson Creek (MT41H003_050)

Jackson Creek (MT41H003_050) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, Jackson Creek is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Jackson Creek was initially listed in 1992 based on FWP data from 1975 citing siltation associated with channel alterations from the road and livestock trampling of the streambanks. Jackson Creek flows 8.6 miles from its headwaters to its mouth, where it joins Timberline Creek to form Rocky Creek.

Physical Condition and Sediment Sources

In 2004 DEQ assessed a site (M05JAKSC01) on land administered by the USFS downstream of an area that was historically logged but appeared revegetated and stable (**Figure 5-1**). The stream contained mostly runs and riffles, and some pools were associated with LWD and boulders. The substrate was dominated by small cobble and coarse gravel; there were some silt accumulations at the channel margin. The silt was attributed to past logging and possibly associated changes in water yield. The streambanks were generally stable but occasional bank erosion was noted as being potentially associated with downcutting. No evidence of grazing was observed at the site.

One PIBO non-reference site (2216) approximately 0.4 mile upstream of M05JAKSC01 was sampled in 2007 (**Figure 5-1**). Additionally, there is a grazing allotment on USFS-administered land within the upper watershed. In 2008 the Gallatin National Forest evaluated conditions in the watershed as part of the Bangtail Allotment Management Plan Update Environmental Assessment (U.S. Forest Service, 2009). According to the report, much of the Bangtail Mountains were roaded and logged in the 1980s and through the mid-1990s prior to a 1998 land exchange. In the Jackson Creek watershed, 1,050 acres were harvested by 1980, an additional 600 acres were harvested by 1988, and 598 acres were harvested by 1998.

Little commercial harvesting has occurred on public land in the watershed since that time, and many of the roads have been decommissioned; however, primary access roads were noted as potential sediment sources. A grazing allotment within the forest is another potential sediment source. The Jackson Creek Allotment includes 2,870 acres on national forest land and 2,301 acres on an adjacent lease on private land; the total number of permitted cow/calf pairs is greater than desired by the USFS (U.S. Forest Service, 2009). The allotment is managed under a single pasture two-month system that typically receives the most use in the uplands. The Environmental Assessment report noted no discernible effects to the stream as a result of grazing. In addition there was no change in channel stability relative to previous assessments, and riparian vegetation at the site was in proper functioning condition (Prichard, 1998). However, the report noted isolated pockets of overuse by livestock during drier years, the need for maintenance to stock water improvements, and conifer encroachment into rangeland.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Jackson Creek (**Figure 5-1**). The upper site (JACK04-01) was located on land administered by the USFS. Similar to observations from 2004, field notes indicated signs of past logging in the upper watershed but that extensive regrowth had occurred. The area was lightly grazed and the channel was overwidened at one cattle access point. There was a high amount of fine sediment in depositional areas, but the source was not apparent. There was extensive LWD, and fine sediment accumulation around LWD aggregates limited pool formation.

Additionally, fine sediment in pool tails likely limits spawning potential. Streambanks were predominantly composed of sand/silt, and erosion mostly occurred at the base of hillslopes and behind

LWD accumulations; sources were cited as natural, grazing, and past timber harvest. The riparian zone was composed of a mix of shrubs and grasses, with conifers in the overstory.

The lower site (JACK10-02) was in an agricultural section of the valley bottom used for haying. Riprap had been added to the right streambank to limit erosion of the hayfield. The stream had a headcut near the lower end the site, which is an indicator of instability and channel adjustment. Rock check dams were observed farther upstream and may have been a contributing factor. The channel was meandering and was locally entrenched, but the riparian vegetation was typically a dense mixture of alder and grasses. Although streambanks were similar to the upper site in composition, the substrate was dominated by coarse gravel, and fine sediment accumulations were not observed. Streambank erosion was limited to areas that did not have riprap or dense riparian vegetation and was attributed to cropland and natural sources.

The nutrient source assessment report (**Attachment B**) noted high riparian quality along much of Jackson Creek, including areas that were being actively logged in the upper watershed. Sediment sources were noted as past and current logging, unpaved roads, stream fords, stream encroachment by pasture, and livestock grazing. Some areas of streambank erosion were observed and attributed to grazing.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Jackson Creek are summarized in **Table 5-19**. The macroinvertebrate bioassessment data for Jackson Creek is in **Table 5-20.** All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-19. Existing sediment-related data for Jackson Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
M05JAKSC01	2004	10.9	B4/E4b	--	12	**11**	**--**	10.0	7.2	--	**--**	--
PIBO2216	2007	10.5	--	--	5	4	**11**	**18.0**	--	**0.5**	162	**95**
JACK04-01	2009	13.7	B4/E4b/G4	B4	**20**	**16**	**64**	13.0	2.2	0.7	**53**	401
JACK10-02	2009	19.9	B4c/C4	C4	6	5	7	18.2	2.4	1.4	106	407

Table 5-20. Macroinvertebrate bioassessment data for Jackson Creek.
Values that do not meet the target threshold (0.80) are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
PIBO_2216	1.9 miles downstream of the headwaters	7/29/2007	Surber	0.97
WMTP99-0749	0.5 miles upstream of the USFS boundary	9/4/2002	WEMAP-RW	1.02
M05JAKSC01	1.5 miles upstream of the USFS boundary	7/27/2004	KICK	**0.62**

Summary and TMDL Development Determination

In 2004 the macroinvertebrate sample failed to meet the target value. The percentage of riffle fine sediment <2mm exceeded the target, indicating excess fine sediment may be limiting the stream's ability to support aquatic life. Both the PIBO site and upper DEQ site from 2009 exceeded the pool tail grid toss target. The upper DEQ site from 2009 also exceeded both fine sediment targets for riffle pebble count. The PIBO site slightly exceeded the target for width/depth ratio but overall, channel form targets were met. The PIBO site also failed to meet the target for residual pool depth and LWD frequency.

However, the extremely high LWD values at both DEQ sites in 2009 indicate there is more than an adequate amount of LWD in the stream. The upper DEQ site from 2009 did not meet the target for pool frequency. Although grazing still appears to be a source of excess sediment, management practices have improved since Jackson Creek was initially listed for impairment. Recent observations also indicate logging practices have improved; however, unpaved roads remain a source of excess sediment and the stream may still be recovering from increased sediment loading, and changes in water yield associated with past harvest practices. This information supports the 303(d) listing; a sediment TMDL will be developed for Jackson Creek.

5.5.7 Reese Creek (MT41H003_070)

Reese Creek (MT41H003_070) is listed for solids (suspended/bedload) on the 2012 303(d) List. Reese Creek was originally listed in 1990 based on reports from the late 1970s identifying Reese Creek as a major sediment source to the East Gallatin as well as a 1989 study by FWP. Reese Creek flows 8.3 miles from the headwaters to its mouth, where it joins Ross Creek to form Smith Creek. Because of the irrigation network, Ross Creek intermixes with the Dry Creek Irrigation Canal (which originates at the East Gallatin River) and then flows for approximately 0.3 mile before it openly mixes with Reese Creek to form Smith Creek (see **Figure 6-9**). The flow contribution from Reese Creek to Smith Creek varies, depending on the flow volume in the irrigation canal.

Physical Condition and Sediment Sources

A small portion of the upper watershed is on land administered by the USFS and contains a grazing allotment (**Figure 5-1**). In an evaluation for the North Bridgers Allotment Management Plan Update Environmental Impact Statement (U.S. Forest Service, 2007), the riparian vegetation for all sites within the allotment was rated as in proper functioning condition (Prichard, 1998). No potential grazing-related effects to water quality were noted for this allotment.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Reese Creek (**Figure 5-1**). The upper site was upstream of Gee Norman Road in an area where flow is split among multiple channels. The assessment was performed in the largest channel, which also coincides with the NHD location of Reese Creek. The site appeared to have been channelized through a field at one time, but riparian vegetation was dense, with an alder understory and cottonwood overstory. Streambank erosion was attributed to past agriculture/channelization and natural sources. Likely because of being channelized, the stream lacked well defined pools.

The lower site (REESE15-06) was near the lower end of the segment, approximately 0.4 mile upstream of Ross Creek. The stream was quite sinuous at the site and typically had a buffer on both sides, but streambank erosion, attributed to cropland and natural sources, was observed at meander bends where the adjacent hayfield encroached on the channel. The riparian zone had occasional shrubs, but most of the reach had a buffer of reed canary grass, with wetland vegetation at the bankfull margin. There were numerous pools at the outside of meander bends that had spawning-size gravels in the pool tails. Downstream of the site, where Reese Creek mixes with water from Ross Creek and the irrigation canal (to form Smith Creek), the resulting flow was observed to be much more turbid.

The nutrient source assessment report (**Attachment B**) identified minimal human sediment sources to Reese Creek. Riparian buffers were noted to be in good condition along most of the stream, including along cropland and pastureland, and streambank erosion was limited. Downstream of Hamilton Road, the riparian buffer narrowed but was dense and confined streambank erosion to areas of pasture encroachment at meander bends. Unpaved road crossings were noted as a minor sediment source.

Comparison with Water Quality Targets

The existing data in comparison with the targets for the Reese Creek are summarized in **Table 5-21**. No macroinvertebrate data are available for Reese Creek. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-21. Existing sediment-related data for Reese Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
REES06-01	2009	9.2	B4c/E4	E4	14	11	9	9.3	**1.4**	**0.6**	105	158
REES15-06	2009	14.7	C4/E4	E4	13	9	14	9.8	15.9	1.7	**79**	**37**

Summary and TMDL Development Determination

Both sites on Reese Creek met all fine sediment targets. The upper site was slightly entrenched and failed to meet the entrenchment ratio target, but the width/depth ratio target was met at both sites. The upper site failed to meet the target for residual pool depth. The lower site was slightly below the pool frequency target; however, its bankfull width was at the upper end of the category (i.e., 15 feet), and the site had deep pools that were well over the residual pool depth target. The lower site was well below the target for LWD frequency. Although pool quality was lacking at the upper site and past vegetation removal has greatly reduced the LWD supply to the lower portion of Reese Creek, recent data do not indicate fine sediment deposition is an issue in Reese Creek.

Although suspended sediment issues are typically associated with the same sources that cause excess sedimentation on the stream bottom, because recent data do not indicate a sedimentation problem, total suspended sediment (TSS) data for Reese Creek were also reviewed. In 1976–1977 samples were analyzed for TSS approximately 1 mile upstream of REES15-06 at one of the same sites DEQ sampled in September 2009 (RS01B). Values in the 1970s were collected during high and low flow and ranged from 10 mg/L to 836 mg/L, with an average concentration of 133mg/L. The 2009 sample had a concentration of 17mg/L, which was the highest value out of three samples collected along Reese Creek.

Although it is only a single sample (and additional sampling is recommended), it indicates that management improvements within the watershed have likely resulted in lower TSS concentrations.

However, given the current listing status, sediment sources (including unpaved roads), streambank erosion, and the irrigation network, and the potential for substantial increases in sediment loading if adequate riparian buffers are not maintained, a TMDL will be developed for Reese Creek.

5.5.8 Rocky Creek (MT41H003_080)

Rocky Creek (MT41H003_080) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, physical substrate habitat alterations, and other anthropogenic substrate alterations, which are non-pollutant listings commonly linked to sediment impairment. Rocky Creek was initially listed for sediment impairment in 2000 based on fisheries abundance data and a channel stability study from the late 1970s documenting sedimentation attributed to channel straightening, armoring, and unvegetated former rights-of-way associated with construction of I-90, as well as overgrazing by livestock along streambanks. Rocky Creek extends 7.9 miles from the confluence of Jackson and Timberline Creeks to its mouth at the East Gallatin River.

Physical Condition and Sediment Sources

In 2004 DEQ assessed a site 0.25 mile upstream of I-90 and upstream of a beaver complex (M05RCKYC01). At the time of the assessment, a hayfield encroached on the riparian zone, and the land was under new ownership but appeared to have been grazed heavily in the past. The streambed was composed of cobble and coarse gravel that was embedded by silt, easily suspended, and pools were predominantly fine sediment. Streambank erosion was primarily on the outside of meander bends lacking woody vegetation and resulted in some eroding streambanks that were 3 feet high. The channel had historically downcut, but beaver dams downstream of the site were providing grade control. Point bars were vegetated with regenerating willows, and the riparian zone was narrow but vegetation appeared to be recovering.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Rocky Creek (**Figure 5-1**). The upper site (ROCK02-01) was on state-owned land upstream of I-90 and approximately 0.5 mile downstream of M05RCKYC01. The site was used for grazing, and while not being actively grazed at the time of the assessment, the growth pattern and distribution of willows indicated it has a long history of heavy livestock use. The stream was eroding the hillslope on the river’s right side, and extensive erosion was observed on the left streambank (attributed to grazing). Similar to the site evaluated upstream in 2004, some of the eroding streambanks were several feet high. The channel was entrenched and overwidened in places from streambank erosion and livestock access. Willows were the primary formative feature for pools, and fine sediment accumulations were noted in pool bottoms. However, pool tails tended to have substrate that was too large for spawning. The riparian vegetation had some dense sections of willow but was largely grass with the occasional willow.

The lower site (ROCK03-01) was located in a channelized portion of stream that paralleled Trail Creek Road. Upstream and downstream of the site, the stream is confined by a steep hillslope, including bedrock outcrops along the river’s left side in a narrow canyon, but the largest sources of confinement are the railroad and I-90. Downstream of the site at mile marker 315, direct road sand inputs from the westbound lane were observed. The channel was meandering and slightly entrenched with deep pools at the outside of bends. Substrate was predominantly small cobble, which likely limits spawning potential. Where streambank erosion was caused by the canyon or bedrock control, it was attributed to natural sources; however, the majority of streambank erosion was attributed to channelization from the transportation network.

In 2009 DEQ evaluated one additional site for streambank erosion (ROCK07-03). The site was located approximately 0.7 mile from the bottom of the segment. The site contained deep pools that were formed by LWD aggregates, and numerous fish were observed in the pools. The channel was slightly entrenched, with actively eroding streambanks at the outside of meander bends and indications of active streambank retreat. Streambank erosion was attributed to past agriculture and vegetation removal, residential development, and natural sources. Riparian vegetation included willow, alders, and red-osier dogwood, but eroding streambanks typically lacked woody vegetation.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Rocky Creek are summarized in **Table 5-22**. The macroinvertebrate bioassessment data for Rocky Creek is in **Table 5-23**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-22. Existing sediment-related data for Rocky Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
ROCK02-01	2009	26.1	B4c/F4	C4	8	6	**18**	**26.5**	**1.3**	1.4	63	**90**
ROCK03-01	2009	25.2	B3c/C3/G3c	C3	8	7	No Data	17.7	**2.0**	1.8	**32**	**21**

Table 5-23. Macroinvertebrate bioassessment data for Rocky Creek.
Values that do not meet the target threshold (0.80) are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
M05RCKYC01	0.4 miles downstream of Jackson and Timberline creeks	7/27/2004	KICK	1.19

Summary and TMDL Development Determination

Riffle pebble count targets were met at both sites, but the upper site exceeded the pool tail grid toss target. The macroinvertebrate sample collected near the upper end of the segment met the target. The upper site was also overwidened and entrenched and failed to meet both targets for channel form. The lower site failed to meet the target for entrenchment. Both sites had deep pools, but because channelization often results in a riffle-dominated system, the lower site was well below the pool frequency target. Both sites failed to meet the target for LWD. Based on recent observations, roads as well as bank erosion associated with agriculture and the transportation network continue to be sources of excess sediment to Rocky Creek. This information supports the 303(d) listing; a sediment TMDL will be developed for Rocky Creek.

5.5.9 Smith Creek (MT41H003_060)

Smith Creek (MT41H003_060) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers and physical substrate habitat alterations, which are non-pollutant listings commonly linked to sediment impairment. Smith Creek was originally listed in 1992 based reports from the late 1970s documenting eroding streambanks, overgrazing along the channel, and erosion from cropland. Smith Creek extends 6.8 miles from the confluence of Ross and Reese Creeks to its mouth at the East Gallatin River. As described in **Section 5.5.7** for Reese Creek, Ross Creek is contained within and intermixed with water in the Dry Creek Irrigation Canal when it flows into Reese Creek to form Smith Creek (**Figure 6-9**).

Physical Condition and Sediment Sources

In 2009 DEQ assessed sediment and habitat at one monitoring site on Smith Creek (**Figure 5-1**). The site (SMIT01-05) was located downstream of the Dry Creek Road crossing in a meandering section of stream with deep runs and glides. Spring and groundwater inputs were apparent. Although the landowner indicated flows were down, there was still a substantial amount of water in the channel in late August. The site was surrounded by a pasture that appeared to be used lightly for grazing. Riparian vegetation at the site most mostly wetland plants and grasses, with little shrub cover. Eroding streambanks were common and observed on the outside of most meander bends, which typically lacked woody vegetation.

Upstream of the site, riparian shrub density was greater, likely limiting streambank erosion. Downstream of the site, a large eroding streambank was observed at a livestock crossing. Substrate at the site was relatively fine, and riffles were dominated by medium and coarse gravels and contained a large amount of aquatic plants. Although the stream may provide spawning habitat for larger fish and grid toss measurements were performed, because of its spring-like nature, it was difficult to discern the break between the pool tail and riffle crest.

The nutrient source assessment report (**Attachment B**) noted that riparian vegetation was typically dense along Smith Creek but dominated by weeds. Some riparian fencing was observed as well as occasional clumps of willow and buffaloberry. Encroachment by pasture and residential yards was common and tended to correspond with actively eroding streambanks. Since much of the Smith Creek watershed is composed of the Reese and Ross Creek watersheds, the source assessment summary for Ross Creek is also presented here. See **Section 5.5.7** for a description of sources in the Reese Creek watershed. Conditions along Ross Creek were much more variable than along Smith Creek; some areas had dense healthy riparian vegetation and other areas were either overgrazed or had almost no riparian buffer from encroachment by pasture, cropland, or residential lawns. In areas with limited riparian vegetation, particularly downstream of Penwell Bridge Road, eroding streambanks were common. Because of loose gravel observed on culverts and bridge decking, unpaved roads were noted as a potential sediment source.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Smith Creek are summarized in **Table 5-24**. No macroinvertebrate bioassessment data are available for Smith Creek. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-24. Existing sediment-related data for Smith Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
SMITH01-05	2009	50.8	C4	E4	19	**19**	**29**	**27.0**	2.5	1.7	**26**	**5**

Summary and TMDL Development Determination
Riffle fine sediment <2mm exceeded the target, and fine sediment in pool tails exceeded the grid toss target. The width/depth ratio target was exceeded but is likely a factor of the large bankfull width of the channel; the stream did not appear overwidened. The site failed to meet the targets for pool and LWD frequency. Although the current grazing intensity is light, streambank erosion associated with past overgrazing and removal of riparian vegetation continues to be a substantial source of excess sediment. Additionally, the nutrient source assessment indicated Ross Creek may be a significant source of excess sediment to Smith Creek. This information supports the 303(d) listing; a sediment TMDL will be developed for Smith Creek.

5.5.10 Stone Creek (MT41H003_120)

Stone Creek (MT41H003_120) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Stone Creek was initially listed in 1994 for sediment impairment based on sedimentation associated with grazing and logging. Stone Creek flows 6.1 miles from its headwaters to the mouth at Bridger Creek.

Physical Condition and Sediment Sources
In 2004 DEQ assessed two sites. The upper site (M05STONC01) was approximately 4 miles upstream of the mouth within USFS-administered land. The road was typically more than 90 feet from the channel, and the riparian understory was primarily grass. Signs of past logging were noted, and the channel was slightly overwidened in certain areas as a result of historic grazing. The site was mostly riffles and runs with small pools that were formed by LWD, root wads, and boulders. The substrate was predominantly coarse gravels that were not embedded. The channel was well shaded, and streambanks were stable. Residential development had recently started downstream of the site.

The lower site (M05STONC02) was just upstream of Bridger Canyon Road. Pasture occasionally encroached on the channel, but the riparian vegetation was healthy and contained sedges, willows, alders, and multiple age classes of cottonwoods. Helicopter logging was occurring upstream of the site but appeared well managed. Silt accumulations were abundant in the channel, embedding riffles and spawning gravels, and partially filing pools. Some streambank erosion was observed, but there were no indications of mass wasting. Most sediment appeared to originate from channel sources. Potential sources were noted as past logging on steep terrain, which appeared to have a low rock content, as well as roads and residential development.

In 2009 DEQ assessed sediment and habitat at two monitoring sites on Stone Creek (**Figure 5-1**). The upper site (STON08-01) was a meandering section of channel that flowed through a narrow valley on USFS-administered land. The valley floor contained old homesteads/outbuildings, and the hills above the valley contained more recent rural residential development. There was a large eroding hillslope along the channel near the upper part of the site, and most of the streambank erosion appeared natural. However, the upper portion of the watershed has been extensively logged, and some streambank erosion at the site may be associated with increased peak streamflows that occurred after logging. Additionally, the past land use at the site and associated vegetation removal appeared to be minor a source of streambank erosion. Pool tails had large substrate that likely limits spawning potential. Riparian vegetation was predominantly willows and alders.

The lower site (STON13-02) was located approximately 0.3 mile upstream of M05STONC02 in a valley section of the stream lined with a dense overstory of cottonwoods and an understory of rose, snowberry, and red-osier dogwood. The site was in an area used for grazing, and streambank erosion primarily occurred at cattle access points along meander bends where the stream abutted a field.

In 2009 DEQ evaluated one additional site for streambank erosion (STON11-02). The site was located where the stream exits the canyon and enters the valley. The entire channel was lined with trees and shrubs, and all streambank erosion was observed where the stream cut into the base of hillslopes. Streambank erosion at the site was attributed entirely to natural sources.

There is a grazing allotment near the Stone Creek headwaters on land administered by the USFS (**Figure 5-1**). According to the Bangtail Allotment Management Plan Update Environmental Assessment (U.S. Forest Service, 2009), the area has long been grazed and was converted from a sheep to a cattle allotment in the 1950s. The permitted grazing density peaked at 251 yearlings in the 1980s, and certain areas received high levels of use. Since that time, and particularly after a land exchange in 2000 converted much of the allotment to privately owned lands primarily managed for timber, the stocking density has declined dramatically. The allotment allows for 104 cow/calf pairs, and cattle move freely between the allotment and private land to the west of the allotment, whose landowner has relinquished grazing management rights to the USFS. The allotment is used for part of the season (July–September), and use is typically light, but improper livestock distribution was noted as needing to be addressed. The USFS did not conduct a riparian assessment within this allotment, but the Environmental Assessment noted that no grazing or logging is occurring within the allotment along Stone Creek (U.S. Forest Service, 2009).

Comparison with Water Quality Targets

The existing data in comparison with the targets for Stone Creek are summarized in **Table 5-25**. The macroinvertebrate bioassessment data for Stone Creek is in **Table 5-26**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-25. Existing sediment-related data for Stone Creek relative to targets.
Values that do not meet the target threshold (0.80) are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
M05STONC01	2004	11	B3/B4	--	10	8	**--**	17.7	2.1	--	--	--
M05STONC02	2004	9.5	C4	--	**50**	**49**	**--**	10.7	2.3	--	--	--
STONE08-01	2009	13.0	C4b/E4b	C4b	3	3	**11**	10.8	7.5	0.9	84	259
STONE13-02	2009	16.0	C4/E4	C4	4	4	**14**	14.8	8.0	0.9	84	290

Table 5-26. Macroinvertebrate bioassessment data for Stone Creek.
Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
M05STONC01	4 miles upstream of the mouth near road crossing	7/26/2004	KICK	1.13
M05STONC02	Just upstream from Bridger Canyon Road	7/26/2004	KICK	0.93

Summary and TMDL Development Determination

The fine sediment targets for riffles were exceeded at the lower site in 2004, and the pool tail grid toss target was exceeded at both sites in 2009. All channel form targets and instream habitat targets were met. Both macroinvertebrate samples from 2004 met the target. Although some streambank erosion was attributed to grazing and pasture encroachment, fine sediment in riffles has decreased since 2004 and has likely decreased in pools as well. The healthy riparian vegetation, stable channel form, and adequate instream habitat, combined with the decline in fine sediment, reflect improved management practices and most excess sediment in Stone Creek is likely a result of excess loading associated with past management of logging, roads, and grazing. Because Stone Creek is still recovering, this information supports the 303(d) listing; a sediment TMDL will be developed for Stone Creek.

5.5.11 Thompson Creek (Thompson Spring) (MT41H003_090)

Thompson Creek (MT41H003_090) is listed for sedimentation/siltation on the 2012 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Thompson Creek was initially listed for sediment impairment in 1990 based on data from the 1980s indicating sedimentation and degraded conditions that were attributed to land-use practices. Thompson Creek is a spring creek that extends 7.4 miles from it headwaters to its mouth at the East Gallatin River.

Physical Condition and Sediment Sources

In 2004 DEQ assessed two sites. Grazing was identified as the primary source of impairment. The upper site (M05TMPSC02) was heavily grazed and had cows in the stream. The channel was overwidened and contained shallow runs and pools. The substrate was overlain with silt, which ranged in depth from 2 inches to 1 foot, and mostly accumulated in pools and at channel margins. As a result of the excess sediment, mid-channel bars were observed and/or developing. Unstable streambanks and slumping vegetated streambanks from livestock access were common, and eroding streambanks were noted as a significant sediment source. The riparian vegetation was evaluated as not functioning, with a downward trend, and was composed of sedges, grasses, and Canadian thistle. A small section of the site was fenced off and had willows.

The lower site (M05TMPSC01) was in an area that was being restored. Silt was abundant but attributed to upstream sources. As part of the restoration, silt from upstream sources was being retained in a silt trap and dredged approximately every 2 years. The stream channel was narrowing in response to the restoration. Evidence of beavers was observed at the site, and macrophyte growth was abundant in the channel. The riparian vegetation was predominantly sedges, with an occasional willow, and was noted as functioning, with an improving trend. Pools and runs were deep, and vertical streambanks were stable and vegetated with sedges. Grazing management was good at the site, although riparian fencing allowed for pasture/hayfield encroachment onto the channel in places.

In 2009 DEQ assessed sediment and habitat at one monitoring site on Thompson Creek (**Figure 5-1**). The site (THOM02-03) was located upstream of the Hamilton Road crossing in an area used for livestock grazing that was less than 0.2 mile upstream of M05TMPSC02. The substrate was fairly sandy, with larger substrate in some of the riffles. The channel contained extensive aquatic vegetation, and most pools were formed by water deflecting off clumps of vegetation. Spawning-size gravels were observed in portions of the channel. Streambank erosion was a result of cattle access, but loads are likely limited because of the low stream velocity. Current grazing pressure appeared light, and the overwidened channel and pugging and hummocking along the channel margin were attributed to past grazing. Even if grazing practices have recently improved, however, the fine-grained soils, high water table at the site, and consistent low-velocity flows in the spring creek make it sensitive to disturbance and slow to recover without active restoration.

In 2009 DEQ evaluated one additional site for streambank erosion (THOM01-04). The site was located upstream of the Penwell Bridge Road crossing near the upper extent of where surface flow is visible in aerial imagery from 2009. Small eroding streambanks were observed at the outside of meander bends associated with hoof shear but estimated to be a minor sediment source because of the relatively consistent low flow of the spring creek.

The nutrient source assessment report (**Attachment B**) noted healthy riparian buffers within pastures along most of the stream and a minimal amount of streambank erosion. Pasture encroachment and grazing along unobserved sections of stream, as well as unpaved roads, were cited as potential sediment sources.

Comparison with Water Quality Targets

The existing data in comparison with the targets for Thompson Creek are summarized in **Table 5-27**. The macroinvertebrate bioassessment data for Thompson Creek is in **Table 5-28**. All bolded cells are beyond the target threshold; depending on the target parameter, this may equate to being below or above the target value.

Table 5-27. Existing sediment-related data for Thompson Creek relative to targets.
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (mean)		Instream Habitat		
					% <6mm	% <2mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile
M05TMPSC02	2004	21.9	E5	E4	**85**	**85**	--		3.2	--	**--**	**--**
M05TMPSC01	2004	30	E4	E4	17	**17**	--		4.3	--	**--**	**--**
THOM02-03	2009	30.8	B4c/C4	E4	21	**18**	11	**52.9**	2.5	0.7	**21**	**0**

Table 5-28. Macroinvertebrate bioassessment data for Thompson Creek.
Values that do not meet the target threshold (0.80) are in bold.

Station ID	Location	Collection Date	Collection Method	O/E
M05TMPSC01	0.3 mile upstream of the mouth	8/25/2004	KICK	1.15
M05TMPSC02	0.08 miles upstream of Hamilton Road	8/26/2004	KICK	**0.77**
THMPC02	0.4 miles upstream of Hamilton Road	7/26/2008	MAC-R-500	**0.54**
THMPC01	0.25 mile upstream of the mouth	7/26/2008	MAC-R-500	**0.63**

Summary and TMDL Development Determination

The upper site in 2004 failed to meet both riffle fine sediment targets. The other site in 2004, as well as the site assessed in 2009, failed to meet the riffle target for fine sediment <2mm. Riffle fine sediment values in 2009 were much lower than at the nearby location sampled in 2004. That, combined with recent observations of grazing practices, indicates that improvements in grazing management since 2004 have resulted in lower fine sediment values. However, the channel was overwidened in 2004 and remains overwidened, with the recent site being well over the width/depth ratio target.

As mentioned above, the nature of the system likely limits the extent of recovery that will occur without active restoration activities. Three of four macroinvertebrate samples failed to meet the target, indicating excess fine sediment is likely impairing aquatic life. The 2009 site failed to meet both the targets for pool and LWD frequency. As a spring creek, it may not have the same potential for LWD as other streams in the Lower Gallatin TPA, but willows in the fenced-off area at the site indicate it does have the potential for woody riparian vegetation. This information supports the 303(d) listing; a sediment TMDL will be developed for Thompson Creek.

5.6 Sediment TMDL Development Summary

Based on the comparison of existing conditions with water quality targets, 11 sediment TMDLs will be developed in the Lower Gallatin TPA. **Table 5-29** summarizes the sediment TMDL development determinations and corresponds to the waterbodies of concern identified in **Section 5.3**.

Table 5-29 Summary of Sediment TMDL Development Determinations

Stream Segment	Waterbody #	TMDL Development Determination (Y/N)
BEAR CREEK, headwaters to the mouth (Rocky Creek MT41H003_080)	MT41H003_081	Y
CAMP CREEK, headwaters to the mouth (Gallatin River)	MT41H002_010	Y
DRY CREEK, headwaters to the mouth (East Gallatin River)	MT41H003_100	Y
GODFREY CREEK, headwaters to White Ditch	MT41H002_020	Y
JACKSON CREEK, headwaters to the mouth (Rocky Creek)	MT41H003_050	Y
REESE CREEK, headwaters to the mouth (Smith Creek)	MT41H003_070	Y
ROCKY CREEK, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	MT41H003_080	Y
SMITH CREEK, confluence of Ross and Reese Creeks to the mouth (East Gallatin River)	MT41H003_060	Y
SOURDOUGH (aka BOZEMAN) CREEK, Limestone Creek to the mouth (East Gallatin River)	MT41H003_040	Y
STONE CREEK, headwaters to the mouth (Bridger Creek)	MT41H003_120	Y
THOMPSON CREEK (or Thompson Spring), headwaters to mouth (East Gallatin River)	MT41H003_090	Y

5.7 Sediment Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 5.8**. This section focuses on four potentially significant sediment source categories and associated controllable human loading for each of these sediment source categories:

- streambank erosion
- upland erosion and riparian health
- unpaved roads
- permitted point sources

EPA's guidance for developing sediment TMDLs states that the basic procedure for assessing sources includes compiling an inventory of all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999b). Federal regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR 130.2(G)).

Using standard DEQ methods for source assessments, DEQ evaluated loading from the primary sediment sources; however, the sediment loads presented here represent relative loading estimates within each source category and should not be considered as actual loading values. Instead, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. In turn, the percent reduction estimates are the basis for setting load or wasteload allocations. As better information becomes available and the linkages between loading and instream conditions improve, the loading estimates presented here can be further refined through adaptive management.

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

5.7.1 Eroding Streambank Sediment Assessment

Data collected during DEQ's 2009 field work were used to estimate the total sediment load associated with bank erosion for each watershed. Streambank erosion was assessed in 2009 at the 30 assessment reaches discussed in **Section 5.3**. At each site, eroding streambanks were classified as either actively or slowly eroding. The susceptibility to erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements, and the erosive force was determined by evaluating the Near Bank Stress (NBS) (Rosgen, 1996; 2004). BEHI scores were determined at each eroding streambank based on bank height, bankfull height, root depth, root density, bank angle, and surface protection.

In addition to collecting BEHI data, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- (e.g., past sources)
- silviculture
- irrigation-shifts in stream energy
- natural sources
- other

Whether using field observations, aerial photography, or GIS methodology, it is difficult to discern between bank erosion influenced from current or past human practices and bank erosion as a result of natural processes. However, a simple break down of the apparent erosion sources provides a general indicator of the activities that may be affecting bank erosion, which in turn could help land managers prioritize areas for improvement. The erosion sources identified for each reach, and summarized at the watershed scale, are provided in **Attachment A**.

Streambank erosion data from each 2009 monitoring site was extrapolated to its respective reach (which was based on ecoregion, valley gradient, stream order, and valley confinement as described in **Section 5.3**). Then, the field-based estimates of annual streambank erosion were compiled into reach category groupings based on stream order and gradient similarities (e.g., MR-0-2-U, MR-2-2-U, and MR-2-2-C). Then, the average value for each unique reach category grouping was applied to unmonitored reaches within the corresponding category to estimate loading associated with bank erosion at the listed stream segment scales. To estimate existing loading for the remainder of the watershed for each impaired stream, the erosion rate for 1st order reaches (i.e., the lowest rate) was applied to non-303(d) listed tributaries, which were primarily 1st and 2nd order streams.

5.7.1.1 Establishing the Total Allowable Load

Streambank erosion is a natural process typically dominated by slowly eroding streambanks. Human disturbances to riparian vegetation and health and/or stream hydrology can accelerate the natural erosion rate. Human disturbances shift streambanks from being well vegetated and/or armored (and commonly undercut) to being largely, or entirely, unvegetated with vertical banks. The latter become chronic sources of sediment. Therefore, the potential for sediment load reduction was estimated based on the ratio of actively-to-slowly eroding banks at the reference site on South Cottonwood Creek (SCOT25-02). That ratio (i.e., 15% active/85% slowly) was applied to the average active and slow erosion rates for each reach category and extrapolated to all similar reach types for reaches with predominantly human sources (i.e., >75% based on the aerial assessment described in **Section 5.3**).

Tributaries to the 303(d) listed streams were included in the existing load estimate; however, because little is known about them, and the lowest erosion rate was applied to them, no reductions were applied to those waterbodies in determining the total allowable load at the watershed scale. The most appropriate BMPs will vary by site, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream. Applying riparian BMPs should lower the amount of actively eroding banks and result in the estimated reductions. DEQ acknowledges that some streams may have a higher or lower background rate of actively eroding streambanks; thus, although the reduction may not be achievable in all areas, greater reductions will likely be achievable in some areas.

Assessment Summary

Based on the source assessment, streambank erosion loads range from 149 tons per year in the Thompson Creek watershed to 3,187 tons per year in the Dry Creek watershed (**Table 5-30**). The wide range is largely a factor of the variation in stream miles per drainage; per mile, the largest annual streambank erosion load is in the Bear Creek watershed (43.7 tons/mile); the smallest loads are in the Dry and Reese Creek drainages (17.1 and 18.2 tons/mile, respectively). Significant human-caused sources of streambank erosion include grazing, encroachment of pasture/hayfields, logging, roads, and urban development. Depending on the watershed, DEQ estimated that implementing riparian BMPs could decrease the human-caused level of streambank erosion by 31% to 61%. **Attachment A** contains additional information about the streambank erosion source assessment and associated load estimates for the 303(d) listed streams in the Lower Gallatin TPA, including a breakdown by particle size class (i.e., coarse gravel, fine gravel, and sand/silt).

Table 5-30. Existing and Reduced Sediment Load from Eroding Streambanks in the Lower Gallatin TPA.

Subbasin	Existing Sediment Load (tons/year)	Existing Sediment Load (tons/mile/year)	Allowable Sediment Load with Riparian BMPs (tons/year)	Percent Reduction
Bear Creek	758	43.7	374	51%
Bozeman Creek	1,212	22.5	842	31%
Camp Creek	3,119	36.5	1281	59%
Dry Creek	3,187	17.1	2203	31%
Godfrey Creek	526	32.3	270	49%
Jackson Creek	398	30.9	223	44%
Reese Creek	1,257	18.2	864	31%
Rocky Creek (excluding Jackson Creek sub-watershed)	1,149	36.2	583	49%
Smith Creek (including Ross but excluding Reese Creek sub-watershed)	966	23.3	597	38%

Table 5-30. Existing and Reduced Sediment Load from Eroding Streambanks in the Lower Gallatin TPA.

Subbasin	Existing Sediment Load (tons/year)	Existing Sediment Load (tons/mile/year)	Allowable Sediment Load with Riparian BMPs (tons/year)	Percent Reduction
Stone Creek	317	32.5	201	37%
Thompson Creek	149	20.7	58	61%

5.7.1.2 Streambank Assessment Assumptions

The following is a summary of the significant assumptions used during the assessment of eroding streambanks:

- The ratio of actively-to-slowly eroding streambanks at sites with predominantly natural sources is an appropriate and achievable rate in reaches where all reasonable land, soil, and water conservation practices are applied.
- The streambank erosion data collected during 2009 represents conditions within the watershed.
- The average annual load per reach type is applicable to other reaches within the same category.
- The assignment of influence to eroding streambanks and the distinction between natural and human-caused erosion is based on best professional judgment by qualified and experienced field personnel.
- Sources of bank erosion at the assessed stream segment scale are representative of sources for that watershed.
- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies along the Lamar River in Yellowstone National Park. While the predominant geologies differ between the Wyoming research sites and the Lower Gallatin watershed (which has primarily sedimentary rock formations and erosive alluvium with some volcanic geology), the rates are applicable to the Lower Gallatin watershed and suitable for helping estimate the percentage in streambank-associated loading reductions achievable by implementing riparian BMPs.

5.7.2 Upland Erosion and Riparian Buffering Capacity Assessment

Upland sediment is that which originates beyond the stream channel. The erosion rate of sediment from upland sources is influenced by land use and/or vegetative cover. Sediment from the landscape may be entirely natural, or it may be increased by human activities, such as timber harvesting, farming or grazing, or clearing land for development. Upland sediment loading from hillslope erosion was modeled using a GIS application of the Universal Soil Loss Equation (USLE).

USLE uses five main factors to estimate soil erosion: R * K * LS * C * P, where

R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

All factors except for vegetation cover (C-factor) and field practices (P-factor) are environmental variables unaffected by management practices. Because the P-Factor generally relates to practices occurring at a finer scale than is practical for establishing TMDLs in the Lower Gallatin TPA, DEQ set it at 1 for all scenarios. To estimate the existing upland load associated with each land-use category, adjustments were made to the C-Factor, which integrates a number of variables that influence erosion, including vegetative cover, plant litter, soil surface, and land management.

The existing sediment load delivered to each 303(d) listed stream was estimated by combining the USLE model results with a sediment delivery ratio that accounts for downslope travel distance to surface water, along with a riparian buffer factor that reflects ability of buffers to filter sediment from runoff. The ability of existing riparian vegetation to reduce upland sediment loads was based on a riparian health classification performed for the left and right streambank of each 303(d) listed waterbody during the stratification process described in **Section 5.3**. Buffer health was classified as good, fair, or poor, which ranged from a dense riparian buffer to a mix of bare ground and no woody shrubs (in areas with potential for shrub cover). Based on studies that have found that a well-vegetated riparian buffer filters 75% to 90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997), a 75% removal efficiency was applied to good buffers; this was scaled down to 50% and 25% for fair and poor buffers, respectively.

5.7.2.1 Establishing the Total Allowable Load

The allowable load from upland erosion, which is associated with implementing BMPs, was determined by a two-fold approach: (1) C-factors for human-influenced land-use categories were modified to reflect the improvement in ground cover that is expected by implementing upland BMPs and (2) riparian health was improved to a ratio of 75% good/25% fair for human-influenced land-use categories to represent the additional decrease in upland sediment loading that will occur by implementing riparian BMPs.

The land-use categories with modified C-factors were shrub/scrub, grasslands/herbaceous, pasture/hay, and cultivated crops. Although urban land may transport sediment (particularly during storms), because urban landscapes are generally impervious and do not generate sediment, no change in C-factor was applied to that land-use category.

For the categories with unmodified C-factors, the change equated to an approximate 10% improvement in ground cover per category. The C-factor values for both scenarios (i.e., existing and improved conditions) were based on literature values, stakeholder input, and field observations. DEQ acknowledges that C-factor values are variable within land-use categories throughout the watershed and over time; however, because of the model’s scale, DEQ assumed that values for ground cover were consistent throughout each land-use category and throughout the year.

It is important to note that under the improved-conditions scenario, a significant portion of the remaining sediment load, after BMPs are implemented in human-influenced land-use categories, is also a component of the natural background load. Additionally, the allocation to human sources includes both present and past influences and is not meant to represent only current management practices. Many of the restoration practices that address current land use will reduce pollutant loads that are influenced from historic land uses. A more detailed description of the assessment can be found in **Attachment C**.

Assessment Summary

Sediment loads from upland erosion range from 4 tons/year in the Thompson Creek sub-watershed to 6,733 tons/year in the Dry Creek watershed (**Table 5-31**). Since this assessment was conducted at the watershed scale, DEQ expects larger watersheds to have greater sediment loads. A significant portion of the sediment load from upland erosion is contributed by natural sources, but the estimated contribution by all land-use categories is provided in **Attachment C**.

Although many streams are affected by sediment loading associated with historical harvest and vegetation removal, the predominant existing human sources of upland erosion are grazing and cropland, particularly where those activities encroach on the stream channel. By implementing upland and riparian BMPs, annual loading reductions are expected to range from 41% to 72%. Improvement in riparian health comprises a substantial portion (36% to 49%) of the estimated reduction in annual loading from upland sources.

Table 5-31. Existing and Reduced Sediment Loads from Upland Erosion in the Lower Gallatin TPA.

Subbasin	Existing Delivered Sediment Load (tons/year)	Improved Upland and Riparian Conditions Sediment Load (tons/year)	Percent Reduction
Bear Creek	207	122	41%
Bozeman Creek	1,056	577	45%
Camp Creek	5,309	1,832	65%
Dry Creek	6,733	2,455	64%
Godfrey Creek	2,242	625	72%
Jackson Creek	1,175	467	60%
Reese Creek	1,727	662	62%
Rocky Creek (excluding Jackson Creek sub-watershed)	2,100	861	59%
Smith Creek (including Ross but excluding Reese Creek sub-watershed)	47	16	66%
Stone Creek	419	196	53%
Thompson Creek	4	1	63%

5.7.2.2 Upland Assessment Assumptions

As with any modeling effort, and especially when modeling at a watershed scale, a number of assumptions are made. The following is a summary of the significant assumptions used during the assessment of upland erosion:

- The data sources used are reasonable and appropriate to characterize the watershed and build the model.
- The input variables used in the USLE calculations represent their respective land-use conditions.
- The land management practices that define the vegetative cover throughout the year are relatively consistent and represent practices throughout the watershed.
- The riparian condition as estimated through the aerial assessment represents on-the-ground conditions. Riparian buffer health was included to emphasize its importance in reducing upland sediment loading; however, DEQ acknowledges the classification and improvement potential was conducted at a coarse scale.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.
- The USLE model provides an appropriate level of detail and is sufficiently accurate for developing upland sediment loads for TMDL purposes.

5.7.3 Road Sediment Assessment

Roads located near stream channels can reduce stream function by degrading riparian vegetation, encroaching on the channel, and adding sediment. The degree of harm is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, and precipitation, as well as whether BMPs were used. Unpaved road crossings and near-stream parallel road segments typically have the greatest potential to contribute excess sediment to streams. However, paved roads increase surface runoff and can result in loading from inadequately armored/vegetated ditches and hillslopes. Sediment loading from the road network in the Lower Gallatin watershed was assessed using GIS, field data, and sediment modeling.

5.7.3.1 Roads Crossings and Parallel Segments

Each road crossing and near-stream parallel road segment identified using GIS tools was assigned attributes for road name, surface type (i.e., native, gravel, paved), road ownership, stream name, and subwatershed. Additionally, each crossing/parallel segment was associated with one of three nearby climate stations that best matched the elevation and annual precipitation and corresponded to a low, medium, or high precipitation class. In 2010, 20 unpaved crossings, 7 paved crossings, and 6 unpaved near-stream parallel segments were field assessed. The following measurements were collected: road surface, design (insloped or outsloped), soil type, percent rock, traffic level, road and fillslope, contributing road length, fill length, and buffer slope and length. Any existing BMPs were noted.

The field effort aimed to sample roads that represented the range of conditions within the watershed; therefore, sampling sites were randomly selected. However, a site was added in the Bear Creek watershed because it was placed on the 303(d) list largely as a result of road-related sediment, and the random selection process did not identify a site there. The average sediment contribution from field assessed road crossings and near-stream road segments were estimated using the Water Erosion Prediction Project Methodology (WEPP:Road) and a 30- or 50-year simulation period (depending on the precipitation class). The average load per crossing and by road mile for parallel segments was then extrapolated to all roads in the watershed based on road surface type and precipitation class. Because the Bear Creek road crossing site was not randomly selected, and does not necessarily represent other road conditions in the Lower Gallatin TPA, it was used for the Bear Creek load estimate but was not included in the extrapolation process for that or other watersheds.

5.7.3.2 Establishing the Total Allowable Load

Because the existing load estimate for paved road crossings and unpaved parallel segments was such a minimal amount of the overall road load (<3% each), and buffers were well-vegetated, the allowable load for those road types is set at the current load. For unpaved road crossings, the allowable load was determined by re-entering the 2009 field data into the WEPP:Road model and changing inputs that simulated the implementation of reasonable BMPs for each ownership category. For county, city, and state-maintained roads, a regular maintenance scenario was used. This scenario was based on the most common BMP used by Gallatin County and that typically used by the city of Bozeman: gravel roads are bladed and re-graded on average biannually or bimonthly, depending on the condition; native roads are resurfaced at most biannually (Water & Environmental Technologies, 2010).

This scenario effectively reduces the formation of ruts, which can be major sources of and conduits for sediment. For roads under private or USFS ownership, a contributing length reduction scenario was used that set the contributing length to 200 feet (or 100 feet from each direction for crossings with two contributing segments). No adjustment was made to segments with a current contributing length of less than 200 feet.

These scenarios were intended to provide a reasonable estimate of loading reductions that can be achieved from roads; they are not prescriptive measures. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. BMPs that may be used to either reduce the contributing length to less than 200 feet, or achieve the allowable load, include installing full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc.), improving the road surface, and reducing traffic levels (seasonal or permanent road closures). Although the estimated reductions may not be possible at all locations because of site-specific conditions or existing BMPs, additional loading reductions will likely be achievable at other locations. For instance, the contributing length exceeded 200 feet at 93% of the county/city/state road crossings, and improving road maintenance will likely also decrease the contributing length. A more detailed description of this assessment can be found in the Road Sediment Assessment report (**Appendix C**).

Assessment Summary

Based on the source assessment, the sediment load from the road network ranges from 0.7 ton/year in the Thompson Creek watershed to 32 tons/year in the Dry Creek watershed (**Table 5-32**). The magnitude of loading is largely related to watershed size because the size of the stream network and number of roads tends to increase with watershed size; however, precipitation class is also a large factor for certain watersheds, particularly Rocky Creek. Similarly, county roads were estimated to contribute the largest sediment load, which is predominantly a factor of the ownership distribution within the Lower Gallatin TPA (i.e., 65% of roads are maintained by the county).

The only in-road BMP observed was a cross drain, which was seen at two road crossing sites and three parallel segments. Numerous sites had heavily vegetated ditches and swales, which are important in reducing sediment loading to streams from the road network. With improved BMP implementation, loading reductions ranging from 15% to 38% (**Table 5-1**) are achievable.

Table 5-32. Annual Sediment Load (tons/year) from Roads in the Lower Gallatin TPA.

Watershed	Total Load (tons/year)*	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application*
Bear Creek	2.1	27%	1.5
Bozeman Creek	10	27%	7.4
Camp Creek	23	17%	19
Dry Creek	32	19%	26
Godfrey Creek	5.9	17%	4.9
Jackson Creek	16	37%	9.9
Reese Creek	6.1	25%	4.6
Rocky Creek (excluding Jackson Creek sub-watershed)	21	35%	14
Smith Creek (including Ross but excluding Reese Creek sub-watershed)	3.9	19%	3.1
Stone Creek	2.3	39%	1.4
Thompson Creek	0.7	18%	0.6

*Because of rounding, differences in loads presented in this table may not correspond to the percent reduction.

5.7.3.3 Traction Sand

Traction sand applied to paved roads in the winter can be a significant source of sediment loading to streams. A study by the Montana Department of Transportation (MDT) (Staples et al., 2004) found that traction sand predominantly contains particles <6mm and <2mm, sizes that can harm fish and other aquatic life as instream concentrations increase (Irving and Bjorn, 1984; Mebane, 2001; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004; Zweig and Rabeni, 2001).

The significance of loading from traction sand was evaluated for the city of Bozeman and I-90. Within the city, approximately 218 miles of streets and alleys are maintained, and between 3,500 and 5,000 tons of traction sand are applied annually (16–23 tons/mile/year) (Water & Environmental Technologies, 2010). Application mostly occurs at intersections and problem areas. As part of its stormwater program, the city sweeps main arterial roads weekly and residential areas twice a year (spring and fall) (HDR Engineering and Morrison-Maierle,Inc., 2008). In recent years, salt and magnesium chloride have been added to the traction sand mix to improve safety and decrease the application rate of sand (HDR Engineering and Morrison-Maierle,Inc., 2008).

Traction sand was evaluated at all 2009 paved road crossing field sites within the city, and as many additional crossings as possible were also evaluated (**Appendix C**). A few sites were observed to directly deliver traction sand from the road surface; however, most crossings had curbs and/or stormwater infrastructure to limit delivery to surface water (**Figure 5-4**). Additionally, a negligible amount of traction sand was present on the road surface, indicating street sweeping was effective at removing traction sand. Although traction sand has the potential to be a significant source of road-related sediment, particularly during spring runoff, the field observations indicate sediment loading to streams from traction sand has been minimized via street sweeping and bridge design as well as stormwater infrastructure.

No traction sand load from within Bozeman will be incorporated into the existing road-sediment estimate or the allocation to roads, but it is inherently addressed under the city's stormwater permit as part of its Storm Water Management Program (SWMP) (see **Section 5.7.4.5** for more details). The city is expected to continue minimizing loading from traction sand as part of its SWMP as well as when designing and maintaining roads. Particularly because spring runoff on the streets has the potential to deliver large quantities of traction sand to streams, the timing of spring street sweeping is important.

Figure 5-4. Crossing with observed areas of traction sand delivery (left); curbed crossing (right).

Several streams in the Lower Gallatin TPA flow under I-90; however, because of the Interstate's grade, only Bear Creek and Rocky Creek are the primary streams of concern for traction sand. The streams cross under the highway between mile markers 288 and 323, where the application rate averaged 348 tons/mile/year between 2008 and 2010. According to MDT (Water & Environmental Technologies, 2010), BMPs are used to reduce the application rate, and deicer usage decreased the amount of traction sand by 14% between 2008 and 2010.

During the road field assessment in 2009, traction sand depth was measured at distances ranging from 9 feet to 45 feet from the shoulder of the highway. The traction sand depth was 1–2 inches near a culvert 25 feet from the road along Rocky Creek, but traction sand depth was typically minimal beyond 35 feet. Additionally, most fillslope and buffer lengths were greater than the extent of traction sand migration. This indicates traction sand may occasionally be a sediment source to Bear and Rocky Creeks but that it is an insignificant quantity. Therefore, no traction sand load estimate or allocation will be provided for I-90; however, DEQ recommends that MDT continue to implement BMPs, which include seeking to optimize conditions for public safety while minimizing the use of traction sand and properly maintaining roadside buffers.

5.7.3.4 Culvert Failure and Fish Passage

Undersized or improperly installed culverts may be a chronic source of sediment to streams, or a large acute source during failure. They may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for each culvert. After DEQ excluded crossings with bridges, those with no culvert, or those lacking perennial flow, the culvert analysis was performed at 19 of the 24 road crossings. The assessment incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g. 2, 5, 10, 25, 50, and 100 year), as well as measurements to estimate the capacity and amount of fill material of each culvert. DEQ assumed that fill above an undersized culvert will periodically erode into the channel, but the culvert will not completely fail; therefore, the annual amount of sediment at-risk was set at a 25% probability for the loading analysis.

A common BMP for culverts is designing them to accommodate 25-year storm events; this capacity is specified as a minimum in Water Quality BMPs for Montana Forests (Montana State University, Extension Service, 2001), and it is typically the minimum used by the USFS. Therefore, fill was only assumed to be at-risk in culverts that cannot convey a 25-year event. However, other considerations, such as fish passage, the potential for large debris loads, and the level of development and road density upstream of the culvert, should also be considered during culvert installation and replacement. When these are factored in, larger culverts may be necessary. For instance, USFS typically designs culverts to pass the 100-year event, while also accommodating fish and aquatic organism passage on fish bearing streams (U.S. Department of Agriculture, Forest Service, 1995). Therefore, the BMP scenario for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. At a minimum, culverts should meet the 25-year event. For fish-bearing streams, or those with a high level of road development upstream, meeting the 100-year event is recommended.

Fish passage assessments were performed on 15 culverts. Bridges and sites where all measurements could not be collected, as well as sites lacking perennial flow, were excluded. The assessment was based on the methodology defined in **Appendix C**, which is geared toward assessing passage for juvenile salmonids. Considerations for the assessment include streamflow, culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e., culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish barriers and those that need a more in-depth analysis. The culvert assessment in **Appendix C** contains information that may help land managers focus restoration efforts on those culverts that were deemed fish barriers and/or undersized per this analysis.

Assessment Summary
Out of the 19 culverts assessed for failure risk, 6 (32%) were estimated to pass a 25-year event, and none were estimated to pass the 100-year event. All culverts estimated to pass a 25-year event were on county or state roads. However, the sampling of federal and privately owned culverts was quite small (5 out of 19) as a result of their small percentage of all crossings within the watershed. Assuming a 25% probability of failure annually (for culverts meeting less than Q25), DEQ estimated that 4,609 tons of sediment are at-risk; this load is presented to give an estimate of the potential loading associated with undersized culverts in sediment-impaired watersheds within the Lower Gallatin TPA. However, because of the sporadic natural and uncertainty regarding timing of culvert failures, the estimated load at-risk is not included in the existing loads estimates for each impaired stream. For the fish passage assessment, 2 culverts require additional assessment and the other 13 (87%) assessed culverts were determined to pose a significant passage risk to juvenile fish at all flows. The predominant reason cited as a barrier to fish was a steep culvert gradient, but five culverts were perched above the stream channel and five had an insufficient constriction ratio (i.e., culvert width/bankfull width).

5.7.3.5 Road Assessment Assumptions
The following is a summary of the significant assumptions used during the roads assessment:

- The road crossings and parallel segments assessed in the field represent conditions throughout the watershed.
- Although ownership may affect the level of BMP implementation, precipitation class and road surface type were assumed to be the largest determinants of loading per crossing. Field sites were selected to have a representative number per ownership type, but the loads were extrapolated based on precipitation class and road surface type.
- Using modeling scenarios that focus on improving maintenance for city/county/state maintained roads, and reducing the contributing length near road crossings for private and federally maintained roads, will effectively reduce the majority of the sediment load from roads. This is an effective way to represent loading reductions associated with implementing all reasonable, land, soil, and water conservation practices.
- BMPs may have already have been implemented on many roads, and therefore the reductions necessary in some locations may be less than described in this document.

5.7.4 Permitted Point Sources
As of March 19, 2012, the Lower Gallatin TPA had nine Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within sediment-impaired watersheds (**Figure A-22**). All of the permits fall within three watersheds: Bozeman, Rocky, and Smith. There is one individual permit for the city of Bozeman's drinking water treatment plant, but all other permits are general. Five of the general permits are for construction storm water (MTR100000), one is for industrial storm water (MTR000000), one is for construction dewatering (MTG070000), and one is for a small Municipal Separate Storm Sewer System (MS4) (MTR040000). To provide the required wasteload allocation (WLA) for permitted point sources, a source assessment was performed for these point sources. Because of the conditions set within all of the applicable permits, and the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits; DEQ assumed that the WLAs will be met by adhering to the permit requirements.

5.7.4.1 City of Bozeman Water Treatment Plant (MT0030155)
The city of Bozeman has a potable water treatment plant along upper Bozeman Creek near the USFS boundary (**Figure A-22**). The facility currently has a design flow of 0.86 million gallons per day (Mgd) and

an average flow over the year of 0.2 Mgd. An upgrade was started in 2011 (anticipated completion 2012) that will increase the design flow to 1.1 Mgd, with an estimated actual discharge of 0.5 Mgd. The permit has a maximum daily effluent TSS concentration limit of 45 mg/L, a monthly average effluent limit of 30 mg/L, and a monthly average load limit of 215 lbs/day.

The facility is required to monitor the TSS concentration of its effluent weekly. As part of its Discharge Monitoring Report (DMR), the plant submits a 30-day average TSS concentration and load; since 2002, that concentration has ranged from below the detection limit (1 mg/L) to 26 mg/L, with an average value of 5 mg/L. Therefore, the average monthly concentration is well below the permit limit. Also, since the plant usually discharges at a rate less than its design flow, the average monthly load over the past 10 years is 20 lbs/day. Based on this data, the typical annual TSS load is approximately 3.7 tons. Although the facility is upgrading its discharge capacity, because of nondegradation requirements, its permitted average monthly load limit will stay at 215 lbs/day. Therefore, its WLA is based on the monthly load limit in the permit and, abiding by the permit conditions, will meet the WLA. Based on the monthly average load limit, the allowable annual load is 39 tons of sediment (i.e., 215 lbs/day *365 days * conversion factor = 39 tons). This load is more than 10 times greater than its estimated existing load.

5.7.4.2 Construction Storm Water Permits (MTR100000)

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

The permit files were reviewed to determine the amount of disturbed land associated with each permit. In the Bozeman Creek watershed, the estimated level of disturbance is 46 acres for three permits; in the Rocky Creek watershed, 15 acres for one permit; and in the Smith Creek watershed, 7 acres for one permit. All permits are for either road/highway construction or home construction. The SWPPPs contain BMPs, such as silt fencing, retention basins, fiber rolls, erosion control blankets, and vegetated buffers.

To estimate the potential sediment loading for the construction sites if adequate BMPs are not followed, an upland erosion rate for disturbed ground with less than 15% cover was multiplied by the amount of disturbed acreage associated with each permit (**Table 5-33**). Because the Lower Gallatin upland model did not have a disturbed ground category, the erosion rate (1.37 tons/acre/year) from a recently completed upland model for the Little Blackfoot watershed was used (Montana Department of Environmental Quality and U.S. Environmental Protection Agency, 2011).

The Little Blackfoot watershed is also in the Middle Rockies ecoregion, and 1.37 tons/acre/year was determined to be an appropriate estimate of the annual erosion potential for disturbed ground within the Lower Gallatin TPA. To estimate the reduction in loading associated with following proper BMPs and adhering to permit requirements, a 65% reduction was applied based on studies from EPA and the International Storm Water Best Management Practices Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2008; EPA, 2009b). The reduced loads (**Table 5-33**) will be used to set the WLAs for construction stormwater permits. Because following permit conditions meet the intent of the WLA for construction stormwater, any future permits within any watersheds with sediment TMDLs in the Lower Gallatin TPA will meet the TMDL by following all permit conditions, including the SWPPP.

Table 5-33. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Loading rate based on SWAT (T/Acre/ Year)	Annual Disturbed Acres	Estimated Load Without Adequate BMPs (T/Year)	BMP Sediment Load (T/Year)	Percent Reduction
Bozeman Creek	1.37	46	63	22	65%
Rocky Creek	1.37	15	21	7	65%
Smith Creek	1.37	7	9.6	3.4	65%

5.7.4.3 Industrial Storm Water Permit (MTR000095)

Stormwater from the Kenyon Noble Ready Mix concrete batch plant is regulated under the General Permit for Storm Water Discharges Associated with Industrial Activity (MTR000000). This permit regulates the direct discharge of stormwater draining the facility and its grounds. Under the stipulations of the permit, the facility maintains an approved SWPPP. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges. In addition, the SWPPP describes general practices used to reduce pollutants in stormwater discharges. According to the SWPPP, the facility's primary BMP is to use conveyances that minimize contact between runoff and sediment and other pollutants.

The site, which is within the Bozeman Creek watershed, is approximately 2.2 acres and is primarily used for the loading and unloading of trucks with building materials. No monitoring data are available; however, DEQ conducted a site inspection in 2007 and found it in compliance with the permit. DEQ did, however, recommend additional vegetation and site contouring to prevent runoff from the site. According to Attachment B (Monitoring Parameter Benchmark Concentrations) within the general stormwater permit, the benchmark value for TSS is 100 mg/L; this means that the TSS concentration of runoff from the site should not exceed 100 mg/L if permit conditions are followed. Based on the site size of 2.2 acres, an average annual precipitation rate of 18 inches (from the MSU climate station), and the benchmark value of 100 mg/L, the maximum allowable annual sediment load from this site is 0.4 ton/year. The WLA is provided because it is a requirement for permitted point sources but is not intended to add load limits to the permit. DEQ assumed that the WLA will be met by adhering to the permit requirements, including the SWPPP.

5.7.4.4 Construction Dewatering Permit (MTG070687)

There is a construction dewatering permit for a 0.5-acre pond in the Smith Creek watershed, which is covered under the General Permit for Construction Dewatering (MTG070000). The dewatering effluent is routed from the construction site into a vegetated swale and has the potential to eventually flow into Ross Creek, one of the tributaries that forms Smith Creek. The estimated maximum pumping capacity is 1 cfs, and dewatering is expected to occur during the summer season (May–September). Since the maximum pumping rate typically occurs during the initial phase of pumping then drops off drastically, a conservative estimate of the potential load was calculated assuming a constant pumping rate of 1 cfs from May through September.

The permit has a numeric turbidity limit for the effluent of 10 NTU. Because turbidity cannot be expressed as a load, a TSS conversion ratio of 2:1 TSS-to-turbidity was used based on a study used for the Swan TMDL (Bansak et al., 2000) and a study done for the Boulder River (Water Consulting, Inc., 2002). The Boulder River is also in the Middle Rockies ecoregion, so this relationship was determined to be a reasonable approximation of the relationship between turbidity and TSS in the Lower Gallatin TPA. Assuming a 1 cfs discharge at 20 mg/L TSS (10 NTU *2) over 5 months, the estimated annual load is 8.3 tons. This value will also be used for the WLA. Although it is based on the permit, it is not intended to be incorporated into the permit. Adhering to the permit conditions will meet the intent of the WLA.

5.7.4.5 MS4 Permit (MTR040002)

Stormwater within the city of Bozeman is regulated under the General Permit for Storm Water Discharge Associated with Small Municipal Separate Storm Water Sewer System (MS4) (MTR04000). The city shares the permit with Montana State University – Bozeman (MSU) and MDT. The permit primarily applies within the city limits (**Figure A-22**) but also includes some receiving waters outside the city. There are two sediment-impaired receiving waters identified in the permit: Bozeman Creek and Bear Creek. Because they are identified in the permit, TMDLs for both streams must include a WLA for the MS4.

The permit does not include effluent limits but requires the development and implementation of a SWMP to minimize sediment loading to surface waters. The SWMP must include six minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharge; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires semiannual monitoring at two sites, one representing a residential area (the Langhor site) and the other representing a commercial/industrial area (the Tamarack site) (**Figure A-22**).

A Storm Water Management Model (SWMM) initially developed for the city of Bozeman (HDR Engineering and Morrison-Maierle,Inc., 2008) was adapted by DEQ for this project to help estimate existing stormwater-related sediment and nutrient loads. The model includes only the city of Bozeman, and therefore does not include Bear Creek, which is east of the city. Model specifics pertaining to the nutrient source assessment are described in detail in **Section 6.5.2.2**. The model was based on 30 years of climate data from the weather station on MSU's campus (Coop ID 241044), and two scenarios were run to simulate existing loading conditions: one with an average TSS event mean concentration (EMC) from measurements across multiple city stormwater systems in the Intermountain West (literature value scenario) (Caraco, 2000) and the other with benchmark TSS concentrations from the permit (benchmark value scenario) that are based on the median from the Nationwide Urban Runoff Program (NURP). For Bozeman Creek, the literature value scenario estimated an annual sediment load of 288 tons, and the benchmark value scenario estimated an annual sediment load of 177 tons.

To help evaluate the model output and quality of the city's stormwater, the city's TSS monitoring data from 2007 through 2010 were compared with the upper and lower literature TSS EMCs as well as with the permit benchmark TSS concentration for residentially-dominated areas (**Figure 5-5**) relative to commercially-dominated areas of the city (**Figure 5-6**). TSS concentrations from the residential site (Langhor) were well below both the benchmark concentration and the minimum literature EMC. TSS concentrations from the commercial site (Tamarack) commonly exceeded the benchmark concentration and occasionally exceeded the maximum literature EMC. Although the data are limited, it indicates additional BMPs are needed, particularly in commercially-dominated areas.

As discussed in the data review for Bozeman Creek (**Section 5.5.2**), however, there is also room for improvement in residential areas. Based on the data comparison, the benchmark value scenario load is more representative of stormwater TSS loads from a residentially-dominated area of Bozeman and the literature value scenario load is more representative of stormwater TSS loads from a commercially-dominated portion of Bozeman. Therefore, a weighted approach based on the land use breakdown within the MS4 boundary in the Bozeman Creek watershed was used to derive a load estimate that is a composite of both model runs. Using this approach, the estimated existing stormwater sediment load to Bozeman Creek is 218 tons per year.

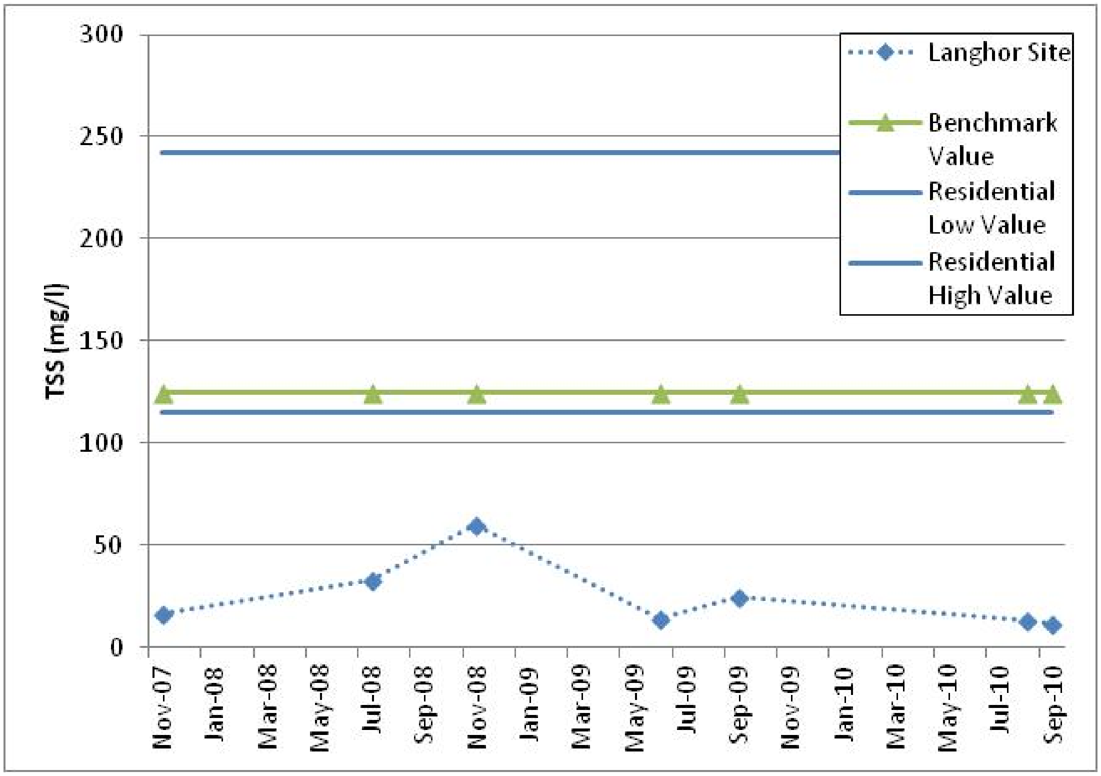

Figure 5-5. Bozeman residentially-dominated stormwater data from 2007 through 2010 at the Langhor site compared with the benchmark value and the maximum and minimum literature value.

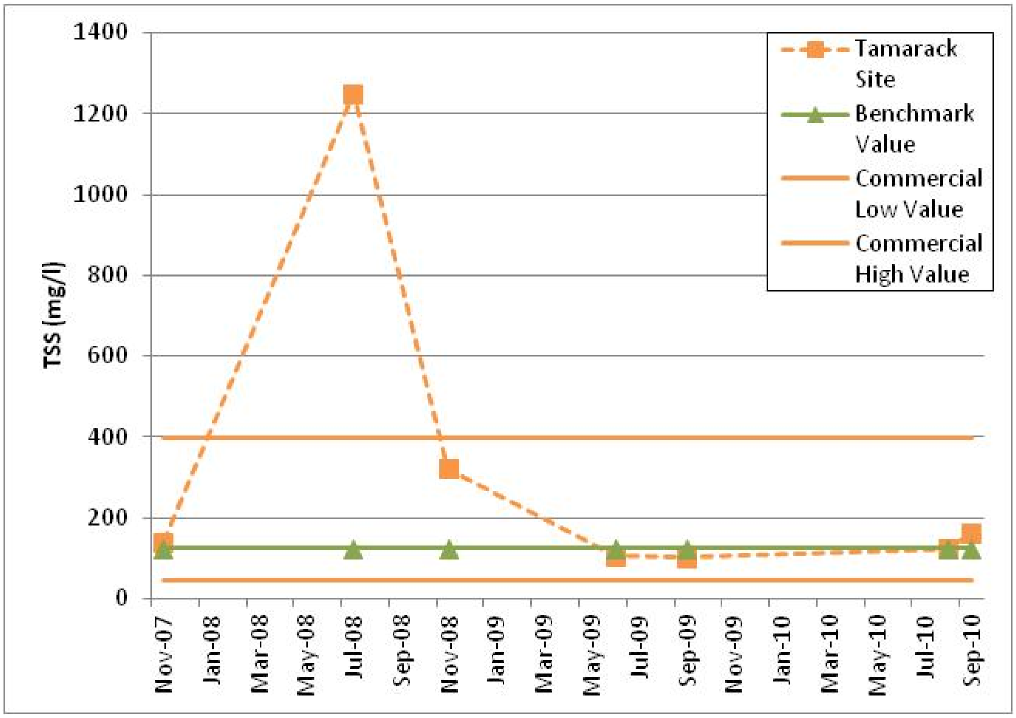

Figure 5-6. Bozeman commercially-dominated stormwater data from 2007 through 2010 at the Tamarack site compared with the benchmark value and the maximum and minimum literature value.

Because Bear Creek was not included in the model, a rough estimate of the existing stormwater TSS load was calculated using the estimated load for Bozeman Creek. The only portion of the Bear Creek watershed that falls under the permit is the I-90 corridor, which means some loading is associated with traction sand (discussed in **Section 5.7.3.3**). Overall, however, there is a limited area that could contribute sediment. Therefore, the loading rate is likely on the lower end of the modeled loads and closer to the benchmark value scenario. The load from the benchmark value scenario (177 tons) was divided by the MS4 acreage in the Bozeman Creek watershed (2,034 acres) to get a loading rate of 0.087 ton/acre. That value was multiplied by the MS4 acreage within the Bear Creek watershed (61.96 acres) to get an estimated existing sediment stormwater load to Bear Creek of 5.4 tons per year.

Establishing the Total Allowable Load

Because of the limited amount of information regarding stormwater BMPs currently in place within the MS4, no BMP scenario was run in the model. Instead, BMP effectiveness values reported from the International Storm Water BMP Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2011) will be used as the basis for the WLA. The database includes statistics for loading reduction efficiencies from a compilation of studies for a variety of BMPs. The BMPs include bioretention, bioswales, detention basins, filter strips, manufactured devices, media filters, porous pavement, retention ponds, wetland basins, and wetland channels. The effectiveness range among different studies and practices are fairly tight. Studies were summarized by evaluating the 75th percentile, median, and 25th percentile concentration of influent and effluent. The quartiles for each percentile category ranged from a reduction efficiency of 53% to 76%. Using the median influent and effluent concentration, the average percent reduction among BMPs was 62%.

Because some BMPs are already in place within all land-use categories, but the monitoring data reflect more effective BMPs within residentially-dominated areas, a reduction less than 62% is necessary at the watershed scale. Therefore, a weighted approach based on the land use distribution in the Bozeman Creek watershed was used to approximate the reduction in loading that additional BMP implementation across all land-use categories could achieve and to determine the WLA.

Approximately 40% of the land within the MS4 boundary in the Bozeman Creek watershed is residential, so no reduction was applied to 40% of the estimated existing load. Although the remainder of the watershed is not all commercial, to err on the conservative side, a 62% reduction was applied to the remaining 60% of the existing load (based on the 62% reduction efficiency from the database). Using this approach, the WLA is 137 tons of sediment per year for the Bozeman Creek watershed, which is a 37% reduction from the estimated existing load. Because of the limited amount of data for Bear Creek, the Bear Creek WLA is also a 37% reduction (3.4 tons/year).

As stated previously, the WLAs are not intended to add load limits to the permit. DEQ assumed that the WLAs will be met by adhering to the permit requirements. As identified in the permit, monitoring data should continue to be evaluated to assess BMP performance and help determine whether and where additional BMP implementation may be necessary.

5.7.5 Source Assessment Summary

Based on field observations and associated source assessment work, all assessed source categories represent significant controllable loads. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, because of the coarse nature of the source assessment work, and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate source effects within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Lower Gallatin TPA; they indicate the relative contribution of different subwatersheds or landcover types for each source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendix C and Attachments A** and **C**).

5.8 TMDL AND ALLOCATIONS

The sediment TMDLs for the Lower Gallatin TPA will be based on a percent reduction approach, discussed in **Section 4.0.** This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. An implicit margin of safety will be applied, further discussed in **Section 5.9**.

5.8.1 Application of Percent Reduction and Yearly Load Approaches

Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools. DEQ assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attaining sediment-related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate the allowable load and because of the uncertainty associated with the loads derived from the source assessment (which are used to establish the TMDL), particularly when comparing different load categories, such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement practices (BMPs) versus focusing on uncertain loading values.

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

5.8.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, roads, and permitted point sources). These BMP scenarios are discussed in **Section 5.7** and associated appendices/attachments. They reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale based on the fact that many sources deliver sediment to tributaries that then deliver the sediment load to the impaired waterbodies.

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

Progress toward TMDL and individual allocation achievement can be gaged by adhering to point source permits, implementing BMPs for nonpoint sources, and improving or attaining the water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for comparison with TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

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

5.8.2.1 Streambank Erosion

Streambank stability and erosion rates are closely linked to the health of the riparian zone. Reductions in sediment loading from bank erosion are expected to be achieved by applying BMPs within the riparian zone. Sediment loads associated with bank erosion are identified by separate source categories (e.g., transportation, grazing, natural) in **Attachment A**; however, because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding the effects of past land management activity, all sources of bank erosion were combined to express the TMDL and allocations.

DEQ acknowledges that the annual sediment loads, and the method by which to attribute human and historic influence, are estimates based on aerial photography, best professional judgment, and limited access to on-the-ground reaches. The assignment of bank erosion loads to the various land uses is not definitive but was done to direct efforts to reduce the loads toward those causes that are likely having the biggest effect on the investigated streams. Ultimately, local land owners and managers are responsible for identifying the causes of bank erosion and for adopting practices to reduce bank erosion wherever practical.

5.8.2.2 Upland Erosion
The allocation to upland sources includes application of BMPs to present land-use activities as well as recovery from past land-use influences, such as riparian harvest. No reductions were allocated to natural sources, which are a significant portion of all upland land-use categories. For all upland sources, the largest percent reduction will be achieved via riparian improvements. The anticipated loading reductions achievable by implementing upland and riparian BMPs for each land cover category are presented in **Attachment C**. For the TMDL, the allocation to upland erosion sources is presented as a single load and percent reduction.

5.8.2.3 Roads
The allocation to roads can be met by incorporating and documenting that all road crossings and parallel segments with potential sediment delivery to streams have the appropriate BMPs in place. Routine maintenance of the BMPs is also necessary to ensure that sediment loading remains consistent with the intent of the allocations. At some locations, road closure or abandonment alone may be appropriate. Further, because of the low erosion potential linked to native vegetation growth on the road surface, additional BMPs may not be necessary. The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culverts. At a minimum, culverts should meet the 25-year event; however, for fish-bearing streams and streams with a high level of road and impervious surface development upstream, or for culvert sites with a large amount of fill, meeting the 100-year event is recommended.

5.8.2.4 Permitted Point Sources
All WLAs are expected to be met by adhering to permit conditions.

5.8.3 Allocations and TMDL for Each Stream
The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 5-34 through 5-44**). Note, sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

5.8.3.1 Bear Creek (MT41H003_081)

Table 5-34. Sediment Source Assessment, Allocations and TMDL for Bear Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads		2.1	1.5	27%
Streambank Erosion		758	374	51%
Upland Sediment Sources		207	122	41%
Point Source	Bozeman MS4 (MTR040002)	5.4	3.4	37%
Total Sediment Load		973	501	48%

5.8.3.2 Bozeman Creek, lower segment (MT41H003_040)

Because TMDLs are presented on a watershed basis, the TMDL for lower Bozeman Creek also includes all loading to the stream upstream of the lower segment.

Table 5-35. Sediment Source Assessment, Allocations and TMDL for lower Bozeman Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads		10	7.4	27%
Streambank Erosion		1,212	842	31%
Upland Sediment Sources		1,056	577	45%
Point Source	Bozeman Water Treatment Plant (MT0030155)	3.7	39	0%
	Bozeman MS4 (MTR040002)	218	137	37%
	Kenyon Noble Ready Mix (MTR000095)	0.4	0.4	0%
	Construction Storm Water (MTR100000)	63	22	65%
Total Sediment Load		2,563	1,625	37%

5.8.3.3 Camp Creek (MT41H002_010)

Table 5-36. Sediment Source Assessment, Allocations and TMDL for Camp Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	23	19	17%
Streambank Erosion	3,119	1,281	59%
Upland Sediment Sources	5,309	1,832	65%
Total Sediment Load	8,451	3,132	63%

5.8.3.4 Dry Creek (MT41H003_100)

Table 5-37. Sediment Source Assessment, Allocations and TMDL for Dry Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	32	26	19%
Streambank Erosion	3,187	2,203	31%
Upland Sediment Sources	6,733	2,455	64%
Total Sediment Load	9,952	4,684	53%

5.8.3.5 Godfrey Creek (MT41H002_020)

Table 5-38. Sediment Source Assessment, Allocations and TMDL for Godfrey Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	5.9	4.9	17%
Streambank Erosion	526	270	49%
Upland Sediment Sources	2,242	625	72%
Total Sediment Load	2,774	900	68%

5.8.3.6 Jackson Creek (MT41H003_050)

Table 5-39. Sediment Source Assessment, Allocations and TMDL for Jackson Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	16	9.9	37%
Streambank Erosion	398	223	44%
Upland Sediment Sources	1,175	467	60%
Total Sediment Load	1,589	700	56%

5.8.3.7 Reese Creek (MT41H003_070)

Table 5-40. Sediment Source Assessment, Allocations and TMDL for Reese Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	6.1	4.6	25%
Streambank Erosion	1,257	864	31%
Upland Sediment Sources	1,727	662	62%
Total Sediment Load	2,990	1,531	49%

5.8.3.8 Rocky Creek (MT41H003_080)

Because TMDLs are presented on a watershed basis, the TMDL for Rocky Creek also includes an allocation to Jackson Creek. See the Jackson Creek TMDL for allocations to sediment source categories.

Table 5-41. Sediment Source Assessment, Allocations and TMDL for Rocky Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads		21	14	35%
Streambank Erosion		1,149	583	49%
Upland Sediment Sources		2,100	861	59%
Jackson Creek watershed		1,589	700	56%
Point Source	Construction Storm Water (MTR100000)	21	7	65%
Total Sediment Load		4,880	2,165	56%

5.8.3.9 Smith Creek (MT41H003_060)

Because TMDLs are presented on a watershed basis, the TMDL for Smith Creek includes an allocation to Reese Creek. See the Reese Creek TMDL for allocations to sediment source categories.

Table 5-42. Sediment Source Assessment, Allocations and TMDL for Smith Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads		3.9	3.1	19%
Streambank Erosion		966	597	38%
Upland Sediment Sources		47	16	66%
Reese Creek watershed		2,990	1,531	49%
Point Source	Construction Storm Water (MTR100000)	9.6	3.4	65%
	Construction Dewatering (MTG070687)	8.3	8.3	0%
Total Sediment Load		4,025	2,159	46%

5.8.3.10 Stone Creek (MT41H003_120)

Table 5-43. Sediment Source Assessment, Allocations and TMDL for Stone Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	2.3	1.4	39%
Streambank Erosion	317	201	37%
Upland Sediment Sources	419	196	53%
Total Sediment Load	738	398	46%

5.8.3.11 Thompson Creek (MT41H003_090)

Table 5-44. Sediment Source Assessment, Allocations and TMDL for Thompson Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	0.7	0.6	18%
Streambank Erosion	149	58	61%
Upland Sediment Sources	4	1	63%
Total Sediment Load	154	60	61%

5.9 Seasonality and Margin of Safety

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

5.9.1 Seasonality

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

- The applicable narrative water quality standards (**Appendix B**) are not seasonally dependent, although low-flow conditions provide the best ability to measure harm-to-use based on the selected target parameters. The low-flow or base-flow condition represents the most practical time period for assessing substrate and habitat conditions, and also represents a time period when high fine sediment in riffles or pool tails will likely influence fish and aquatic life. Therefore, meeting targets during this time frame represents an adequate approach for determining standards attainment.

- The substrate and habitat target parameters within each stream are measured during summer or autumn low-flow conditions consistent with the time of year when reference stream measurements are conducted. This time period also represents an opportunity to assess effects of the annual snow runoff and early spring rains, which is the typical time frame for sediment loading to occur.
- The DEQ sampling protocol for macroinvertebrates identifies a specific time period for collecting samples based on macroinvertebrate life cycles. This time period coincides with the low-flow or base-flow condition.
- All assessment modeling approaches are standard approaches that specifically incorporate the yearly hydrologic cycle specific to the Lower Gallatin TPA. The resulting loads are expressed as average yearly loading rates to fully assess loading throughout the year.
- Allocations are based on average yearly loading, and the preferred TMDL expression is as an average yearly load reduction, consistent with the assessment methods.

5.9.2 Margin of Safety

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

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets; as discussed for each target parameter in **Section 5.4.1**, an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix B** contains additional details about statistical approaches used by DEQ.
- By developing TMDLs for all streams evaluated, even though some streams were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Sediment impairment is typically identified based on excess fine sediment but the targets and TMDLs address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 5.9.1**).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 5.10**, **9.0**, and **10.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.

- By developing TMDLs at the watershed scale to address all potentially significant human-related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.10 TMDL Development Uncertainties and Adaptive Management

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

As noted in **Section 5.9.2**, adaptive management represents an important component of the implicit MOS. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring, and adaptive management (**Sections 9.0** and **10.0**). Furthermore, state law (ARM 75-5-703) requires monitoring to gauge progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

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

5.10.1 Sediment and Habitat Data Collection and Target Development

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

<u>Data Collection</u>

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

Even with the applied quality controls, a level of uncertainty regarding overall accuracy of collected data will exist. There is uncertainty regarding whether the appropriate sites were assessed and whether an adequate number of sites were evaluated for each stream. Also, there is the uncertainty of the representativeness of collecting data from one sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access problems.

Target Development

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

The established targets are meant to apply under median conditions of natural background and natural disturbance. DEQ recognizes that under some natural conditions, such as a large fire or flood event, it may be impossible to satisfy one or more of the targets until the stream and/or watershed recovers from the natural event. Under these conditions the goal is to ensure that management activities do not significantly delay achievement of targets compared with the time for natural recovery to occur.

Also, human activity should not significantly increase the extent of water quality effects from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be significantly increased from a large number of road crossing or culvert failures.

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

5.10.2 Source Assessments and Load Reduction Analyses

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

Bank Erosion

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2010) and the standard BEHI methodology, defined in **Attachment A**. Before any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP and was based on a stratification process described in **Attachment A**. The results were then extrapolated across the Lower Gallatin watershed to provide an estimate of the relative bank erosion loading from various streams and associated stream reaches. Based on this process, the relative contribution from human versus natural sources, as well as the potential for reduction with the implementation of riparian BMPs, was estimated and used for TMDL allocations. Stratifying and assessing each unique reach type was not practical, therefore adding to uncertainty associated with the load extrapolation results.

There is additional uncertainty regarding the amount of bank erosion linked to human activities and the specific human sources, as well as the ability to reduce the human-related bank erosion levels. This uncertainty is largely associated with past disturbances; it is extremely difficult to identify the level to which they still affect streambank erosion, how much is associated with human sources, and what the dominant human sources are. Even if difficult to quantify, the linkages between human activity, such as riparian clearing and bank erosion, are well established, and these linkages clearly exist at different locations throughout the Lower Gallatin watershed. Evaluating bank erosion levels, particularly where BMPs have been applied along streams, is an important part of adaptive management that can help define the level of human-caused bank erosion as well as the relative effect that bank erosion has on water quality throughout the Lower Gallatin watershed.

Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape soil loss equation (USLE), defined in **Attachment C**. As with any model, there will be uncertainty in the model input parameters, including land use, land cover, and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type. In other words, the model cannot reflect land management practices that change vegetative cover from one season to another, so an average condition is used for each scenario in the model. The potential to reduce sediment loading was based on modest land cover improvements, along with riparian improvements, to reduce the generation of eroded sediment particles. Thus, there is uncertainty regarding existing erosion prevention BMPs and the ability to reduce erosion with additional BMPs.

The upland erosion model integrates sediment delivery based on riparian health; riparian health evaluations linked to the stream stratification work are discussed in **Attachment A**. The riparian health classifications were performed using aerial imagery and a coarse classification system (i.e., poor, fair, good). This particularly introduced uncertainty in watersheds that had limited woody vegetation but that may have had a high buffering capacity from other vegetation, such as wetland grasses.

Additionally, because of the coarseness of the categories, the process resulted in a large quantity of riparian vegetation being classified as fair, which limits analysis of fine-scale differences. However, the analysis was not performed with the expectation that it would identify specific locations for implementation of additional BMPs. Instead it was performed to simulate the buffering capacity of riparian vegetation and emphasize the importance of a healthy riparian buffer. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, and the estimated reductions are consistent with literature values for riparian buffers.

Roads

As described in **Appendix C**, the road crossings sediment load was estimated via a standardized simple yearly model developed by USFS. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 24 sites were randomly selected for evaluation, representing about 5% of the total population of roads. The results from these 24 sites were extrapolated to the whole population of roads stratified by road surface type and precipitation class.

The reduction potential for all roads was also based on road ownership, although DEQ acknowledges that actual reductions will vary by site, depending on the existing maintenance level and site-specific factors. Random selection of the stratified sites was intended to capture a representative subset of the road crossings for existing conditions and level of BMP implementation. However, some uncertainty is introduced because of the small sample size relative to the total number of road crossings.

Although the traction sand assessment indicated traction sand is a minor source of sediment, there is some uncertainty because the assessment was not performed during the spring, when its effects are most apparent. Also, although the culvert assessment is a coarse level assessment, there is uncertainty in the peak flow capacity that was calculated for each culvert because it is based on regional regression equations, which may substantially overestimate or underestimate peak flow.

6.0 Nutrient TMDL Components

This section focuses on nutrient causes of water quality impairment in the Lower Gallatin planning area. The section (1) describes how excess nutrients impair beneficial uses, (2) discusses the affected stream segments, (3) discusses the currently available data pertaining to nutrient impairments in the Lower Gallatin, (4) describes the sources of nutrients based on recent studies, and (5) proposes nutrient TMDLs and their rationales.

6.1 Nutrient Effects on Beneficial Uses

Nitrogen and phosphorus are naturally occurring elements required for healthy functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, which can enter streams from various sources. Healthy streams strike a balance between organic and inorganic nutrients from sources such as natural erosion, groundwater discharge, and instream biological decomposition. This balance relies on autotrophic organisms (e.g., algae) to consume excess nutrients and on the cycling of biologically fixed nitrogen and phosphorus into higher levels on the food chain, as well as on nutrient decomposition (e.g., changing organic nutrients into inorganic forms). Human influences may alter nutrient cycling, damaging biological stream function and degrading water quality. The effects on streams of total nitrogen (TN), nitrate+nitrite (NO_3+NO_2; a component of TN), and total phosphorus (TP) are all considered in assessing the effects on beneficial uses.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with wastewater) can be toxic to fish and other aquatic life. Excess nitrogen in the form of nitrate in drinking water can inhibit normal hemoglobin function in infants. In addition, excess nitrogen and phosphorus from human sources can cause excess algal growth, which in turn depletes the supply of dissolved oxygen, killing fish and other aquatic life. Excess nutrient concentrations in surface water create blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans. Aside from the toxicity effects, nuisance algae can shift the structure of macroinvertebrate communities, which may also negatively affect the fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish communities, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can also increase the cost of treating drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

6.2 Stream Segments of Concern

Stream segments of concern in the Lower Gallatin watershed include those listed as impaired for nitrogen and/or phosphorous on the 2012 303(d) List (**Table 6-1)**. However, this document reflects 2011 impairment determinations made by DEQ's Water Quality Planning Bureau. DEQ used data collected during the past several years to update nutrient assessments on all streams identified in **Table 6-1**. The assessment results are presented in **Section 6.4**, along with an updated impairment summary (**Table 6-38**) for the Lower Gallatin planning area. The three segments of Hyalite Creek, from headwaters in the Gallatin Range to the mouth (East Gallatin River), present a unique case regarding listing history and water quality impairments. An in-depth analysis of human influences and water quality impairments on Hyalite Creek is found in **Appendix E**.

Table 6-1. Stream Segments of Concern for Nutrients and Nutrient Pollutant Impairments Based on the 2012 303(d) List

Stream Segment	Waterbody ID	2012 303(d) Nutrient Pollutant Listing(s)
Bozeman Creek	MT41H003_040	Total Nitrogen, Total Phosphorous
Bear Creek	MT41H003_081	Total Phosphorous
Bridger Creek	MT41H003_110	Total Nitrogen, Total Phosphorous
Camp Creek	MT41H002_010	Total Nitrogen
Dry Creek	MT41H003_100	Total Nitrogen, Total Phosphorous
East Gallatin River, upper	MT41H003_010	Total Nitrogen, Total Phosphorous
East Gallatin River, middle	MT41H003_020	Total Nitrogen, Total Phosphorous, pH
East Gallatin River, lower	MT41H001_030	Total Nitrogen, pH
Godfrey Creek	MT41H002_020	Total Nitrogen, Total Phosphorous
Hyalite Creek, upper	MT41H003_129	Total Nitrogen, Total Phosphorous
Hyalite Creek, middle	MT41H003_130	Total Nitrogen, Total Phosphorous
Hyalite Creek, lower	MT41H003_132	None
Jackson Creek	MT41H003_050	Total Phosphorous
Mandeville Creek	MT41H003_021	None
Reese Creek	MT41H003_070	Nitrate+Nitrite
Smith Creek	MT41H003_060	Nitrate+Nitrite
Thompson Creek	MT41H003_090	Total Nitrogen

6.3 Water Quality Data Sources

DEQ's nutrient water quality assessment method has specific objectives and decision-making criteria for assessing the validity and reliability of data. DEQ uses a Data Quality Assessment (DQA) process to evaluate data for use in assessments and decision making. The DQA considers the technical, representativeness, currency, quality, and the spatial and temporal components of the readily available data. The specific data requirements are detailed in the nutrient assessment method (Suplee and Sada de Suplee, 2011).

Primary data sources used to evaluate existing instream nutrient concentrations in the Lower Gallatin River watershed include the following:

1) **DEQ TMDL sampling.** In support of TMDL development, DEQ collected water quality samples from 55 different sites in the planning area: 2001–2005, 2007, and 2009–2010. Samples were collected from sites on Bear Creek, Bridger Creek, Bozeman Creek, Camp Creek, Dry Creek, East Gallatin River, Hyalite Creek, Gallatin River, Smith Creek, South Cottonwood Creek, Stone Creek, and Thompson Creek (where *n* = number of samples). All samples listed below were collected during the summer period (July 1 – September 30).
    a. 2001 – 12 sites (*n* = 41)
    b. 2002 – 1 site (*n* = 1)
    c. 2003 – 5 sites (*n* = 15)
    d. 2004 – 16 sites (*n* = 49)
    e. 2005 – 12 sites (*n* = 38)
    f. 2007 – 10 sites (*n* = 41)
    g. 2009 – 5 sites (*n* = 10)
    h. 2010 – 4 sites (*n* = 8)

2) **DEQ Contractor sampling.** As part of several different projects, contractors collected water samples from streams in 2003 and 2007-2010 in support of TMDL development.
    a. 2003 – 8 sites (*n* = 224) from Bear Creek (April–August)
    b. 2007 – 3 sites (*n* = 6) for stormwater modeling for the city of Bozeman (May, November)
    c. 2008 – 72 sites on 18 streams (*n* = 264) during the growing season
    d. 2009 – 83 sites on 16 streams (*n* = 124) during the growing season
    e. 2009-2010 – 4 sites (*n* = 13) for a streamflow and nutrient monitoring project on Bridger Creek, Bozeman Creek and the East Gallatin River.

3) **Volunteer Group Sampling.** Volunteers from the Greater Gallatin Watershed Council collected water quality samples and flow measurements from Bridger Creek, Thompson Creek, Hyalite Creek, and Bozeman Creek between 2008 and 2011**.**

4) **Macroinvertebrate Sampling.** The Greater Gallatin Watershed Council and DEQ sampled macroinvertebrates at several locations in the Lower Gallatin Watershed from 2008–2011. Samples were collected from Bozeman Creek, Bridger Creek, Hyalite Creek, and Thompson Creek and were frequently paired with water quality sampling (3).

5) **DEQ Assessment Files.** The files contain information used to make the existing nutrient impairment determinations. This includes water quality and algal data results and historical information collected or obtained by DEQ.

6) **MBMG Ground Water Investigation Program Lower Gallatin Projects.** Data collected by the Montana Bureau of Mines and Geology's (MBMG) Ground Water Investigations Program in 2010–2011 in the Lower Gallatin will also be used where appropriate.

7) **USFS PIBO Data.** The U. S. Forest Service's (USFS) PACFISH/INFISH Biological Opinion (PIBO) group collects macroinvertebrate data throughout the Mountain West. Data collected in 2007 on identified assessment units was used in the analysis.

8) **City of Bozeman Water Treatment Facilities.** Data collected by the city of Bozeman from 2008-2011 on Bozeman Creek, Hyalite Creek, and Lyman Creek were used where appropriate.

Secondary data sources used to evaluate existing instream nutrient concentrations in the Lower Gallatin River watershed:

- Groundwater quality data from MBMG's Groundwater Information Center (GWIC) database
- U. S. Geological Survey's National Water Information System (NWIS) database
- Discharge monitoring report data from the city of Bozeman's water treatment plants, water reclamation facility, and municipal storm sewer system (MS4)

Primary data sources include those collected in the assessment units and within the specific waterbody segment(s). Only primary data sources that passed DEQ's Data Quality Assessment (DQA) process were used to make impairment determinations. Secondary data sources include data collected as part of Discharge Monitoring Reports (DMR) by MPDES permitees and other groundwater and surface water data sources used to quantify or describe point and nonpoint sources within a sub-basin. This includes surface water data collected outside the summer period (July 1 – September 30) when nutrient water quality targets apply.

Because these sampling events represent the most recent, and the most exhaustive, water quality characterization of nutrients, DEQ used data from these events as the primary source for evaluating water quality targets and assessing nutrient sources. Raw data from these sources is extensive and is not included but is publicly available via EPA's STORET water quality database and DEQ's EQuIS water quality database. It is also available from DEQ upon request. It should be noted that extensive chlorophyll-*a* samples were collected in multiple streams in the 2008 by a DEQ contractor. However, collection and processing protocols were violated by the contracted laboratory and 26 of 34 samples did not meet DEQ Quality Control standards and were discarded.

Groundwater data are available from the USGS and MBMG databases. The following section provides an evaluation of water quality conditions with respect to nutrients for stream segments of concern in the Lower Gallatin River watershed. **Figure 6-1** identifies the streams of concern for nutrients and the available water quality data for the Lower Gallatin TMDL project area, excluding MBMG data for surface water and groundwater.

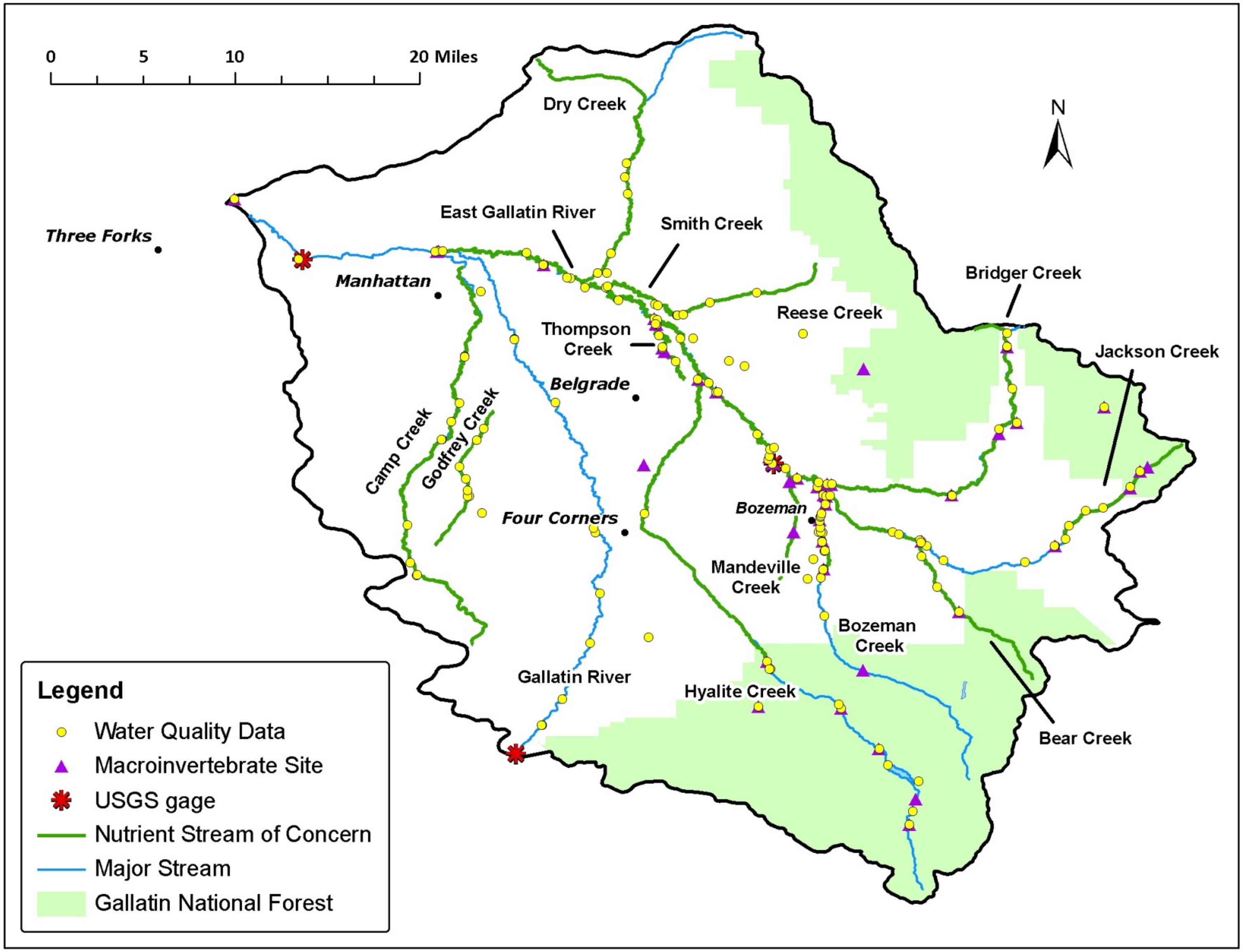

Figure 6-1. Nutrient sampling sites on the streams of concern

6.4 Water Quality Targets

TMDL water quality targets are numeric indicators used to evaluate attainment of water quality standards. They are discussed in **Section 4.0**. The following section presents nutrient water quality targets and compares those values with recently collected nutrient data in the Lower Gallatin River watershed using DEQ's draft assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's draft assessment methodology, and because analytical methods have improved; only data from the past 10 years (2001–2011) are included in the review of existing data. Additionally, many of the nutrient samples collected before 2005 were analyzed for total Kjeldahl nitrogen (TKN), which DEQ has since replaced with total persulfate nitrogen as the preferred analytical method for determining total nitrogen. TN has also replaced TKN as a preferred parameter for evaluating nitrogen impairment. It should be noted that DEQ Circular 12 includes both of these analytical methods as means of determining total nitrogen.

6.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous forms) are narrative and are addressed via narrative criteria requiring that state surface waters be free from substances attributable to municipal, industrial, or agricultural practices or other discharges that produce nuisance conditions; create concentrations or combinations of material toxic or harmful to aquatic life; or create conditions that produce undesirable aquatic life [ARM 17.30.637(1)]. DEQ is currently developing numeric nutrient criteria at levels consistent with the requirements of narrative criteria. These draft numeric criteria are the basis for the nutrient TMDL targets consistent with EPA's TMDL development guidance (http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/strategy/) and federal regulations (40 CFR §131.11(a) & (b)).

6.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae chlorophyll-*a* (a form of undesirable aquatic life at elevated concentrations). The target concentrations for nitrogen and phosphorus are established at levels believed to protect aquatic life and recreation. Since 2002 Montana has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms) and has developed draft nutrient criteria for total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* concentration, based on two factors: (1) the results of public perception surveys (Suplee et al., 2009) on what level of algae was perceived as undesirable and (2) the results of nutrient stressor-response studies to determine nutrient concentrations that will maintain algal growth below undesirable levels and to identify reference values (Suplee et al., 2008b). When algal levels in a stream increase, shifts in biomass and community structure are likely as dissolved oxygen concentrations decrease and salmonid growth and survival becomes impaired.

Nutrient targets for TN, TP, and chlorophyll-*a* are based on the draft nutrient criteria and are presented in **Table 6-2**. Included in this table are draft numeric criteria for the Level IV ecoregion Absaroka-Gallatin Volcanic, which has naturally high levels of phosphorous (Suplee et al., 2012). A map of the Level IV ecoregions in the Lower Gallatin TMDL project area may be found in **Appendix A, Figure A-8**.

The draft nutrient criteria apply during summer months (generally July 1–September 30), when algal growth has the highest potential to affect beneficial uses. Note that targets in this document are established specifically for nutrient TMDL development in the Lower Gallatin project area and may or may not apply to streams in other TMDL project areas. See **Section 6.5.4.3** for the adaptive management strategy related to nutrient water quality targets.

Table 6-2. Nutrient targets* in the Lower Gallatin project area by ecoregion

Parameter	Target values	
	Middle Rockies (Level III)	Absaroka-Gallatin Volcanics Ecoregion (Level IV, within Middle Rockies)
Nitrate+Nitrite (NO_3+NO_2)	≤ 0.100 mg/L	≤ 0.100 mg/L
Total Nitrogen (TN)	≤ 0.300 mg/L	≤ 0.250 mg/L
Total Phosphorous (TP)	≤ 0.030 mg/L	≤ 0.105 mg/L
Chlorophyll-*a*	≤ 125 mg/m² (≤35 g AFDW/m^2)	≤ 125 mg/m² (≤35 g AFDW/m^2)

*see **Section 6.5.4.3** for the adaptive management strategy for nutrient targets; AFDW = ash-free dry weight

Since this Level IV ecoregion has naturally high levels of TP, DEQ established site-specific nutrient criteria using the following process. The 75th percentile of the reference dataset for the Level IV Absaroka-Gallatin-Volcanics and the Level III Middle Rockies were used to determine the natural background of streams that flow through both ecoregions and for receiving waterbodies. Relative flow contributions were calculated from available discharge data from USGS and from flow sampling projects conducted by DEQ and its contractors. Mean estimates were used to determine the relative flow contributions from drainage areas in the Level IV Absaroka-Gallatin-Volcanics ecoregion. Water quality target values were used with relative flow contributions to calculate segment specific water quality targets. **Table 6-3** identifies these water quality targets for stream segments influenced by the Level IV Absaroka-Gallatin-Volcanics ecoregion inside the Lower Gallatin TMDL project area. A description of the water quality targets and how they were calculated for streams draining the Absaroka-Gallatin-Volcanics Level IV ecoregion in the Lower Gallatin TMDL project area may be found in Suplee and Watson (2012).

Table 6-3. Nutrient Targets in the Lower Gallatin project area per stream segment receiving flow from the Absaroka-Gallatin-Volcanics Level IV ecoregion

Stream segment	TN target (mg/L)	TP target (mg/L)
Bozeman Creek	≤0.270	≤0.080
East Gallatin between Bozeman and Bridger Creeks	≤0.290	≤0.050
East Gallatin between Bridger and Hyalite Creeks	≤0.300	≤0.030
Lower Hyalite Creek	≤0.260	≤0.090
East Gallatin between Hyalite Creek and Smith Creek	≤0.290	≤0.060
East Gallatin between Smith Creek and mouth	≤0.300	≤0.030

In Suplee and Watson (2012), equations relating benthic algal chlorophyll-*a* to total nutrients were used to calculate the benthic chlorophyll-*a* biomass that would occur at the criteria levels shown for the stream and river reaches listed in **Table 6-3**. In all cases, benthic algae were maintained at ≤ 125 mg chlorophyll-*a* /m2, therefore that value (and the accompanying AFDM value) is an appropriate and realistic level for these stream segments (Suplee and Watson, 2012). The nutrient criteria are adequate to protect the coldwater fisheries use by assuring that dissolved oxygen levels always remains above standards.

6.4.3 Existing Conditions and Comparison with Targets

DEQ evaluated nutrient target attainment by comparing existing water quality conditions with the water quality targets in **Tables 6-2** and **6-3**, using the methodology in DEQ's guidance document "2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and

Phosphorus Levels" (Suplee and Sada de Suplee, 2011). For each waterbody segment, a data summary will be presented along with a comparison of existing data with targets, using the assessment methodology and a TMDL development determination. Because most of the impairment listings are based on older data, or were listed before numeric criteria were developed, each stream segment will be evaluated for impairment from NO_3+NO_2, TN, and TP using data collected within the past 10 years. TMDL development determinations will depend on results of the data evaluation, and these updated impairment conclusions will be captured in the 2014 303(d) List and associated 2014 Water Quality Integrated Report. Some streams in the Lower Gallatin TMDL project area lacked adequate data for a full assessment. In these situations, the determination to develop a TMDL is based on the current listing status.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, water quality targets are not attained (a) when nutrient chemistry data has a target exceedance rate of >20% (Exact Binomial Test), (b) when the results of mean water quality nutrient chemistry exceed target values (Student T-test), or (c) when a single chlorophyll-*a* result exceeds benthic algal target concentrations (125 mg/m^2 or 35 g AFDW/m^2). In some cases, the chlorophyll-*a* SOP allows for a visual assessment where the collector determines that at all sampling transects, chlorophyll-*a* densities are less than 50 mg/m^2. In these cases, samples are not collected and the site is qualitatively assessed as having a chlorophyll-*a* density <50 mg/m^2. Where water chemistry and algae data do not provide a clear determination of impairment status, or when other limitations exist, the Hilsenhoff Biotic Metric (HBI) biometric is considered in further evaluating whether nutrient targets have been achieved, as directed by the assessment methodology. The Hilsenhoff Biotic Metric is a biometric based on tolerance values. A large number of macroinvertebrate taxa have been assigned a numeric value which represents the organism's tolerance to organic pollution (Barbour et al., 1999). HBI is then calculated as a weighted average tolerance value of all individuals in a sample (Suplee and Sada de Suplee, 2011). Higher index values indicate increasing tolerance to pollution.

Periphyton biometrics were developed by DEQ for Montana as an indicator of impairment. The exception to this use of diatoms is the Middle Rockies Level III ecoregion, for which there are no validated diatom increaser metrics. The Lower Gallatin TMDL project area is entirely within the Middle Rockies ecoregion and, therefore, diatom metrics were not included in impairment assessments.

Note: to ensure a higher degree of certainty for removing an impairment determination and making any new determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form, which may result in a different number of allowable exceedances for nutrients within a single stream segment. This helps assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample.

6.4.312 Bear Creek

Bear Creek is listed on the 2012 303(d) List for TP nutrient impairment. The assessment unit for Bear Creek includes its entire length from the headwaters in the Gallatin National Forest to the mouth (East Gallatin River) the streamflows a distance of 10.15 miles. Bear Creek was first listed in 2006 as being impaired for TP based on nutrient, chlorophyll-*a*, and macroinvertebrate samples from 2003. The TP impairment is linked to sediment entering the stream from grazing in the shoreline or riparian zone and from unspecified roads or trails.

Water quality sampling before 2008 included detections above the water quality standard for TP in all samples collected, which included four above the forest boundary and one below the forest boundary. Cooperative studies in 2003 by the Gallatin National Forest, DEQ, and the Gallatin Local Water Quality District determined that recreational use of the road/trail above the forest boundary was a significant disturbance, resulting in sediment deposition of highly erodible soils to the stream corridor. In summer 2007 a portion of the road/trail in Bear Canyon was closed to some motorized uses, and a section of the trail was decommissioned and relocated to reduce sediment loading to a portion of the stream. In samples collected since 2007, water quality has improved significantly. Therefore, for the purposes of this assessment only data collected since 2007 is included, given the significant restoration work that occurred before 2008.

Summary statistics for nutrient data and results of the assessment method evaluation for Bear Creek are provided in **Tables 6-4** and **6-5**, respectively. In 2008 and 2009, a total of nine growing season samples were collected on Bear Creek for NO_3+NO_2, eight for TN, and nine for TP. Algal samples were analyzed for chlorophyll-*a* (*n* = 3) and AFDW (*n* = 1) between 2008 and 2009. One macroinvertebrate sample was collected in 2011 and had an HBI score less than 4. This sample was collected immediately downstream of the road/trail decommissioning project that occurred in 2007. The NO_3+NO_2 and TN data passed both statistical tests, and there were no exceedances of target values for either parameter. The TP data failed the binomial statistical test and had two exceedances of the target value; TP passed the student t-test. Algal samples did not exceed target values for chlorophyll-*a* or for AFDW. Omitting the pre-2008 data does not allow for a full assessment because the minimum sample size is not met. Lacking sufficient data for a full assessment, a TMDL was developed for TP.

Table 6-4. Nutrient Data Summary for Bear Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2008-2009	9	0.016	0.049	0.031	0.038
TN	2008-2009	8	0.091	0.220	0.150	0.206
TP	2008-2009	9	0.016	0.049	0.026	0.031
Chlorophyll-*a*	2008-2009	3	NA	NA	27.6	NA
AFDW	2009	1	NA	NA	17.2	NA
Macroinvertebrate HBI	2011	1	NA	NA	3.155	NA

Table 6-5. Assessment Method Evaluation Results for Bear Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	9	0.100	0	PASS	PASS	PASS	NO
TN	8	0.300	0	PASS	PASS	PASS	NO
TP	9	0.030	2	FAIL	PASS	PASS	YES

6.4.3.2 Bozeman Creek (Sourdough Creek)

Lower Bozeman Creek is listed on the 2012 303(d) List for TN and TP nutrient impairments. The lower segment of Bozeman Creek flows 4.9 miles from the confluence with Limestone Creek to the mouth (East Gallatin River). Bozeman Creek originates in the Gallatin Range and flows out of Sourdough Canyon above the forest boundary. The total length of the stream is 14 miles from its confluence with North Fork and South Fork to the mouth (East Gallatin River) however, the assessment unit only includes the lower segment from the Limestone Creek confluence to the mouth (East Gallatin River). The nutrient impairments for the stream segment are based on nutrient, chlorophyll-*a*, and macroinvertebrate samples from 2004.

From 2004 to 2011 extensive water quality sampling was conducted on the lower segment of Bozeman Creek; more than 30 samples were collected for NO_3+NO_2, TN (used as an improved water quality indicator in preference to TKN), and TP (**Table 6-6**). Exceedance rates were high with targets values for NO_3+NO_2 and TN exceeded in 100% and 97% of samples, respectively. Both the binomial and student t-tests were failed for NO_3+NO_2 and TN (**Table 6-7**). TP had only a single exceedance of the target value and passed both statistical tests. Biological data include six chlorophyll-*a* samples collected between 2004 and 2008 and 11 macroinvertebrate samples collected between 2004 and 2011. There is no ash-free dry weight (AFDW) data available for this segment. Including three visual estimates, chlorophyll-*a* did not exceed target criteria (>125 mg/m^2) in any sample. Secondary indicators of impairment were also reviewed for the lower segment of Bozeman Creek. HBI scores for macroinvertebrates were elevated above criteria (>4) in 8 of 11 samples. The high target exceedance rate for the macroinvertebrate and water chemistry samples indicates a nutrient impairment from TN and/or TP. Based on the assessment, a TMDL for TP will not be developed for the lower segment of Bozeman Creek. Because the NO_3+NO_2 exceedances are reflected in the TN data (NO_3+NO_2 is a component of TN), only a TMDL for TN is required.

Table 6-6. Nutrient Data Summary for Bozeman Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2004-2011	35	0.170	0.860	0.548	0.708
TN	2004-2011	31	0.270	1.700	0.757	0.850
TP	2004-2011	32	0.031	0.111	0.048	0.056
Chlorophyll-*a*	2004-2008	3*	6.7	112.0	54.9	112.0
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	2004-2011	11	3.464	5.641	4.380	4.638

* 3 additional observations were visual estimates of < 50 mg/m^2 and were not included in the summary statistics.

Table 6-7. Assessment Method Evaluation Results for Bozeman Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	35	0.100	35	FAIL	FAIL	PASS	YES
TN	31	0.270	30	FAIL	FAIL	PASS	YES
TP	32	0.080	1	PASS	PASS	PASS	NO

6.4.3.3 Bridger Creek

Bridger Creek is listed on the 2012 303(d) List for TN and TP nutrient impairment. Bridger Creek flows 21.5 miles from the headwaters in the Gallatin National Forest to the mouth (East Gallatin River) and was first included on the 2006 303(d) List as being impaired for TP based on nutrient, chlorophyll-*a*, and macroinvertebrate samples from 2004.

Extensive nutrient sampling occurred between 2004 and 2011. Chlorophyll-*a* samples were collected in 2004 and 2008, and macroinvertebrates were sampled in 2004 and 2011 (**Table 6-8)**. More than 25 samples were collected for NO_3+NO_2 (n = 29), TN (n = 26), and TP (n = 29). TN and TP passed both statistical tests and each had only a single target exceedance in the sampling period **(Table 6-9)**. NO_3+NO_2 had nine target exceedances and failed the binomial test. The initial assessment was not conclusive so the macroinvertebrate data was reviewed as a secondary indicator. Ten of 11 macroinvertebrate samples exceeded assessment thresholds. The elevated HBI scores and failed binomial test for NO_3+NO_2 suggests a nutrient impairment, although nutrient concentrations were not significantly elevated above the target. The current listing for TN and TP are clearly not supported by the data, which implies a nutrient impairment from NO_3+NO_2. Because the NO_3+NO_2 exceedances are not reflected in the TN data, only a TMDL for NO_3+NO_2 will be developed for Bridger Creek.

In Suplee (2008c) a recommendation for a water quality target of 0.1 mg/L for Nitrate+Nitrite was made for the Middle Rockies Level III ecoregion. This is still regarded as the impairment benchmark value and is used as the water quality target in the Lower Gallatin TMDL project area.

Table 6-8. Nutrient Data Summary for Bridger Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2007-2011	29	0.005	0.170	0.066	0.120
TN	2004-2011	26	0.080	1.150	0.269	0.290
TP	2004-2011	29	0.005	0.046	0.013	0.017
Chlorophyll-*a*	2004-2008	6	1.40	106.0	46.7	101.0
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	2004-2011	11	3.857	6.128	4.662	4.822

Table 6-9. Assessment Method Evaluation Results for Bridger Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	29	0.100	9	FAIL	PASS	PASS	YES
TN	26	0.300	1	PASS	PASS	PASS	NO
TP	29	0.030	1	PASS	PASS	PASS	NO

6.4.3.4 Camp Creek

Camp Creek is included on the 2012 303(d) List for TN nutrient impairment. Camp Creek flows 29.6 miles from the headwaters on the Madison Plateau (Camp Creek Hills) to the mouth (Gallatin River). Camp Creek was first included in 1996 303(d) List for a TN impairment based on data collected in the late 1980s, which examined nonpoint source loading effects on the waterbody.

Nutrient samples were collected on Camp Creek from 2001 to 2009 (**Table 6-10**). Target values were exceeded in 13 of 14 samples for NO_3+NO_2, in 10 of 11 samples for TN, and in 10 of 14 samples for TP (**Table 6-11**). Nutrient mean concentrations were significantly above the target per respective parameter. Per DEQ's assessment method, the lack of sufficient chlorophyll-*a* and macroinvertebrate data preclude the clear interpretation of nutrient sampling results. The existing data suggest a significant nutrient impairment from TN and TP. In addition to the current TN listing, a TMDL for TP will be developed for Camp Creek based on the failure of both statistical analyses. Because the NO_3+NO_2 impairment is reflected in the TN data, NO_3+NO_2 will not be addressed with a specific TMDL but will be addressed by the TMDL for TN.

Table 6-10. Nutrient Data Summary for Camp Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2001-2009	12	0.380	1.990	1.380	1.886
TN	2001-2009	9	0.600	2.400	1.508	1.936
TP	2001-2009	12	0.027	0.175	0.101	0.144
Chlorophyll-*a*	2008	1	NA	NA	<50	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA	NA

Table 6-11. Assessment Method Evaluation Results for Camp Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	12	0.100	12	FAIL	FAIL	PASS	YES
TN	9	0.300	9	FAIL	FAIL	PASS	YES
TP	12	0.030	8	FAIL	FAIL	PASS	YES

6.4.3.5 Dry Creek

Dry Creek is included on the 2012 303(d) List for TN and TP nutrient impairments. Dry Creek flows 20.1 miles from the headwaters in the Horseshoe Hills to the mouth (East Gallatin River) and was first listed in 2000 for nutrient impairments based on nutrient sampling, including impairment documentation from the late 1970s.

Nutrient data were collected from 2007 to 2009 (**Table 6-12**). There were no target exceedances for TP and it passed both statistical analyses. There were four exceedances of target values for NO_3+NO_2 and for TN; both parameters failed the binomial and student t-tests (**Table 6-13**). There is no algal or macroinvertebrate data available from the sample period to provide a more in-depth assessment of the nutrient data, specifically TP. The data support the current listing for TN but fail to eliminate TP as a cause of impairment because of an inadequate sample population and lack of biological data. Therefore, a TMDL for both TN and TP will be developed for Dry Creek based on the current listing status. Because the NO_3+NO_2 impairment is reflected in the TN data, a TMDL for NO_3+NO_2 will not be developed but will be addressed by the TMDL for TN.

Table 6-12. Nutrient Data Summary for Dry Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2007-2009	7	0.026	0.450	0.211	0.384
TN	2007-2009	7	0.100	0.590	0.374	0.554
TP	2007-2009	7	0.015	0.027	0.021	0.026
Chlorophyll-*a*	NA	0	NA	NA	NA	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA	NA

Table 6-13. Assessment Method Evaluation Results for Dry Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	7	0.100	4	FAIL	FAIL	NA	YES
TN	7	0.300	4	FAIL	FAIL	NA	YES
TP	7	0.030	0	PASS	PASS	NA	NO

6.4.3.6 Upper East Gallatin River

The upper segment of the East Gallatin River (MT41H0003_010) is included on the 2012 303(d) List as being impaired for TN and TP. The upper segment of the East Gallatin River flows 7.3 miles from its starting point at the confluence of Bear Creek and Rocky Creek to the confluence with Bridger Creek (**Figure 6-2**) and was first included on the 2006 303(d) List for TN and TP. There were no nutrient impairment listings on the segment before 2006. Bozeman Creek flows into the East Gallatin River ~1 mile upstream of the confluence of the East Gallatin River and Bridger Creek.

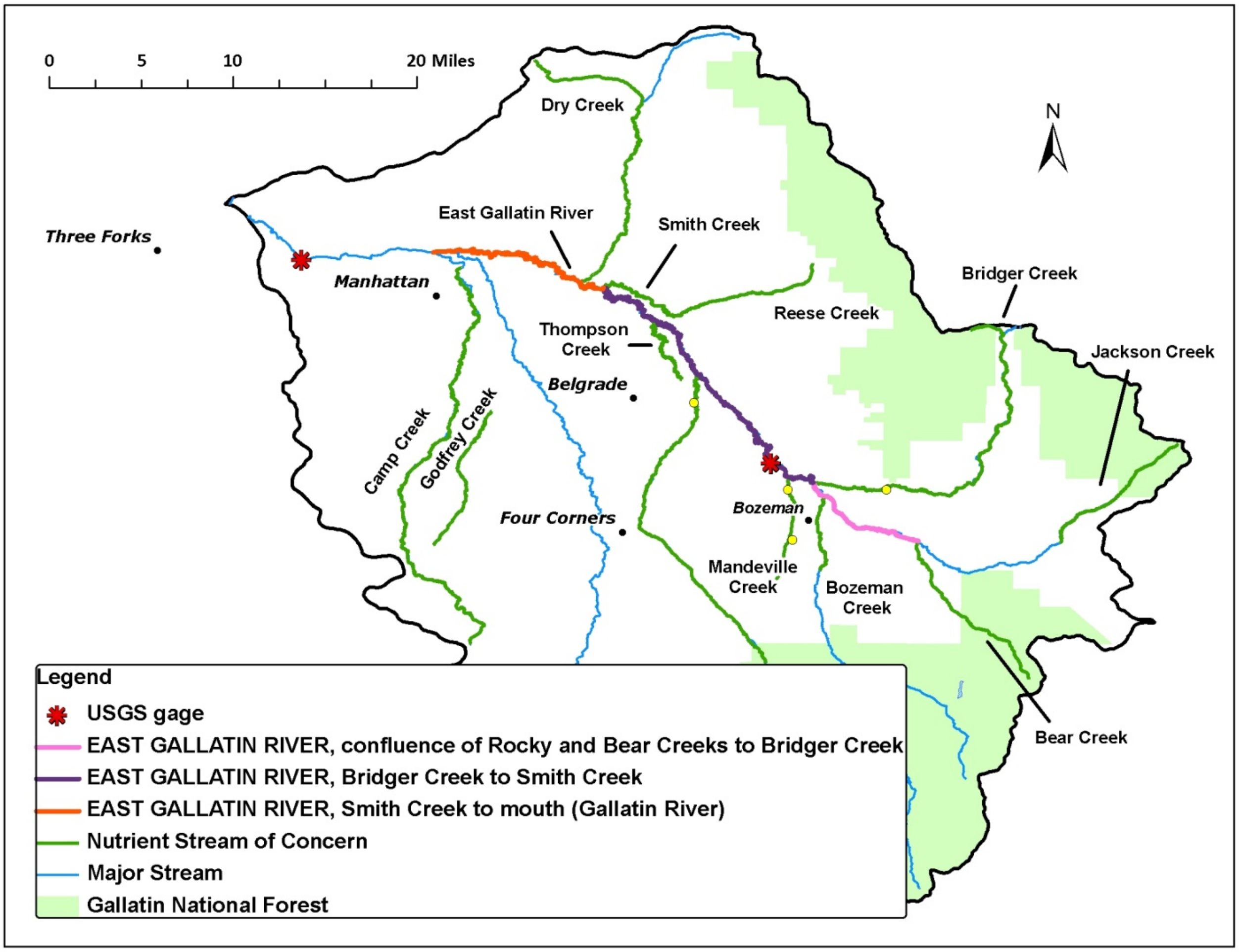

Figure 6-2. Map of East Gallatin River upper, middle and lower assessment units

Bozeman Creek flows into the East Gallatin River at Bozeman, and its drainage includes the Absaroka-Gallatin-Volcanics Level IV ecoregion. As outlined in **Section 6.4.2** in **Table 6-3**, water quality targets are different upstream and downstream of Bozeman Creek. Therefore, assessments of water quality in reference to target values in this segment are done separately and will be presented as such. However, the overall impairment determination is for the entire assessment unit from the confluence of Rocky and Bear Creeks to the confluence of Bridger Creek and the East Gallatin River. Therefore, if 1 reach is determined to be impaired, the entire assessment unit follows that determination.

In the reach above the Bozeman Creek confluence (Reach 1), nutrient data was collected between 2005 and 2010. Two chlorophyll-*a* samples were collected in 2005 and 2009 and one AFDW sample was analyzed in 2009. A single sample for macroinvertebrate data was collected in 2005. Summary nutrient data statistics and assessment method evaluation results for the upper segment of the East Gallatin River are provided in **Tables 6-14** and **6-15**, respectively. There were no target exceedances for TN or TP, but there were three for NO_3+NO_2. There was not enough data to complete all statistical analyses. The chlorophyll-*a* samples were below criteria, but AFDW was above criteria. The macroinvertebrate sample was >4 HBI, indicating nutrient impairment.

Table 6-14. Nutrient Data Summary for Upper East Gallatin River from confluence of Rocky and Bear Creeks to the confluence of Bozeman Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2010	6	0.005	0.200	0.118	0.17
TN	2005-2010	6	0.025	0.300	0.224	0.28
TP	2005-2010	7	0.001	0.027	0.018	0.023
Chlorophyll-*a*	2005-2009	2	5.2	103.1	NA	NA
AFDW	2009	1	NA	NA	66.8	NA
Macroinvertebrate HBI	2005	1	NA	NA	4.24	NA

Table 6-15. Assessment Method Evaluation Results for Upper East Gallatin River from confluence of Rocky and Bear Creeks to the confluence of Bozeman Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	Indicates Impairment?
Nitrate+Nitrite	6	0.100	3	FAIL	FAIL	PASS	YES
TN	6	0.300	0	NA	NA	PASS	NO
TP	7	0.030	0	PASS	NA	PASS	NO

In the reach below the Bozeman Creek confluence (Reach 2), nutrient data was collected between 2005 and 2008. Two chlorophyll-*a* samples were collected in 2005 and 2009. Macroinvertebrate data comprise three samples collected in 2005. No AFDW data are available for this reach. Summary statistics for nutrient data and results of the assessment method evaluation for the upper segment of the East Gallatin River are provided in **Tables 6-16** and **6-17**, respectively. There were three target exceedances each for TN and NO_3+NO_2; TP had two target exceedances. There was not enough data to complete all statistical analyses. Chlorophyll-*a* samples were below criteria, but the macroinvertebrate samples were >4 HBI, indicating nutrient impairment.

Table 6-16. Nutrient Data Summary for Upper East Gallatin River from the confluence of Bozeman Creek to the confluence of Bridger Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2007	3	0.17	0.41	0.32	0.393
TN	2005-2007	3	0.65	2.00	1.12	1.48
TP	2005-2008	5	0.026	0.133	0.057	0.071
Chlorophyll-*a*	2005	2	7.2	13.4	NA	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	2005	2	4.07	4.32	NA	NA

Table 6-17. Assessment Method Evaluation Results for Upper East Gallatin River from the confluence of Bozeman Creek to the confluence of Bridger Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?*
Nitrate+Nitrite	3	0.100	3	NA	NA	PASS	YES
TN	3	0.290	3	NA	NA	PASS	YES
TP	5	0.050	2	NA	NA	PASS	YES

*Impairment decision result of water quality target exceedances for N03+N02, TN and TP and macroinvertebrate HBI scores >4.

Because of the influence of Bozeman Creek, the upper segment of the East Gallatin River has two different water quality targets for TN and TP. Although there is currently not enough data to complete the statistical analyses, the biological results and the observed exceedances of water quality targets support the current listing for TN and TP, for which TMDLs will be developed. It does appear that the reach upstream of the Bozeman Creek confluence (Reach 1) is not impaired for TP. Because the NO_3+NO_2 impairment is reflected in the TN data, a TMDL for NO_3+NO_2 will not be developed but will be addressed by the TN TMDL. TN and TP TMDLs will be developed based on the current impairment listings.

As stated above, the upper segment comprises 1 assessment unit with 2 different sets of water quality targets as bounded by the location where Bozeman Creek flows into the East Gallatin River. TMDLs are tied to an assessment unit; therefore, a TN and TP TMDL will be developed for the entire upper segment of the East Gallatin River from the confluence of Bear and Rocky Creeks to where Bridger Creek flows into the East Gallatin River.

6.4.3.7 Middle East Gallatin River

The 2012 303(d) List identifies TN and TP nutrient impairments on the middle segment of the East Gallatin River (MT41H0003_020). The segment includes the portion of the East Gallatin River from the confluence of Bridger Creek to the confluence with Smith Creek and flows 25.5 miles (**Figure 6-2**). First included for nutrients and pH on the 1996 303(d) List, the segment includes the outfall from the Bozeman wastewater treatment plant. For assessment purposes, data were not adjusted to reflect the October 2011 completion of the upgrade to the city of Bozeman's Water Reclamation Facility (WRF). For TMDL development however, a concentration based model was developed for the East Gallatin River downstream of the WRF discharge location to reflect post-October 2011 upgrades (**Appendix G**).

The pH listing on the middle segment was originally tied to Bozeman's municipal wastewater treatment facility, which was believed to be impairing the receiving waterbody for pH. Analysis of flow rates and pH of the receiving waterbody found that the Bozeman WRF is not violating the water quality standard for pH for the East Gallatin River (per ARM 17.30.623(c)). This was specifically documented by a 1997 USGS study that examined effluent mixing characteristics for several wastewater discharges, including Bozeman's WRF, on the East Gallatin River (Cleasby and Dodge, 1999). Sampling results determined that mixing was probably complete at approximately 200 feet downstream of the location of the WRF outfall at that time. The report provides evidence that when completely mixed, the WRF discharge did not cause a change of more than 0.5 pH units. Therefore, the pH impairment for this segment will be delisted.

Hyalite Creek flows into the East Gallatin River at Bozeman, and its drainage includes the Absaroka-Gallatin-Volcanics Level IV ecoregion. As outlined in **Section 6.4.2** in **Table 6-3**, water quality targets in the upper segment of the East Gallatin River are different upstream and downstream of the Hyalite Creek confluence. Therefore, assessments of water quality in reference to target values in this segment are done separately and will be presented as such. However, the overall impairment determination is for the entire assessment unit from the confluence of Bridger Creek and the East Gallatin River to the confluence of Smith Creek and the East Gallatin River. Therefore, if 1 reach is determined to be impaired, the entire assessment unit follows that determination.

Upstream of the Hyalite Creek confluence (Reach 1), nutrient samples were collected on the middle segment of the East Gallatin River from 2005 to 2010 (**Table 6-18**). Target values were exceeded for NO_3+NO_2, TN, and TP in 93%, 93%, and 61% of samples, respectively (**Table 6-19**). Mean concentrations were significantly greater than targets for all nutrient parameters; NO_3+NO_2, TN, and TP failed both statistical tests. Although none of the chlorophyll-*a* samples were above target criteria, the AFDW sample was above the target. Failure of water chemistry statistical tests in combination with the AFDW sample result indicates impairment. Although secondary data is not necessary in this case it is worth noting that all macroinvertebrate samples (4/4) exceeded the assessment threshold HBI score (>4).

Table 6-18. Nutrient Data Summary for Middle East Gallatin River from the confluence of Bridger Creek to the confluence of Hyalite Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2010	15	0.060	4.270	1.080	1.38
TN	2005-2010	15	0.025	5.100	1.328	1.522
TP	2005-2010	18	0.003	0.870	0.238	0.353
Chlorophyll-*a*	2005-2009	5	3.9	83.4	51.10	77.320
AFDW	2009	1	NA	NA	87.4	NA
Macroinvertebrate HBI	2005	4	4.97	7.05	5.63	5.97

Table 6-19. Assessment Method Evaluation Results for Middle East Gallatin River from the confluence of Bridger Creek to the confluence of Hyalite Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	15	0.100	14	FAIL	FAIL	PASS	YES
TN	15	0.300	14	FAIL	FAIL	PASS	YES
TP	18	0.030	11	FAIL	FAIL	PASS	YES

Downstream of the Hyalite Creek confluence (Reach 2), nutrient samples were collected on the middle segment of the East Gallatin River from 2005 to 2009 (**Table 6-20**). Target values were exceeded for NO_3+NO_2, TN, and TP in all samples (**Table 6-21**). Mean concentrations were significantly greater than targets for all nutrient parameters. However, there was not enough data to complete all statistical analyses for water chemistry. Chlorophyll-*a* and AFDW samples were above assessment thresholds, and the single macroinvertebrate sample exceeded the threshold HBI score (>4).

Table 6-20. Nutrient Data Summary for Middle East Gallatin River from the confluence of Hyalite Creek to the confluence of Smith Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2009	4	0.93	0.99	0.978	0.994
TN	2005-2009	4	1.09	1.40	1.183	1.244
TP	2005-2009	6	0.081	0.189	0.126	0.149
Chlorophyll-*a*	2005-2009	2	71.4	135.9	NA	NA
AFDW	2009	1	NA	NA	82.3	NA
Macroinvertebrate HBI	2005	1	NA	NA	4.88	NA

Table 6-21. Assessment Method Evaluation Results for Middle East Gallatin River from the confluence of Hyalite Creek to the confluence of Smith Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	4	0.100	4	NA	NA	FAIL	YES
TN	4	0.290	4	NA	NA	FAIL	YES
TP	6	0.060	6	NA	NA	FAIL	YES

Examining data collected in both reaches of the middle segment, exceedances of nutrient targets for water quality, combined with biological indicators, indicate TN and TP impairments and support the current listings. TMDLs will be developed for both TN and TP. Because the NO_3+NO_2 exceedances are reflected in the TN data, only a TMDL for TN will be developed to address the nitrogen impairment in the middle segment of the East Gallatin River.

6.4.3.8 Lower East Gallatin River

The lower segment of the East Gallatin River (MT41H0003_030) is included on the 2012 303(d) List for TN nutrient impairment. The lower segment flows 13.5 miles from the confluence of Smith Creek to the mouth (Gallatin River) (**Figure 6-2**). The segment was first included on the 1996 303(d) List for nutrient and pH impairments. For assessment purposes, data were not adjusted to reflect the October 2011 completion of the upgrade to the city of Bozeman's Water Reclamation Facility (WRF). For TMDL development however, a concentration based model was developed for the East Gallatin River downstream of the WRF discharge location to reflect post-October 2011 upgrades (**Appendix G**).

The pH listing on the lower segment was originally tied to Bozeman's municipal wastewater treatment facility, which was believed to be impairing the receiving waterbody for pH. Analysis of flow rates and pH of the receiving waterbody found that the WRF is not violating the water quality standard for pH for the East Gallatin River (per ARM 17.30.623(c)). This was specifically documented by a 1997 USGS study that examined effluent mixing characteristics for several wastewater discharges, including the city of Bozeman WRF, on the East Gallatin River (Cleasby and Dodge, 1999). Sampling results from the 1997 study determined that mixing was probably complete at approximately 200 feet downstream of the location of the WRF outfall at that time. The report provides evidence that when completely mixed, the WRF discharge did not cause a change of more than 0.5 pH units. Therefore, the pH impairment for this segment will be delisted.

Nutrient data was collected from 2005 to 2010. Summary statistics for nutrient data and results of the assessment method evaluation for the lower segment of the East Gallatin River are provided in **Tables 6-22** and **6-23**, respectively. There were eight exceedances each of target values for NO_3+NO_2, TN and TP. NO_3+NO_2, TN and TP all failed both statistical tests. Algal samples were above criteria for chlorophyll-*a* and AFDW. The dataset indicates nutrient impairment from TN and TP. Although the segment is not listed for TP, based on the data analysis, a TMDL for TP will be developed for the waterbody segment in addition to a TN TMDL. This new TP impairment listing is supported by the water chemistry data and the chlorophyll-*a* and AFDW exceedances.

Table 6-22. Nutrient Data Summary for Lower East Gallatin River

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2010	8	0.420	0.810	0.600	0.706
TN	2005-2010	11	0.620	1.000	0.826	0.930
TP	2005-2010	8	0.003	0.097	0.044	0.069
Chlorophyll-*a*	2005-2009	3	8.7	161.0	60.2	160.97
AFDW	2009	1	NA	NA	146.9	NA
Macroinvertebrate HBI	2005	2	3.821	4.642	4.232	4.478

Table 6-23. Assessment Method Evaluation Results for Lower East Gallatin River

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	Indicates Impairment?
Nitrate+Nitrite	8	0.100	8	FAIL	FAIL	FAIL	YES
TN	11	0.300	8	FAIL	FAIL	FAIL	YES
TP	8	0.030	8	FAIL	FAIL	FAIL	YES

6.4.3.9 Godfrey Creek

Godfrey Creek is included on the 2012 303(d) List for TN and TP nutrient impairments. Godfrey Creek flows 9 miles from the headwaters on the Madison Plateau (Camp Creek Hills) to the mouth, where it flows into Moreland Ditch, an irrigation canal. The waterbody was first listed for nutrient impairments in 1996.

Nutrient data was collected during two growing seasons in 2008 and 2009 (**Table 6-24**). Target values were exceeded in 6 of 7 samples for NO_3+NO_2, in 7 of 8 samples for TN, and in 6 of 10 samples for TP (**Table 6-25**). Only one chlorophyll-*a* sample was collected, and it was below the target value. No AFDW or macroinvertebrate data is available for Godfrey Creek. Per DEQ's assessment method, the lack of sufficient chlorophyll-*a* and macroinvertebrate data preclude the clear interpretation of nutrient sampling results. However based on the magnitude and number of target exceedances, the existing data suggest a significant nutrient impairment from TN and TP. Because the NO_3+NO_2 exceedances are reflected in the TN data, only a TMDL for TN will be developed to address the nitrogen impairment in Godfrey Creek. A TMDL for TP will also be developed for Godfrey Creek.

Table 6-24. Nutrient Data Summary for Godfrey Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2008-2009	7	0.040	2.040	1.105	2.010
TN	2008-2009	8	0.210	2.200	1.303	2.120
TP	2008-2009	10	0.016	0.166	0.053	0.065
Chlorophyll-*a*	2009	1	NA	NA	42.4	NA
AFDW	NA	NA	NA	NA	NA	NA
Macroinvertebrate HBI	NA	NA	NA	NA	NA	NA

Table 6-25. Assessment Method Evaluation Results for Godfrey Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	7	0.100	6	FAIL	FAIL	PASS	YES
TN	8	0.300	7	FAIL	FAIL	PASS	YES
TP	10	0.030	6	FAIL	FAIL	PASS	YES

6.4.3.10 Lower Hyalite Creek

The lower segment of Hyalite Creek is not included on the 2012 303(d) List for nutrient impairment but is included in this review because data collected in this segment to assist with TMDL development for the middle and upper segments of Hyalite Creek indicated elevated nutrient concentrations. The lower segment extends 21 miles from the Bozeman water supply diversion to the mouth (East Gallatin River). The middle and upper segments are located in the Absaroka-Gallatin-Volcanic Level IV ecoregion, which has documented natural sources of phosphorous; therefore, the lower segment of Hyalite Creek has target values for TN and TP different than other Level IV ecoregions in the Middle Rockies ecoregion (**Table 6-3**). A complete summary of the listing history and water quality assessments of all three segments may be found in **Appendix E.**

Nutrient data was collected each year from 2008 to 2012. Summary nutrient data statistics and assessment method evaluation results for the lower segment of Hyalite Creek are provided in **Tables 6-26** and **6-27.** Nineteen samples were analyzed for TN, and twenty samples were analyzed for NO_3+NO_2, and TP. TN and NO_3+NO_2 each exceeded the target value in 12 and 13 samples, respectively; TP had five exceedances of the target value but passed both statistical tests. TN and NO_3+NO_2 failed both the binomial test and student t-test. There were 2 chlorophyll-*a* samples and 4 macroinvertebrate samples collected in 2004-2011. None of the chlorophyll-*a* samples exceeded the target criteria but 2 of the 4 macroinvertebrate samples had an HBI score >4. Both AFDW samples were below thresholds for impairment.

Combined with the macroinvertebrate data, the large number of exceedances of water chemistry target values for TN and NO_3+NO_2 indicate a nutrient impairment for nitrogen. Because the NO_3+NO_2 exceedances are reflected in the TN data, only a TMDL for TN will be developed to address the nitrogen impairment in the lower segment of Hyalite Creek.

Table 6-26. Nutrient Data Summary for Lower Hyalite Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2004-2012	20	<0.01	0.55	0.178	0.29
TN	2004-2012	19	<0.05	1.91	0.452	0.598
TP	2008-2012	20	0.012	0.14	0.064	0.091
Chlorophyll-*a*	2008, 2012	3*	15.8	83.6	41.2	59.9
AFDW	2008, 2012	2	24.2	37.1	NA	NA
Macroinvertebrate HBI	2009-2011	4	2.618	4.695	3.672	4.537

*A fourth sample was a visual estimate of <50.

Table 6-27. Assessment Method Evaluation Results for Lower Hyalite Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	Indicates Impairment?
Nitrate+Nitrite	20	0.100	13	FAIL	FAIL	PASS	YES
TN	19	0.260	12	FAIL	FAIL	PASS	YES
TP	20	0.090	5	PASS	PASS	PASS	NO

6.4.3.11 Jackson Creek

Jackson Creek is included on the 2012 303(d) List for a TP nutrient impairment. Jackson Creek is located in the Absaroka-Gallatin-Volcanic Level IV ecoregion and flows 8.6 miles from the headwaters to the mouth (Rocky Creek). Rocky Creek begins at the confluence of Jackson and Timberline Creeks. This ecoregion, in the Level III Middle Rockies, has documented natural sources of phosphorous and therefore has target values for TN and TP different than other Level IV ecoregions in the Middle Rockies ecoregion (**Table 6-2**). However, an analysis of the surficial geology in the basin did not identify any phosphorus bearing geology and water quality samples did not suggest that there was a large natural source of phosphorus in the basin. Therefore the Middle Rockies water quality targets were used for assessment purposes. Jackson Creek was first listed for a TP nutrient impairment in 2006 based on nutrient, chlorophyll-*a*, and macroinvertebrate data collected in 2002 and 2004.

Water chemistry data was collected on Jackson Creek between 2004 and 2009 (**Table 6-28**). The data is limited to six samples for NO_3+NO_2, five samples for TN, and six samples for TP. There were no target exceedances for any of these parameters; NO_3+NO_2, TN, and TP passed both statistical tests (**Table 6-29**). There is no AFDW data available for this segment. Biological sampling includes two chlorophyll-*a* samples (from 2004 and 2008) and three macroinvertebrate samples collected between 2002 and 2007. All of the macroinvertebrate samples had an HBI score <4, indicating non-impairment. Chlorophyll-*a* samples were collected in 2004 and 2008; one exceeded target criteria (>125 mg/m^2). Given the original listing for TP in 2006, and the chlorophyll-*a* exceedance, a TMDL for TP will be developed for Jackson

Creek. Even though there were no detected TP exceedances, the elevated chlorophyll-*a* value suggests nutrient impairment, and the sample size is not adequate to conclude no impairment for TP.

Table 6-28. Nutrient Data Summary for Jackson Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2004-2009	6	0.005	0.070	0.028	0.062
TN	2004-2009	5	0.110	0.200	0.162	0.196
TP	2004-2009	6	0.007	0.029	0.015	0.026
Chlorophyll-*a*	2004-2008	2*	76.3	145.0	NA	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	2002-2007	3	2.357	2.357	2.781	3.110

* A third observation was a visual estimate of < 50 mg/m2 and was not included in the summary statistics.

Table 6-29. Assessment Method Evaluation Results for Jackson Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	Indicates Impairment?
Nitrate+Nitrite	8	0.100	0	PASS	PASS	FAIL	NO
TN	6	0.300	0	PASS	PASS	FAIL	NO
TP	8	0.030	0	PASS	PASS	FAIL	YES

6.4.3.12 Mandeville Creek

Mandeville Creek is not included on the 2012 303(d) List for nutrient impairments as the formal assessment first occurred after the 2012 303(d) List inclusion deadline. The stream will be included in future 303(d) lists beginning in 2014. Mandeville Creek flows 5.6 miles from the headwaters to the mouth (East Gallatin River).

Summary nutrient data statistics and assessment method evaluation results for Mandeville Creek are provided in **Tables 6-30** and **6-31**, respectively. NO_3+NO_2, TN, and TP samples were collected in 2009, 2010 and 2011. All nutrient samples exceeded water quality target values. There is no AFDW or chlorophyll-*a* data available for the stream, but the macroinvertebrate data exceeded the threshold HBI score in all 6 samples. The combination of nutrient and macroinvertebrate results overwhelmingly indicate TN and TP nutrient impairments for Mandeville Creek. TMDLs for both TN and TP will be developed based on the existing data. Because the NO_3+NO_2 exceedances are reflected in the TN data, only a TMDL for TN will be developed to address the nitrogen impairment in Mandeville Creek.

Table 6-30. Nutrient Data Summary for Mandeville Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2009-2011	18	0.280	6.000	1.342	2.050
TN	2009-2011	18	0.580	5.971	1.692	2.320
TP	2009-2011	18	0.056	0.210	0.099	0.107
Chlorophyll-*a*	NA	0	NA	NA	NA	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	2009-2011	6	4.487	5.971	5.031	5.596

Table 6-31. Assessment Method Evaluation Results for Mandeville Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	18	0.100	18	FAIL	FAIL	NA	YES
TN	18	0.300	18	FAIL	FAIL	NA	YES
TP	18	0.030	18	FAIL	FAIL	NA	YES

6.4.3.13 Reese Creek

Reese Creek is included on the 2012 303(d) List for NO_3+NO_2 nutrient impairment. Reese Creek flows 8.3 miles from the headwaters in the Bridger Range to the mouth (Smith Creek). Smith Creek is a tributary to the East Gallatin River. Reese Creek was first listed for a nutrient impairment in 2000.

Data is limited for Reese Creek. Summary nutrient data statistics and assessment method evaluation results for Reese Creek are provided in **Tables 6-32** and **6-33**, respectively. NO_3+NO_2, TN, and TP samples were collected in 2008 and 2009 but were too few to complete a full assessment since the minimum samples size was not met. However, all four NO_3+NO_2 samples and all four TN samples exceeded target values. There is no AFDW or macroinvertebrate data available for the stream, and there is not enough data for Reese Creek to complete a full assessment. TMDLs for TN and NO_3+NO_2 will be developed based on the extremely high probability of impairment per the existing data and the current listing status.

Table 6-32. Nutrient Data Summary for Reese Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2008-2009	4	0.560	0.690	0.638	0.690
TN	2008-2009	4	0.700	0.810	0.753	0.810
TP	2008-2009	5	0.007	0.020	0.015	0.020
Chlorophyll-*a*	2008	1*	NA	NA	<50	NA
AFDW	NA	0	NA	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA	NA

* This was a visual estimate of < 50 mg/m^2.

Table 6-33. Assessment Method Evaluation Results for Reese Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	4	0.100	4	NA	NA	PASS	YES
TN	4	0.300	4	NA	NA	PASS	YES
TP	5	0.030	0	NA	NA	PASS	NO

6.4.3.14 Smith Creek

The 2012 303(d) List contains a NO_3+NO_2 nutrient impairment for Smith Creek. Smith Creek flows 6 miles from the confluence of Ross and Reese Creeks to the mouth (East Gallatin River). The stream was first listed in 2000 for a nutrient impairment based on instream water quality samples.

Water quality and biological data is limited to five samples analyzed for NO_3+NO_2, TN, and TP collected from 2007 to 2009 (**Table 6-34**). There is no AFDW, macroinvertebrate, or chlorophyll-*a* data available for Smith Creek. There was not enough data to complete a binomial test for TP. The exact binomial test assumes a datum will either exceed the target value or it will not. All five samples for NO_3+NO_2 and TN had exceedances and the binomial test yielded a FAIL determination (**Table 6-35**). Three of five samples had exceedances for TP, which were too few total samples to determine whether TP had a significant number of exceedances compared with non-exceedances of target values for the exact binomial test. NO_3+NO_2 and TN had an overwhelming frequency of exceedance (4/4 for both parameters). According to the 2012 assessment protocol, there is not enough data to complete a full assessment to identify TP as a cause of impairment; thus, TMDL development will be limited to TN and NO_3+NO_2 based on the extremely high probability of impairment per the existing data and the current listing status.

Table 6-34. Nutrient Data Summary for Smith Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2007-2009	5	0.805	1.290	1.071	1.262
TN	2007-2009	5	0.520	1.250	1.024	1.226
TP	2007-2009	5	0.013	0.064	0.035	0.062
Chlorophyll-*a*	NA	NA	NA	NA	NA	NA
AFDW	NA	NA	NA	NA	NA	NA
Macroinvertebrate HBI	NA	NA	NA	NA	NA	NA

Table 6-35. Assessment Method Evaluation Results for Smith Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	Indicates Impairment?
Nitrate+Nitrite	5	0.100	5	FAIL	FAIL	NA	YES
TN	5	0.300	5	FAIL	FAIL	NA	YES
TP	5	0.030	3	NA	PASS	NA	NO

6.4.3.15 Thompson Creek

Thompson Creek is included on the 2012 303(d) List for a TN nutrient impairment. Also known as Thompson Spring, the creek flows 7.4 miles from the headwaters to the mouth (East Gallatin River). Thompson Creek was first listed for a TN nutrient impairment in 2006 based on chlorophyll-*a*, macroinvertebrate, and water chemistry samples collected in 2004.

Nutrient parameter data was collected on Thompson Creek between 2004 and 2009. Summary statistics for nutrient data and results of assessment method evaluations for Thompson Creek are provided in **Tables 6-36** and **6-37**, respectively. There were 10 exceedances of the target value for NO_3+NO_2 and 8 exceedances for the TN target value. For TP, 3 of 10 samples exceeded the target criteria. However, TP passed both statistical tests. TN and NO_3+NO_2 failed both the binomial and student t-tests. There are no AFDW data available for this stream. None of the chlorophyll-*a* samples were above criteria (>1205mg/m^2), but all macroinvertebrate samples were >4 HBI, indicating impairment. Combined with the statistical results for NO_3+NO_2 and TN, the HBI scores above the threshold value indicate nitrogen impairment. Because the NO_3+NO_2 exceedances are reflected in the TN data, only a TMDL for TN will be developed to address the nitrogen impairment in Thompson Creek.

Table 6-36. Nutrient Data Summary for Thompson Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2004-2009	10	0.370	1.570	0.932	1.188
TN	2004-2009	8	0.800	1.540	1.1650	1.348
TP	2004-2009	10	0.013	0.039	0.025	0.035
Chlorophyll-*a*	2004-2009	3	30.1	108.0	75.8	108.0
AFDW	NA	NA	NA	NA	NA	NA
Macroinvertebrate HBI	2004-2008	4	5.849	6.555	6.155	6.374

Table 6-37. Assessment Method Evaluation Results for Thompson Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	10	0.100	10	FAIL	FAIL	PASS	YES
TN	8	0.300	8	FAIL	FAIL	PASS	YES
TP	10	0.030	3	PASS	PASS	PASS	NO

6.4.4 Nutrient TMDL Development Summary

Table 6-38 summarizes the 2012 nutrient 303(d) listings for the Lower Gallatin TMDL project area and updated TMDL development determinations for the waterbodies of concern identified in **Section 6.3**. TMDLs will be developed mostly for TN and TP. TMDLs for NO_3+NO_2 will be developed for Bridger, Reese, and Smith Creeks. Additionally, TMDLs will be developed for a currently unlisted segment on Lower Hyalite Creek and for Mandeville Creek, which were not identified as impaired for nutrients on the 2012 303(d) List.

Overall, these changes from the 2012 303(d) List are the result of limited data at the time the waterbody segments were initially listed, particularly when compared with the significant increase in data collected over the past 10 years (**Section 6.3**). They are also the result of different criteria that were used as the listing basis, such as the introduction of water quality standards specific to the Absaroka-Gallatin-Volcanics Level IV ecoregion, which affected listings on Hyalite Creek. The updated impairment determinations will be reflected in the 2014 Water Quality Integrated Report.

Table 6-38. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2012 303(d) Nutrient Impairment(s)	TMDLs Prepared
BOZEMAN CREEK, confluence of Limestone Creek and Bozeman Creek to the mouth (East Gallatin River)	MT41H003_040	TN, TP	TN
BEAR CREEK, headwaters to mouth (Rocky Creek)	MT41H003_081	TP	TP
BRIDGER CREEK, headwaters to mouth (East Gallatin River)	MT41H003_110	TN, TP	NO_3+NO_2
CAMP CREEK, headwaters to mouth (Gallatin River)	MT41H002_010	TN	TN, TP
DRY CREEK, headwaters to mouth (East Gallatin River)	MT41H003_100	TN, TP	TN, TP
EAST GALLATIN RIVER, confluence of Rocky and Bear Creeks to Bridger Creek	MT41H003_010	TN, TP	TN, TP
EAST GALLATIN RIVER, Bridger Creek to Smith Creek	MT41H003_020	TN, TP, pH	TN, TP
EAST GALLATIN RIVER, Smith Creek to mouth (Gallatin River)	MT41H001_030	TN, pH	TN, TP
GODFREY CREEK, headwaters to mouth (Moreland Ditch)	MT41H002_020	TN, TP	TN, TP
HYALITE CREEK, Headwaters to Hyalite Reservoir	MT41H003_129	TN, TP	None (see **Appendix E**)
HYALITE CREEK, Hyalite Reservoir to Bozeman water supply intake	MT41H003_130	TN, TP	None (see **Appendix E**)
HYALITE CREEK, Bozeman water supply intake to the mouth (East Gallatin River)	MT41H003_134	None	TN
JACKSON CREEK, headwaters to mouth (Rocky Creek)	MT41H003_050	TP	TP
MANDEVILLE CREEK, headwaters to mouth (East Gallatin River)	MT41H003_021	None	TN, TP
REESE CREEK, headwaters to mouth (Smith Creek)	MT41H003_070	NO_3+NO_2	TN, NO_3+NO_2

Table 6-38. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2012 303(d) Nutrient Impairment(s)	TMDLs Prepared
SMITH CREEK, confluence of Ross and Reese Creeks to mouth (East Gallatin River)	MT41H003_060	NO_3+NO_2	TN, NO_3+NO_2
THOMPSON CREEK (Thompson Spring), headwaters to mouth (East Gallatin River)	MT41H003_090	TN	TN

6.5 Nutrient Source Assessment and Quantification

This section summarizes the assessment approach, current nutrient load estimates, and the rationale for load reductions and allocations within the Lower Gallatin TMDL planning area (TPA). The nutrient data discussed in **Section 6.3** were used to identify whether nitrogen and/or phosphorus are causing impairment.

To evaluate loading contributions from different sources, a source area-based approach was used with available water quality and flow data for the July 1–September 30 summer period. Supporting documentation, including source assessments and water quality reports specific to assessment units in the Lower Gallatin TPA, was used to interpret instream observations. Land-use datasets from the United States Department of Agriculture (USDA) were also used to interpret water quality data. Detailed source assessments using this approach for streams with TMDLs is found in **Appendix F**.

6.5.1 Nonpoint Sources of Nutrients

Nutrient inputs into streams in the Lower Gallatin planning area come from several nonpoint sources (i.e., diffuse sources that cannot easily be pinpointed). DEQ's source area-based assessment evaluated nutrient contributions from the following nonpoint sources:

- Forest (and wetlands)
- Agriculture (cropping and pasture/rangeland)
- Residential/Developed (infrastructure including roads and residential development)
- Subsurface wastewater disposal and treatment (individual, community septic systems and WWTPs that discharge to groundwater)
- Point sources
- Natural background

6.5.1.1 Forest

The forested areas in the Lower Gallatin watershed are heavily timbered. Additionally, coniferous forests do not lose a large percentage of their biomass each fall (as a deciduous forest does). Therefore, overall runoff values are low for forested areas because of their capacity to infiltrate, transpire, and otherwise capture rainfall.

Recent data collected by MBMG upstream of the forest boundary from streams draining the Bridger Range documented NO_3+NO_2 concentrations above reference concentrations for that ecoregion. Because the data could not be separated from natural background with high confidence, assessment units with headwaters in the Bridger Range combined load allocation to forest and natural background sources (Bridger Creek, Reese Creek, and Smith Creek).

6.5.1.2 Agriculture

There are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of winter grazing on vegetative health and its ability to uptake and nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989).

Pastures/Rangeland

Pastures are managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are fairly thickly vegetated in the summer; less so in the fall through spring. The winter grazing period is long (October–May), and trampling and feeding further reduces biomass when it is already low. Commercial fertilizers are used infrequently in the watershed, but cattle manure—naturally applied—occurs in higher quantities from October through May because of higher cattle density than that found on range and forested areas (PBS&J, 2007).

Rangeland differs from pasture in that rangeland has much less biomass therefore contributes fewer nutrients from biomass decay. However, manure deposition does play a role. Similar to the forest areas, rangeland is grazed during the summer in the watershed and is managed similarly to the grazing in the forest areas. This is sometimes an important contribution to an impaired waterbody via tributaries.

Irrigated and Dryland Cropping

Cropping in the Lower Gallatin TPA is predominately irrigated and dryland production of small grains, with smaller acreages of potatoes, peas, and corn (PBS&J, 2007). This category also includes sod farms. Irrigated lands are usually in continuous production and have annual soil disturbance and fertilizer inputs. Dryland cropping may have fallow periods of 16 to 22 months, depending on site characteristics and landowner management. Nutrient pathways include overland runoff, deep percolation, and shallow groundwater flow, which transport nutrients off site.

6.5.1.3 Residential/Developed

Developed areas contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Golf courses are included in this category. Although developed areas often have the highest nutrient loading rates, in the Lower Gallatin watershed developed areas make up a small percentage of the overall area. For reference, the boundaries for the city of Bozeman are functionally identical to the sewered areas.

6.5.1.4 Subsurface Wastewater Disposal and Treatment

Nitrogen and phosphorus discharge by septic systems that migrate to surface waters were initially determined using the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS) model. MEANSS used septic location data in the Lower Gallatin TPA to calculate distance to perennial streams and calculate a load to surface water based on local soil types. The model accounted for identified septic systems (Gallatin City-County Health Department, 2009; Gallatin Local Water Quality District, 2010) and systems that have a Montana Ground Water Pollution Control System (MGWPCS) permit. For non-residential MGWPCS permitted systems where actual current wastewater flow rates are not available, design loading rates were used in the analysis. Although design rates are typically larger than average daily rates, they were used in the absence of an accurate method to estimate average rates. Due to the large amount of septic systems in the TPA, this potential error associated with these specific permitted systems should not have any significant effect on the final analysis.

The daily load from each system was based on literature values and conservative assumptions used during permitting for subdivisions in Montana (Montana Department of Environmental Quality, 2009). Because a complete system failure is typically addressed very quickly, conservative assumptions were used for the load. The model worked well in watersheds with medium to high septic density but often appeared to overestimate loads in watersheds with low septic density. Also, the model calculated annual loads whereas the TMDLs focus on summer loading (July 1 - September 30). Annual load estimates do not take into account higher uptake rates and changes in septic use during the summer period. Another assumption of the model was that perennial streams are gaining in all reaches which does not apply to many of the streams in the Lower Gallatin TPA. For these reasons, the results of the MEANSS model were not used as derived. Model estimates from MEANNS for nutrient loading were compared with the area-weighted approach but were not used in place of the area-weighted analysis as MEANSS tended to overestimate summer loading rates based on the reasons outlined above. An outline of the MEANSS model may be found in Appendix A of Montana's DRAFT policy for nutrient trading at http://deq.mt.gov/wqinfo/NutrientWorkGroup/default.mcpx.

The area-weighted approach assigned loads to septic systems based on relative septic density in the vicinity of the stream, dominant groundwater flow paths and changes to instream nutrient concentrations. In order to better define septic sources, available water chemistry data was reviewed to determine relative inorganic versus organic fractions of nitrogen and changes in total phosphorus fractions (dissolved versus particulate). The assumption being that phosphorus loading from septic systems is minor short of total system failure in close proximity to a waterbody and that a spike in inorganic nitrogen relative to the organic fraction is indicative of septic loading.

Separate from the MEANSS model, loading estimates for total nitrogen and total phosphorus were calculated using available influent water quality data and loading rates for wastewater treatment facilities discharging to groundwater in drainages with nutrient impaired streams. These calculations were done for the Belgrade WWTP (MTX000116), the Amsterdam-Churchill WWTP (MTUS00015), and the Riverside Water & Sewer District WWTP (unpermitted; private facility). Facility outlines and load calculation assumptions for these treatment facilities are provided below and in **Appendix F**. Methods used to estimate nutrient loading to impaired waterbodies differed between the facilities based on facility design, current operation, available water quality data and geographic relation to nutrient impaired waterbodies.

Belgrade WWTP (MTX000116)

Overview

The City of Belgrade wastewater treatment plant is located approximately 2 miles northeast of Belgrade, MT in the Gallatin Valley. The facility has three outfalls to Rapid Infiltration Percolation (IP) Beds that discharge to Class 1 groundwater. The facility underwent a large upgrade in 2003-2004.

The facility consists of 3 lined treatment ponds/cells. The disposal method includes a spray irrigation system and 3 groups of IP beds which discharge to groundwater. Retention times in cell #1 and #2 combined is 53.9 days. Cell #3 is used for settling and storage prior to discharge and has a retention time of 137 days. The design capacity is 903,000 gpd with a design population of 3,918 single family residences (~10,500 persons).

IP Beds A were previously determined to be exempt from nondegradation significance review based on ARM 17.30.702(18)(b), which states that a facility that has been operational on or prior to April 29, 1993, is not required to meet the nondegradation criteria. Nondegradation significance reviews were conducted on IP beds B and C previously. The spray irrigation discharge is an exempt/non significant land application according to 75-5-317(2)(h), MCA.

Based on an annual average flow rate, the IP beds discharge approximately 644,000 gpd of effluent and 274,000 gpd is discharged by the spray irrigation system. This is a total of 918,000 gpd (102% of design capacity). Average groundwater flow direction has been determined as N 63° W due in part to mounding of the water table in the immediate vicinity of the IP beds. The soils in the area of the facility are comprised of gravelly and coarse sand and the subsoil is predominantly fine sand with medium gravel and gravel. The hydraulic conductivity has been estimated at 600 feet per day.

TN Analysis

The existing permit allows a TN load of 47.1 lbs/day from IP Beds A, 2.13 lbs/day from IP Beds B, and 24.2 lbs/day from IP Beds C. The mixing zone for IP Beds B is downgradient of the IP Beds A mixing zone and therefore the allowable load is very low. The total permitted TN load is 73.43 lbs/day from the 3 I/P beds. The permit requires that at the end of the 500-foot mixing zone the nitrate (as N) concentrations must not exceed 10 mg/L for IP Beds A and 5 mg/L for IP Beds B and C. Based on the average daily discharge and the mixing zone reduction requirements, the TN load to groundwater at the edge of the mixing zones from the Belgrade WWTP is permitted at 35.96 lbs TN/day.

Total phosphorus effluent limits were not calculated for this facility based on the 50-year breakthrough analysis. The 50-year breakthrough nondegradation criterion is based on the amount of soil available to absorb the phosphorus between the discharge point and the receiving waterbody using the average load of phosphorus from the wastewater source. For the permit, it was determined that the East Gallatin River was the nearest waterbody located ~4 miles from the facility and, therefore, greater than the 50-year breakthrough analysis. However, this distance does not seem to have accounted for the smaller spring-fed streams draining the area north of the Belgrade WWTP.

The area north and east of Belgrade was historically an extensive riparian corridor in the Gallatin Valley due in part to low-elevation, spring-fed streams and a wide floodplain adjacent to the East Gallatin River. Downstream of the confluence of Hyalite Creek and the East Gallatin River, several spring-fed streams enter the East Gallatin River. In upstream to downstream order these streams are: Thompson Creek, Ben Hart Creek, Story Creek, Cowan Creek and Gibson Creek. Water quality data was collected by DEQ from these streams in September 2008 and September 2009.

Given the groundwater flow direction at the Belgrade WWTP and the elevation gradient north of the facility, Ben Hart Creek is the most likely receiving waterbody of the groundwater discharge from the Belgrade WWTP. As the other spring-fed streams have very similar land use characteristics, flow and concentration data were analyzed in comparison to the nutrient loads in Ben Hart Creek. Relative flows and nutrient loads in Thompson, Story, Gibson and Cowan Creeks were compared with Ben Hart Creek to identify the probable Ben Hart nutrient load without the influence of the Belgrade WWTP. Given the similar hydrologic characteristics and land uses in these adjacent systems, it was assumed that nutrient loads in the adjacent drainages would provide the average nutrient load in Ben Hart Creek if that waterbody was not under the influence of the Belgrade WWTP.

This analysis identified that groundwater discharge from the Belgrade WWTP constitutes 12% (16.74 lbs TN/day) of the Ben Hart TN load and 1.5% of the TN load to the lower segment of the East Gallatin River (**Table 6-39**). If the Belgrade WWTP is meeting the permit requirements, the TN load at the end of the groundwater mixing zone is 35.96 lbs/day. The TN load of 16.74 lbs/day from the Belgrade WWTP in Ben Hart Creek is 47% of the permitted load at the end of the 500-foot mixing zone at the WWTP.

Table 6-39. City of Belgrade WWTP TN Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Discharge via I/P beds	644,000	gpd	When irrigation system in use
Discharge via I/P beds	0.9982	cfs	When irrigation system in use
Permitted load to I/P beds	73.43	lbs/day TN	
Permitted load at end of groundwater mixing zone	35.96	lbs/day TN	Based on permit requirements; estimated load to aquifer
Estimated load to Ben Hart Creek	16.74	lbs/day TN	
As % of existing TN load in Ben Hart Creek	12.0	%	
As % of existing TN load in the Lower East Gallatin River	1.5	%	
Existing load in the Lower East Gallatin River*	1114.98	lbs/day TN	80th percentile of all summer period water quality data (*n* = 12)

*Ben Hart Creek enters the East Gallatin River upstream of Smith Creek very near the boundary (Smith Creek) between the middle and lower segments of the river.

<u>TP Analysis</u>

Although the permit did not set a TP effluent limit given the 50-year breakthrough criterion, a flow/load analysis was also calculated for TP from the Belgrade facility. A total load from the end of mixing zone at the Belgrade WWTP was calculated using influent TP data collected at the Amsterdam-Churchill WWTP as no influent TP data could be obtained for the Belgrade WWTP. The analysis assumed a 30% reduction in influent concentrations before the outfall point and a 98% reduction by the end of the mixing zone. This analysis found that the discharge load to the IP beds is approximately 173.40 lbs TP/day and 3.47 lbs TP/day at the end of the mixing zone (**Table 6-40**). Using the same analysis outlined above, it was estimated that the Belgrade WWTP is discharging 1.03 lbs/day TP to Ben Hart Creek. This is 30% of the assumed TP load at the end of the 500-foot mixing zone at the plant.

Table 6-40. City of Belgrade WWTP TP Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Discharge via I/P beds	644,000	gpd	When irrigation system in use
Discharge via I/P beds	0.9982	cfs	When irrigation system in use
Median influent concentration	46.125	mg/L TP	*n* = 9
30% reduction concentration in facultative lagoon	32.29	mg/L TP	
Load (Discharge*concentration)	173.41	lbs/day TP	
98% removal efficiency in soil matrix for TP	3.47	lbs/day TP	Estimated load to aquifer
Estimated load to Ben Hart Creek	1.03	lbs/day TP	
As % of existing TP load in Ben Hart Creek	28.0	%	
As % of existing TP load in the Lower East Gallatin River	1.2	%	
Existing load in the Lower East Gallatin River*	86.55	lbs/day TP	80th percentile of all summer period water quality data (*n* = 13)

*Ben Hart Creek enters the East Gallatin River upstream of Smith Creek very near the boundary (Smith Creek) between the middle and lower segments of the river.

An analysis of the DEQ ambient water quality data identified that groundwater discharge from the Belgrade WWTP comprises 28% (1.03 lbs TP/day) of the Ben Hart TP load and 1.2% of the TP load to the lower segment of the East Gallatin River.

Summary

The Belgrade facility is currently operating above design capacity according to the most recent permit data. Analysis of flow and TN concentration in the spring-fed streams north of the Belgrade on the south side of the East Gallatin River determined that 12% of the TN load and 28% of the TP load in Ben Hart Creek is from the Belgrade WWTP. This corresponds to 1.5% of the TN load and 1.2% of the TP load in the lower segment of the East Gallatin River, which is impaired for total nitrogen and total phosphorus. There is still some question whether these estimates accurately quantify the impacts of the Belgrade WWTP on water quality in Ben Hart Creek and the East Gallatin River.

Amsterdam-Churchill WWTP (MTUS00015)

The Amsterdam-Churchill WWTP services approximately 927 persons in 335 households and includes a facultative lagoon and 2 storage lagoons for spray irrigation with a design capacity of 78,000 gallons per day (gpd). The existing system was installed in 1977. Currently, the facility receives 85,000 to 90,000 gpd. On-site measurements by DEQ in 2010 determined that the facility is leaking 85,000 gpd of poorly-treated wastewater to the groundwater aquifer from the storage lagoon. The system was designed to provide some treatment in the facultative lagoon with the storage lagoons periodically pumped out for land application. It is not known if the facility was ever utilized in this fashion.

The TN and TP load to groundwater was determined based on the daily leakage rate (85,000 gpd or 0.13175 cfs) and the median influent TN and TP concentrations. Estimated loads to groundwater were different for TN and TP. To determine treatment load reductions, a decay equation was used for TN while a general reduction of 30% was applied to TP concentrations (**Tables 6-41** and **6-42**).

Table 6-41. Amsterdam-Churchill WWTP TN Load Calculations to Camp Creek

Parameter	Value	Units	Notes
Lagoon Leakage	85,000	gpd	
Lagoon Leakage	0.13175	cfs	
Median influent concentration	45.5	mg/L TN	*n* = 9
Estimated lagoon retention time	79	days	75% of minimum of 105 days
Influent concentration * exp (-0.0075*Retention time)	25.16	mg/L TN	
Load (Leakage*concentration)	17.83	lbs/day TN	
76% removal efficiency in soil matrix for TN	4.28	lbs/day TN	Estimated load to aquifer
Change in load on 9/23/2009	1.35	lbs/day TN	Observed change in load between sample points bracketing WWTP
Existing load in Camp Creek	101.73	lbs/day TN	80th percentile of all summer period water quality data (*n* = 12)

In the case of TN, assuming a removal efficiency of 76% in the TN load between the bottom of cell 2 and Camp Creek, the estimated load from the Amsterdam-Churchill WWTP is 4.28 lbs/day TN. In the only bracket sampling event available for Camp Creek in the vicinity of the WWTP, the change in load from upstream to downstream of the WWTP was 1.354 lbs/day TN.

Table 6-42. Amsterdam-Churchill WWTP TP Load Calculations to Camp Creek

Parameter	Value	Units	Notes
Lagoon Leakage	85,000	gpd	
Lagoon Leakage	0.13175	cfs	
Median influent concentration	46.125	mg/L TP	*n* = 9
30% TP reduction in facultative lagoon	32.29	mg/L TP	
Load (Leakage*concentration)	22.89	lbs/day TP	
98% removal efficiency in soil matrix for TP	0.46	lbs/day TP	Estimated load to aquifer
Change in load on 9/23/2009	0.127	lbs/day TP	Observed change in load between sample points bracketing WWTP
Existing load in Camp Creek	6.57	lbs/day TP	80th percentile of all summer period water quality data (*n* = 15)

For TP, a 98% removal efficiency was used to calculate the TP load to Camp Creek due to the leaking lagoon. The estimated load was 0.46 lbs/day TP. The observed change in TP load above and below the WWTP was 0.127 lbs/day TP on 9/25/2009.

Riverside Water & Sewer District WWTP (unpermitted; private facility)
Constructed in 1974, the Riverside Water and Sewer District WWTP is an unpermitted facility with a design capacity of 20,000 gpd. It services 124 households plus the clubhouse on the golf course for an estimated population of 325 persons plus 200 transient (clubhouse). The facility is comprised of an aeration pond (treatment cell) and a storage lagoon (holding cell). The original design called for the septic effluent to be stored in the lagoon following initial treatment and then pumped out and used to irrigate the Riverside golf course. According to current facility operator, it is not known that the system was ever utilized in this manner. This failing system is losing approximately 20,000 gpd to the underlying aquifer and is sited adjacent to the East Gallatin River downstream of the city of Bozeman Water Reclamation Facility.

Water quality data from the facility could not be used in the analysis as it failed DEQ QA/QC requirements for data acceptability. Instead, water quality influent data collected at the Amsterdam-Churchill WWTP was used in its stead; as these 2 facilities are comparable in the number of service connections and resident populations that they serve. Different removal efficiencies of TN and TP were used for the Riverside Water & Sewer District WWTP then were applied in the Amsterdam-Churchill WWTP analysis. This was done for several reasons including the lack of a fully functioning aeration pond at Riverside, the coarse soils and shallow depth to groundwater and the relatively short groundwater flow path from Riverside to the East Gallatin River. In comparison to the Amsterdam-Churchill WWTP, the TN removal efficiency was reduced from 76% to 25% and for TP from 98% to 40% (**Tables 6-43** and **6-44**).

Table 6-43. Riverside Subdivision District WWTP TN Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Lagoon Leakage	20,000	gpd	
Lagoon Leakage	0.031	cfs	
Median influent TN concentration	45.5	mg/L TN	*n* = 9
Assumed retention time	79	days	75% of minimum of 105 days
Influent concentration * exp (-0.0075*Retention time)	25.16	mg/L TN	
Load (Leakage*concentration)	4.20	lbs/day TN	
25% removal efficiency in soil matrix for TN	3.22	lbs/day TN	Estimated load to aquifer
Change in load on 9/16/2009	-8.59	lbs/day TN	Observed change in load between sample points bracketing WWTP location
Existing load on East Gallatin River below WRF discharge and above Hyalite Creek	272.35	lbs/day TN	80th percentile of all summer period water quality data (*n* = 13)

Upstream of the Riverside Water & Sewer District WWTP, the City of Bozeman WRF discharges to the East Gallatin River. It was difficult to separate the Riverside Subdivision TN and TP contribution from the significant WRF loads. In the case of TN, samples bracketing the Riverside Water & Sewer District WWTP showed a decrease in the TN load on 9/19/2009 of 8.59 lbs/day TN.

Table 6-44. Riverside Water and Sewer District WWTP TP Load Calculations to the East Gallatin River

Parameter	Value	Units	Notes
Lagoon Leakage	20,000	gpd	
Lagoon Leakage	0.031	cfs	
Median influent concentration	46.125	mg/L TP	*n* = 9
30% TP reduction in facultative lagoon	32.29	mg/L TP	
Load (Leakage*concentration)	5.37	lbs/day TP	
40% removal efficiency in soil matrix for TP	3.22	lbs/day TP	Estimated load to aquifer
Change in load on 9/16/2009	1.58	lbs/day TP	Observed change in load between sample points bracketing WWTP location
Existing load on East Gallatin River below WRF discharge and above Hyalite Creek	30.59	lbs/day TP	80th percentile of all summer period water quality data (*n* = 15)

On 9/16/2009, there was an observed increase of 1.58 lbs/day in the TP load in samples collected upstream and downstream of the Riverside Water & Sewer District WWTP. The increase was less than the estimated load of 3.22 lbs/day TP from Riverside.

6.5.1.5 Natural Background

Once the source assessment for a given waterbody was completed, natural background was determined based on median values (50^{th} percentile) for reference sites as compiled by the DEQ in the associated ecoregions (**Table 6-45**). With the exception of the middle and lower segments of the East Gallatin River, this was done by using the median stream discharge from all available sampling data for a given waterbody and the median instream nutrient concentration for reference streams as determined by DEQ to calculate the natural background load. Values used for the middle and lower East Gallatin River segments are discussed in detail in those sections.

For streams receiving natural flows from the Level IV Absaroka-Gallatin-Volcanics ecoregion water quality target values were used with relative flow contributions to calculate segment specific natural background concentrations for TN and TP (**Table 6-46**). All other nutrient source categories were then uniformly decreased to account for natural background.

Table 6-45. Natural background concentrations in the Lower Gallatin project area by ecoregion

Parameter	Median reference values	
	Middle Rockies (Level III)	**Absaroka-Gallatin Volcanics Ecoregion (Level IV, within Middle Rockies)**
Total nitrogen (TN)	0.095 mg/L	0.080 mg/L
Total phosphorous (TP)	0.010 mg/L	0.081 mg/L

Table 6-46. Natural background concentrations in the Lower Gallatin project area per stream segment receiving flow from the Absaroka-Gallatin-Volcanics Level IV ecoregion

Stream segment	TN (mg/L)	TP (mg/L)
Bozeman Creek	0.085	0.055
East Gallatin between Bozeman and Bridger Creeks	0.091	0.031
East Gallatin between Bridger and Hyalite Creeks	0.095	0.010
Lower Hyalite Creek	0.084	0.063
East Gallatin between Hyalite Creek and Smith Creek	0.091	0.027
East Gallatin between Smith Creek and the Gallatin River	0.095	0.010

The exception to this approach is for streams listed for nitrite + nitrate (N03+ N02). DEQ has not compiled ecoregion statistics for natural background of inorganic nitrogen. For these cases, natural background was grouped with forest as instream water quality data collected upstream of the forest boundary in the Bridger Range suggested that there was a natural load of nitrite + nitrate (N03+ N02). It was not possible to separate the forest/natural background sources. This exception applies to Bridger Reese and Smith Creeks for nitrite + nitrate (N03+ N02) TMDL development.

The use of median concentrations to determine natural background differs from that outlined in **Section 6.4.2** in the document where the 75th percentile of the reference dataset was used to determine natural background nutrient concentrations. This is due to the fact that the reference dataset for the Level III Middle Rockies ecoregion includes few sites below the forest boundary in low valley landforms. In light of the uncertainty of background nutrient concentrations in these lower elevation systems, median values for nutrients in the reference dataset were deemed more appropriate to calculate natural background in nutrient impaired waterbodies below the forest boundary in the Lower Gallatin TMDL project area.

Geology

Portions of the Hyalite Creek and Bozeman Creek drainages upstream of the forest boundary are underlain by the Phosphoria Formation (Berg et al., 1999; Berg et al., 2000; Kellogg and Williams, 2006; Vuke et al., 2002). This formation has the potential to cause elevated phosphorus concentrations in groundwater and surface water. Studies done by the Gallatin National Forest and Montana State University in the 1970s documented phosphorus concentrations up to 0.50 mg/L (mean 0.07 mg/L) in Bozeman Creek above the forest boundary and elevated natural background concentrations in the Hyalite Creek drainage (Glasser and Jones, 1982; Schillinger and Stuart, 1978). Researchers determined that phosphorus concentrations were linked more strongly to natural processes than to land uses such as grazing and logging.

Wildlife

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, in a multi-state study with varying densities of wildlife and livestock, wildlife were estimated to contribute a minimal nutrient load relative to livestock (Moffitt, 2009).

6.5.2 Point Sources

In addition to nonpoint sources, nutrient inputs into streams in the Lower Gallatin planning area come from several point sources (i.e., distinct, identifiable sources, such as pipes feeding directly into a waterbody). Point sources include the city of Bozeman Water Reclamation Facility (WRF) and MS4 storm water system, as well as the US Fish & Wildlife Service's Bozeman Fish Technology Center. By law, these point sources must be permitted. As of March 19, 2012, there were 81 permitted point sources under the Montana Pollutant Discharge Elimination System (MPDES) within the Lower Gallatin TMDL Project Area (**Appendix A; Figure A-22**):

- City of Bozeman Water Reclamation Facility (WRF) (MT0022608)
- City of Bozeman Water Treatment Facility (MT0030155)
- City of Bozeman – Lyman Creek Reservoir (MT0031631)
- City of Bozeman MS4 Storm Water System (MTR040002)
- Town of Manhattan Wastewater Treatment Facility (WWTF) (MT0021857)
- United States Fish & Wildlife Service (USFWS) Bozeman Fish Technology Center (MTG130006)
- One permit for petroleum cleanup (MTG790003)
- One permit for construction dewatering (MTG070687)
- Two permits for disinfected water (MTG770015 and MTG770018)
- Three permits for sand and gravel (MTG490019, MTG490024, and MTG490026)
- Four Concentrated Animal Feeding Operations (MTG010052, MTG010188, MTG010219, and MTG010225)
- Five permits for industrial activity stormwater (MTR000095, MTR000192, MTR000358, MTR000403, and MTR000483)
- Fifty-nine general permits for construction activity stormwater

Of the complete list of MPDES permits, only three have direct nutrient discharges to nutrient-impaired streams in the Lower Gallatin TPA. The city of Bozeman WRF (MT0022608) discharges directly to the East Gallatin River, the USFWS Fish Tech Center (MTG130006) discharges to Bridger Creek, and the city of Bozeman's MS4 sends stormwater flows to Bridger Creek, Bozeman Creek, Mandeville Creek and the East Gallatin River. Other significant nutrient sources, such as the town of Manhattan WWTF and CAFOs, all discharge to the Gallatin River and are not addressed in this document, since no TMDLs are currently required for the Gallatin River. There is not enough data for a formal assessment of the Gallatin River and there are no current nutrient impairment listings on the Gallatin River on the 2012 303(d) List.

To provide the required wasteload allocations (WLAs) for permitted point sources, a source assessment was performed for the city of Bozeman WRF and MS4 permits and for the USFWS Fish Tech Center. Point source allocations are detailed in **Section 6.6.1**. The development of the Bozeman WLAs is consistent with the reasonable assurance approach defined within **Section 4.4**.

6.5.2.1 City of Bozeman Water Reclamation Facility (MT0022608)

The city of Bozeman Water Reclamation Facility (WRF) completed an extensive upgrade in fall 2011, in addition to a smaller upgrade completed in November 2007. Existing nutrient loads to the East Gallatin River were calculated using the primary assumption that since October 1, 2011, the WRF is able to treat wastewater to 7.5 mg/L TN and 1.0 mg/L TP. The long-term mean discharge from the facility during the summer period (July 1 – September 30) is 5.39 million gallons per day (MGD) (8.34 cfs). Therefore, the mean continuous nutrient load from the WRF to the East Gallatin River is approximately 336 lbs TN/day and 45 lbs TP/day.

6.5.2.2 City of Bozeman Municipal Separate Storm Sewer System (MTR040002)

The city of Bozeman's Municipal Separate Storm Sewer System (MS4) falls under the "MPDES General Permit For Storm Water Discharge Associated with Small Municipal Separate Storm Sewer System (MS4)" (MTR04000). The most recent permit was issued by DEQ on February 22, 2010, to three co-permittees: the city of Bozeman (city), Montana State University – Bozeman (MSU), and the Montana Department of Transportation (MDT). This permit allows the discharge of stormwater to the following surface waters:

- Spring Creek (for city)
- Bozeman Creek (for city and MDT)
- Bridger Creek (for city)
- East Gallatin River (for city and MDT)
- Farmers Canal (for city and MSU)
- Bear Creek (for city)
- Baxter Creek (for city and MDT)
- Maynard Border Ditch (for city and MDT)
- Mandeville Creek (for city and MSU)
- Middle Creek Ditch (for city and MSU)
- West Gallatin Canal (for MSU)
- Unnamed Ditch – West End MSU Boundary (for MSU)

The stormwater system is designed for a 2-hour event of 0.41 inch of precipitation with a 10 year recurrence interval. The MS4 area comprises 6% of the Bozeman Creek watershed, 0.4% of the Bridger Creek watershed, 2.5% of the East Gallatin River watershed, and >90% of the Mandeville Creek watershed. The East Gallatin River receives approximately 82% of the stormwater flow, Bozeman Creek 16%, and Bridger Creek <2% from the MS4. Based on 30 years of precipitation data (1980–2009), ≥0.05 inch of precipitation falls, on average, 18.6 days per summer period (July 1–September 30). Activation of the MS4 is relatively infrequent during the summer period.

DEQ ran a Storm Water Management Model (SWMM) with different Event Mean Concentrations (EMCs) based on 30 years of climate data from the weather station at the Montana State University campus (Coop ID 241044). A description of the model and its output may be found in **Attachment D.** DEQ ran the model with literature values from stormwater systems in the Intermountain West and with permit benchmark values from the Nationwide Urban Runoff Program (NURP). The NURP data is representative of national mean values in stormwater runoff while the data specific to city stormwater systems in the Intermountain West were theorized to better represent conditions in Bozeman. Initial analyses determined that the literature values from the Intermountain West overestimated the nutrient loading and the NURP data underestimated the loads. Data from discharge monitoring reports (DMRs) collected in sub-basins of the Bozeman Creek drainage were used to adjust relative discharge water quality values by sub-basin.

Upgradient land-use characteristics were determined for the two Bozeman MS4 DMR sampling locations and were compared to the land-use attributes for each sub-basin delineated in the SWMM model. DMR data collected at the Tamarack site represented commercial land use, with lower levels of residential land use, and reflected the literature values observed in the Intermountain West stormwater study. The Langhor DMR sampling location was more representative of open-space and residential areas and was more comparable to NURP data. Based on the DMR data, the two SWMM model iterations (Intermountain West literature values and NURP values) were combined based on land-use characteristics in each sub-basin. In this way, sub-basins reflecting commercial land use used the Intermountain West literature values to estimate loads; sub-basins reflecting open-space/residential use used the NURP data to derive load estimates. The SWMM model did not include any best management practices scenarios.

Table 6-47 includes the total allowable summer load (July 1–September 30) for TN and TP based on the calculated median (50th percentile) flow for each receiving waterbody. For comparison, the table also contains the estimated loading from the MS4 during the same period.

Table 6-47. July 1–Sept 30 allowable loading and SWMM model results for the city of Bozeman MS4 based on 1980-2009 precipitation data

	Allowable TN Loading (lbs/summer)	MS4 TN Load (lbs/summer) SWMM model	Allowable TP Loading (lbs/summer)	MS4 TP Load (lbs/summer) SWMM model
Bozeman Creek	1691.604	980.52	169.16	167.22
Bridger Creek	1691.604	27.88	169.16	5.69
East Gallatin	6036.12	4678.69	603.61	747.03

The SWMM model suggests that the loading from the MS4 is very large in comparison with the calculated allowable load during the summer period (July 1–September 30). At times of high flow from storm events during the summer period, the nutrient load from the MS4 is likely a large percentage of the total load in the receiving waterbodies. The allowable load is based on the water quality target and the median flow in the receiving waterbody. The chlorophyll-*a* and AFDW data suggest exceedances of water quality criteria in Bozeman Creek and the East Gallatin River. However, it is impossible to link the exceedances directly to the MS4 discharges because there are other nutrient sources in the drainages receiving flows from the MS4. Implementing the SWMP and best management practices is required to reduce the concentration and discharge volume so that the total summer loading from the MS4 is reduced.

While the MS4 delivers a nutrient load to its receiving waterbodies, an analysis of climatic and hydrologic data suggest that it is active only infrequently during the summer period and is not active during baseflow conditions for which the TMDL is developed. Since the system should not be actively discharging during typical summer low flow conditions, both the existing load and WLA are defined as 0 (zero).

6.5.2.3 USFWS Bozeman Fish Technology Center (MTG130006)

The US Fish & Wildlife Service's Bozeman Fish Technology Center uses several water rights to run operations at the facility, including diversions on a warm spring and a cold spring located at the mouth of Bridger Canyon. The spring diversions have documented concentrations of NO_3+NO_2 above the target value (0.1 mg/L) for Bridger Creek. The spring sources previously discharged to Bridger Creek and still do when spring discharge exceeds facility demand. An extensive water reuse system in the main research facility recycles water several times for reuse before the water is filtered in a 60-micron drum filter, followed by two 1500-micron filters, and then a baffle system, after which the water is discharged to

Bridger Creek. Currently the outdoor fish runs at the facility are not being used until concerns about PCB-contaminated building materials are addressed.

NO_3+NO_2 loading from the point discharge was estimated based on available data collected from the discharge flow and from the springs that supply water to the facility. According to DMR data, summer discharge from the center is between 800 and 1,000 gpm (1,000 gpm = 2.33 cfs). Based on the water quality data collected from the source waters, and the facility effluent in 2005 and 2010, the center generates a NO_3+NO_2 as N load of 0.777 lb/day. The load was determined by calculating the source water load, based on flow diversions and site-specific water quality data, and subtracting the outgoing load at the discharge point, also based on actual water quality data and approximate flow rates. The load calculated from real data (0.777 lb/day NO_3+NO_2) compares well with a load of 0.745 lb/day based on literature values and the center's operating parameters (Wright and Anderson, 2001). Per their existing discharge permit, the Fish Tech Center is not required to sample their effluent for nutrient concentrations.

The TN water quality target for Bridger Creek is 0.3 mg/L TN. DEQ assessed the Fish Tech Center discharge to determine will have a water quality standard for Bridger Creek of 0.3 mg/L, DEQ analyzed the situation to determine if the discharge will exceed the TN water quality target by calculating several flow scenarios for Bridger Creek and for effluent concentrations from the fish hatchery. For the Fish Tech Center effluent, assuming that the inorganic fraction of TN is 65% and is discharging at 2.33 cfs into Bridger Creek at low flow (7Q10= 3.9 cfs), the TMDL target water quality standard of 0.3 mg/L for TN will not be exceeded in Bridger Creek.

6.5.3 Existing Nutrient Load Summary

As detailed in **Appendix F**, source assessments, geospatial data, and synoptic sampling results were used to determine the existing nutrient source allocations in each basin. The results of this source assessment analysis were used to determine the existing load and the needed reductions to meet the TMDL. The tables in this section represent the existing nutrient loads during the summer period (July 1 – September 30) for each waterbody and impairment (TN, TP or NO_3+NO_2). Existing nutrient loads were calculated using the median flow and concentration data of the entire available dataset per assessment unit. The exception to this is for the middle and lower segments of the East Gallatin River. Because of the complex nature of the East Gallatin River with large nutrient point sources (city of Bozeman WRF) and substantial irrigation diversions and returns (i.e. Buster Gulch, Dry Creek Irrigation Canal), load estimates and natural background calculations were determined using specific site data for each segment. East Gallatin River sites were selected that best represented hydrologic and water quality conditions in a specific reach. Details of the East Gallatin River source assessment and all other nutrient source assessments may be found in **Appendix F**

For TN (**Figure 6-3 through 6-16**), agricultural land uses constitute 67% of the existing load in watersheds where agriculture is the dominant land use. This falls to 37% in catchments with a mix of agriculture and residential/urban land uses, such as Bozeman Creek and Mandeville Creek. In these mixed basins, developed areas (28%) and subsurface wastewater treatment and disposal areas (17%) comprise larger portions of the TN load on average. On the East Gallatin River, the WRF discharge comprises 53% of the TN load in the middle segment above Hyalite Creek confluence, 42% of the TN load below the Hyalite Creek confluence and 16% of the TN load in the lower segment of the river downstream of the Smith Creek confluence. On average, 31% of the existing TN load in these segments originates from agricultural land uses. The influence of flow diversions which transport East Gallatin River nutrient loads to Hyalite Creek and Smith Creek were removed for this analysis.

The source assessment results for TP (**Figure 6-17 through 6-27**) indicate that in catchments dominated by agricultural land use, rangeland and pasture and cropping practices constitute 40% of the TP load on average. The exception is Bear Creek where forest is the dominant TP source category (at 48% of the existing load), with agricultural land uses comprising only 8%. In watersheds with a mix of agriculture and residential land use, developed areas comprise 15% of the TP load, while TP from agriculture decreased to 18%. Concerning TP, the East Gallatin River receives a load from the city of Bozeman Water Reclamation Facility (WRF) discharge, which is the most significant nutrient point source in the Lower Gallatin TPA. The WRF discharge comprises 79% of the TP load in the middle segment above Hyalite Creek confluence, 46% of the TP load below the Hyalite Creek confluence and 22% of the TP load in the lower segment of the river downstream of the Smith Creek confluence. On average, 7% of the existing TP load in these segments originates from agricultural land uses.

For $N0_2$+$N0_3$ (**Figure 6-28 through 6-30**), agricultural land uses constitute 60% of the existing load. Forest/natural background loads range from 9% to 48% of the existing load. These $N0_2$+$N0_3$ impairments all originate in the Bridger Range.

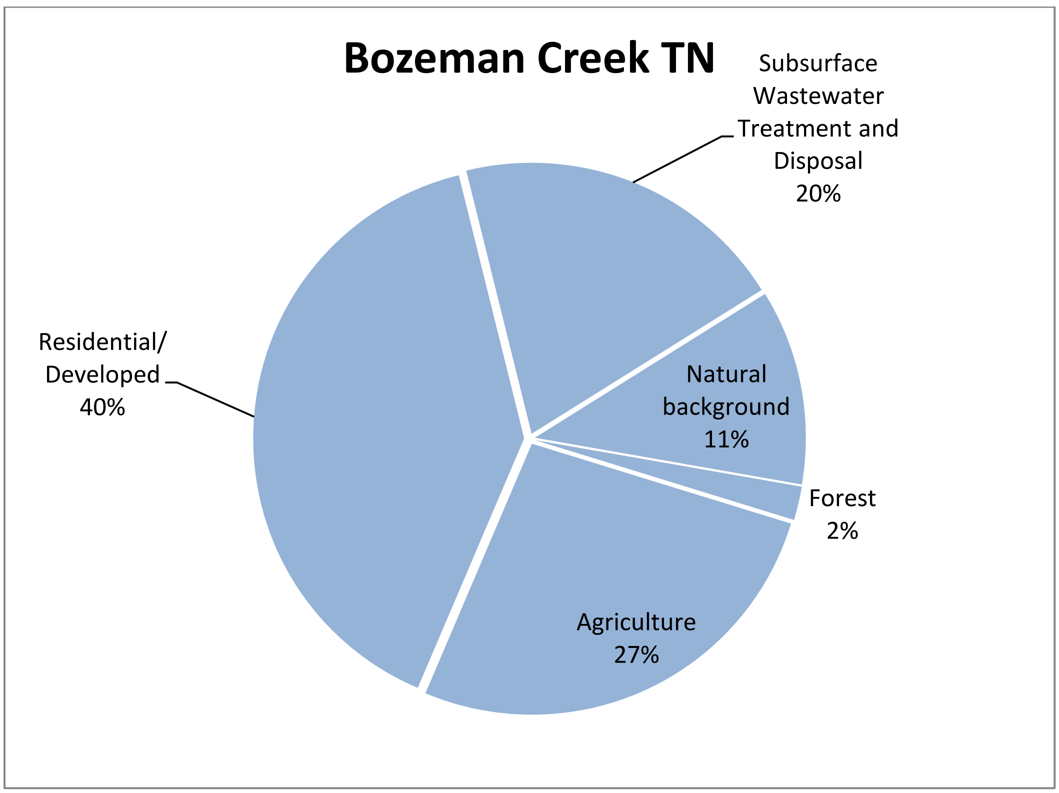

Figure 6-3. Existing TN sources for Bozeman Creek

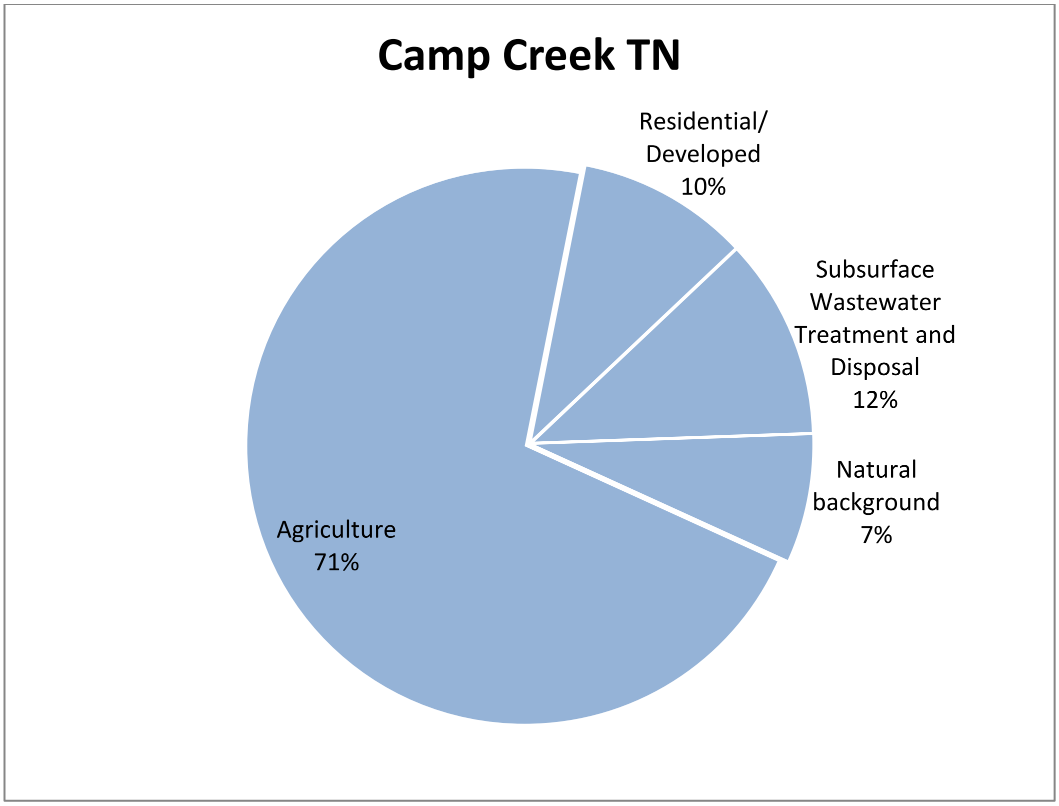

Figure 6-4. Existing TN sources for Camp Creek

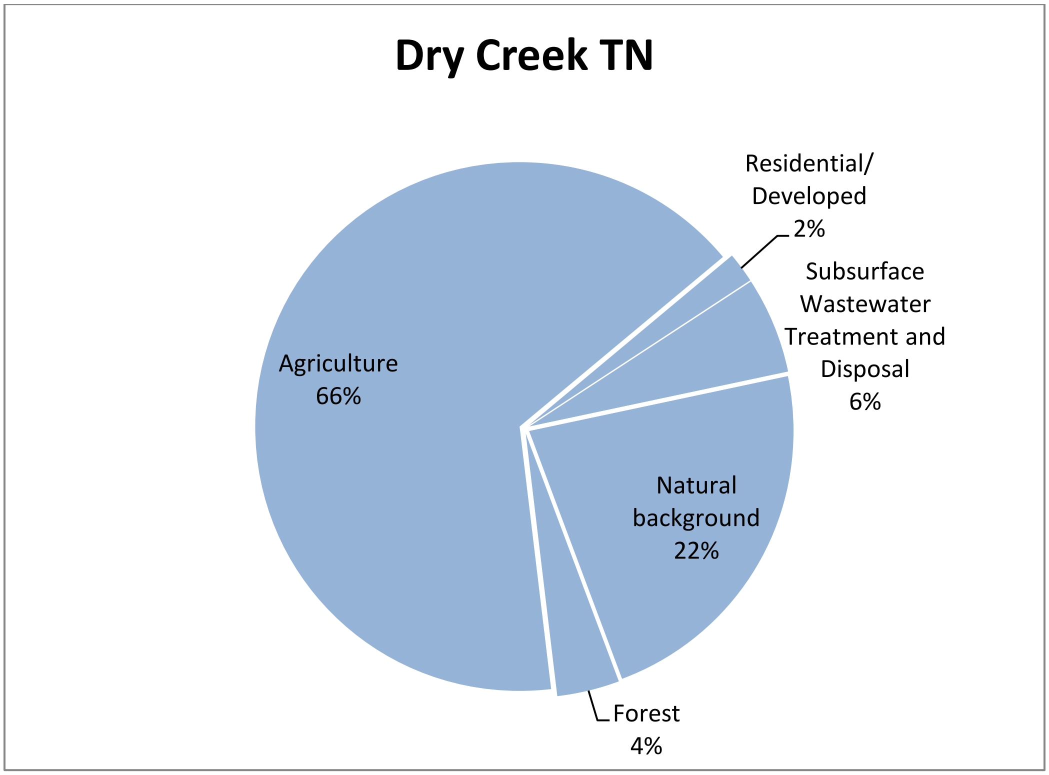

Figure 6-5. Existing TN sources for Dry Creek

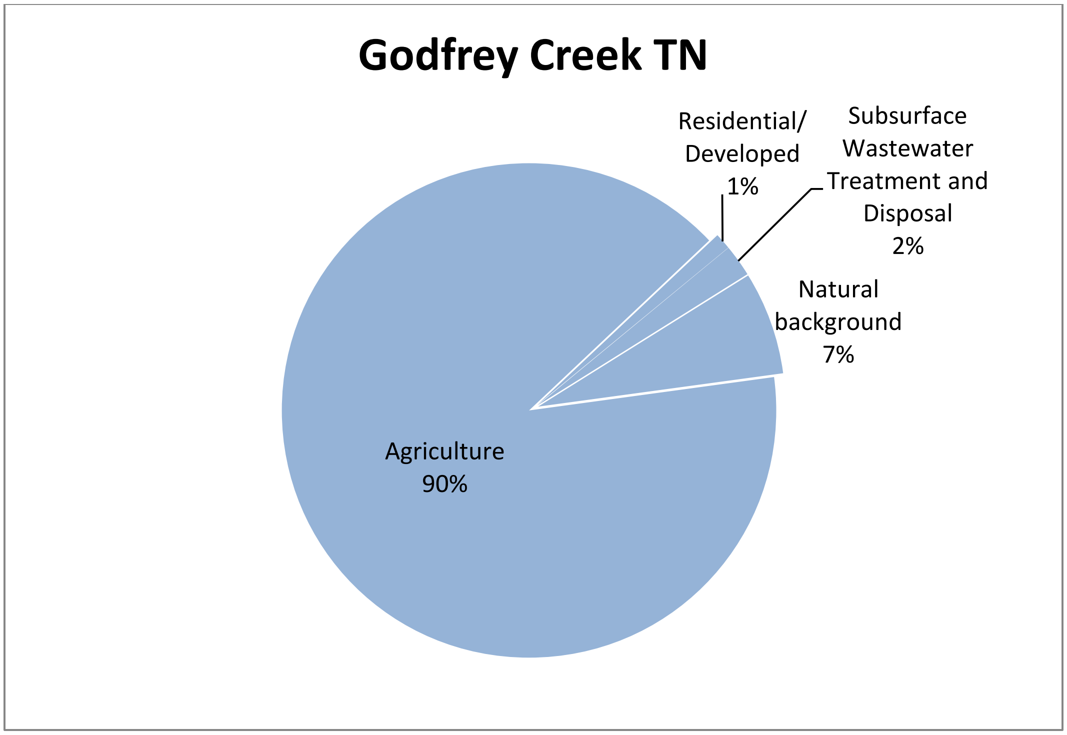

Figure 6-6. Existing TN sources for Godfrey Creek

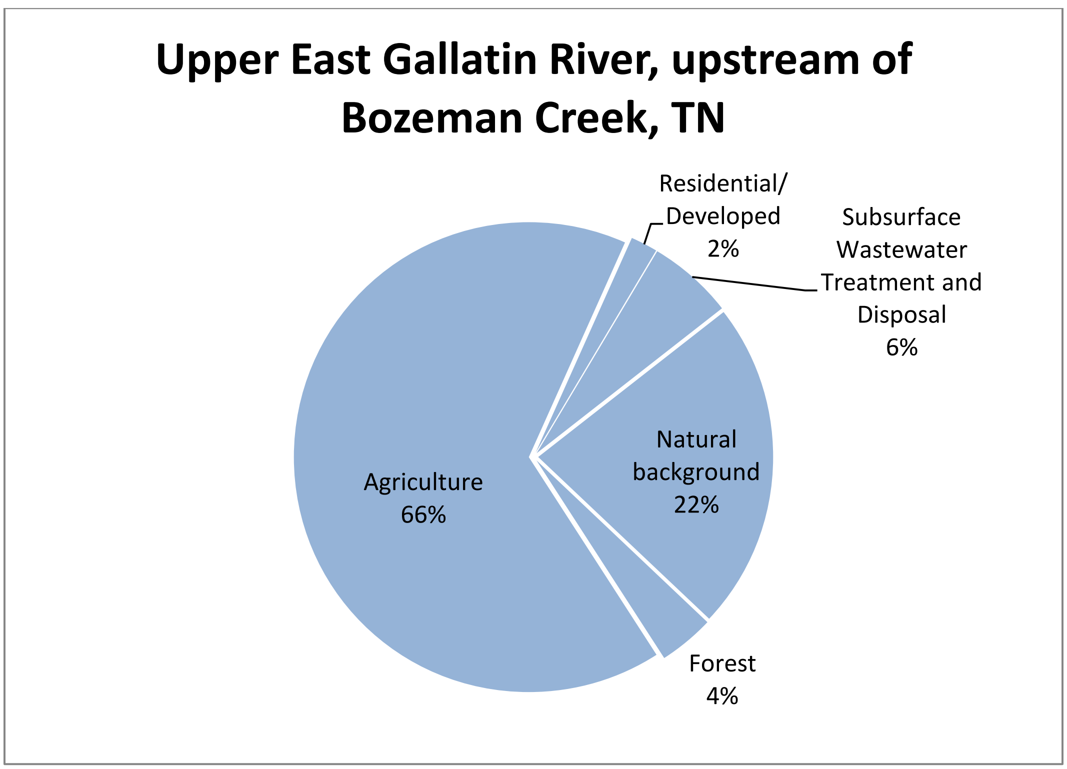

Figure 6-7. Existing TN sources for Upper East Gallatin River upstream of Bozeman Creek

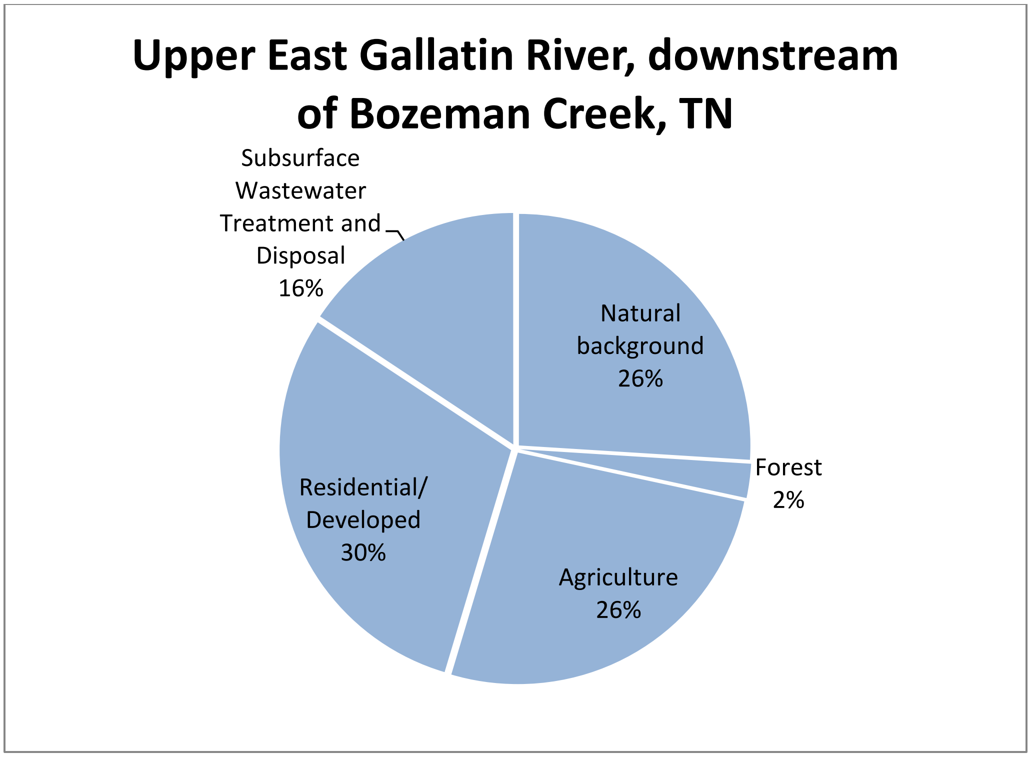

Figure 6-8. Existing TN sources for Upper East Gallatin River downstream of Bozeman Creek

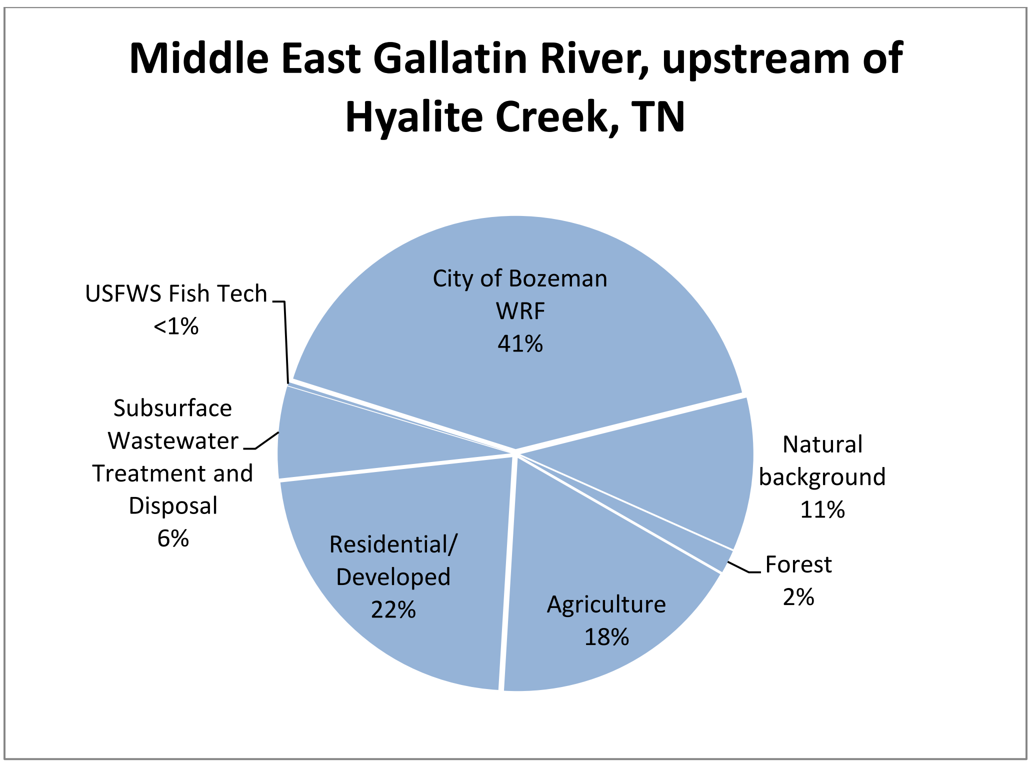

Figure 6-9. Existing TN sources for Middle East Gallatin River upstream of Hyalite Creek

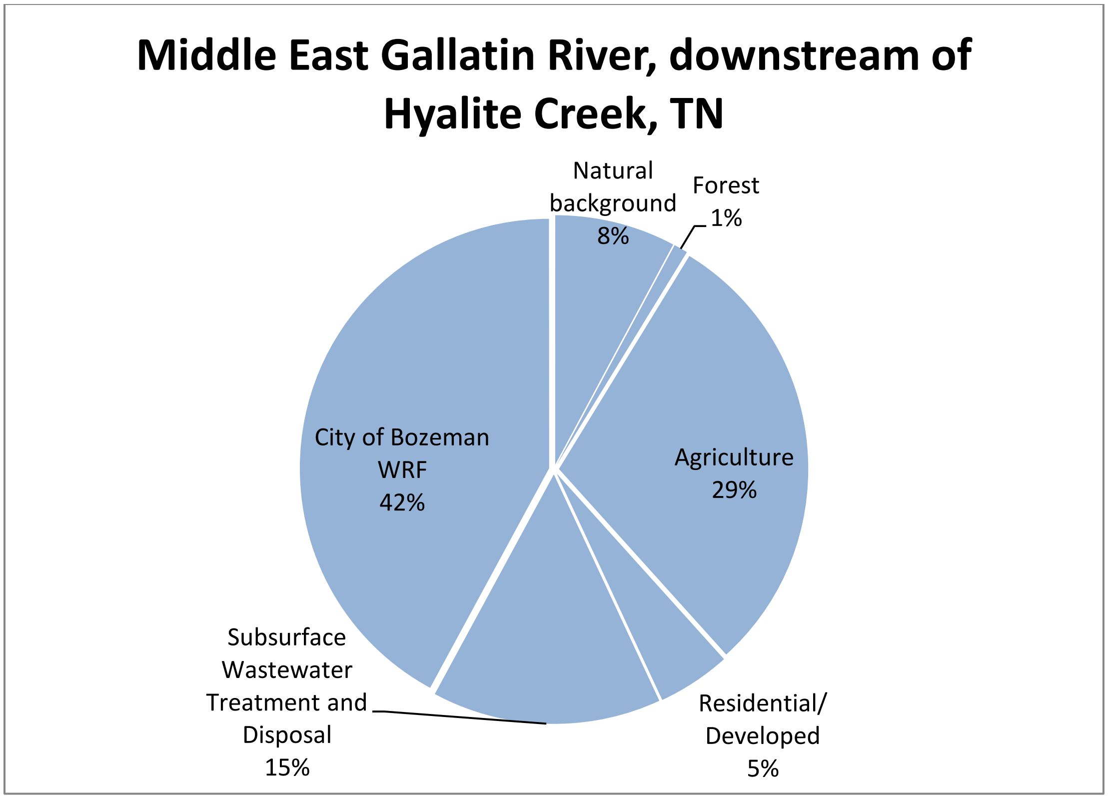

Figure 6-10. Existing TN sources for Middle East Gallatin River downstream of Hyalite Creek

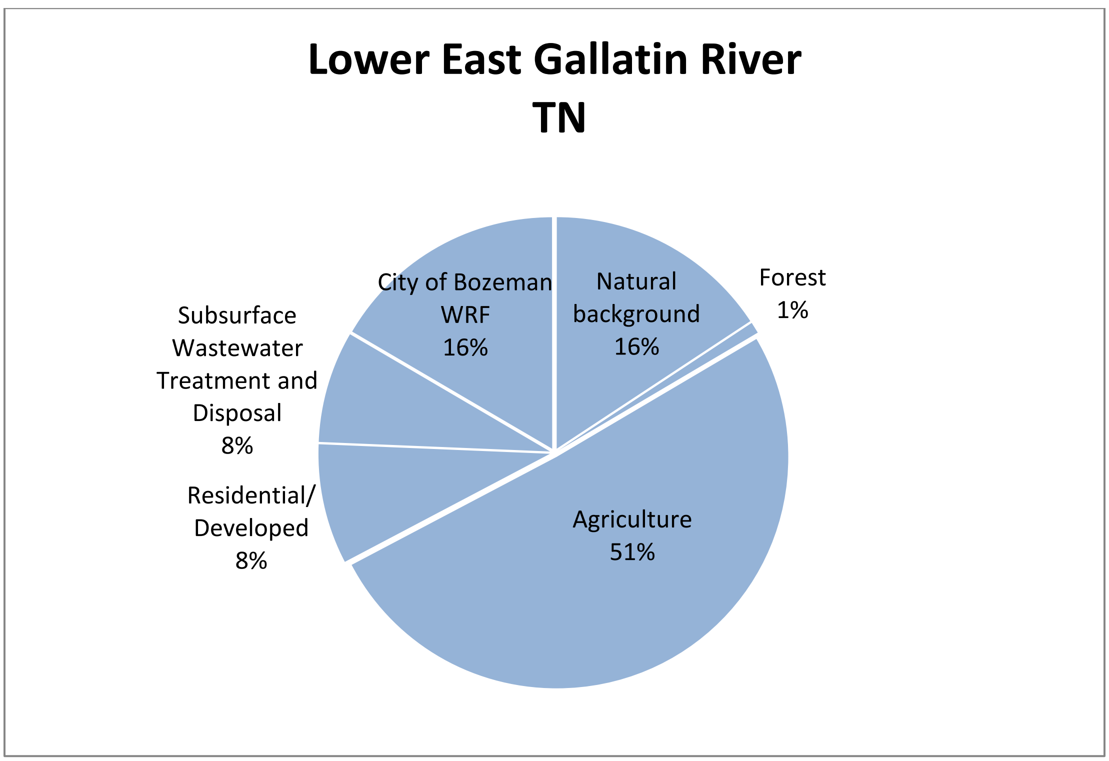

Figure 6-11. Existing TN sources for Lower East Gallatin River

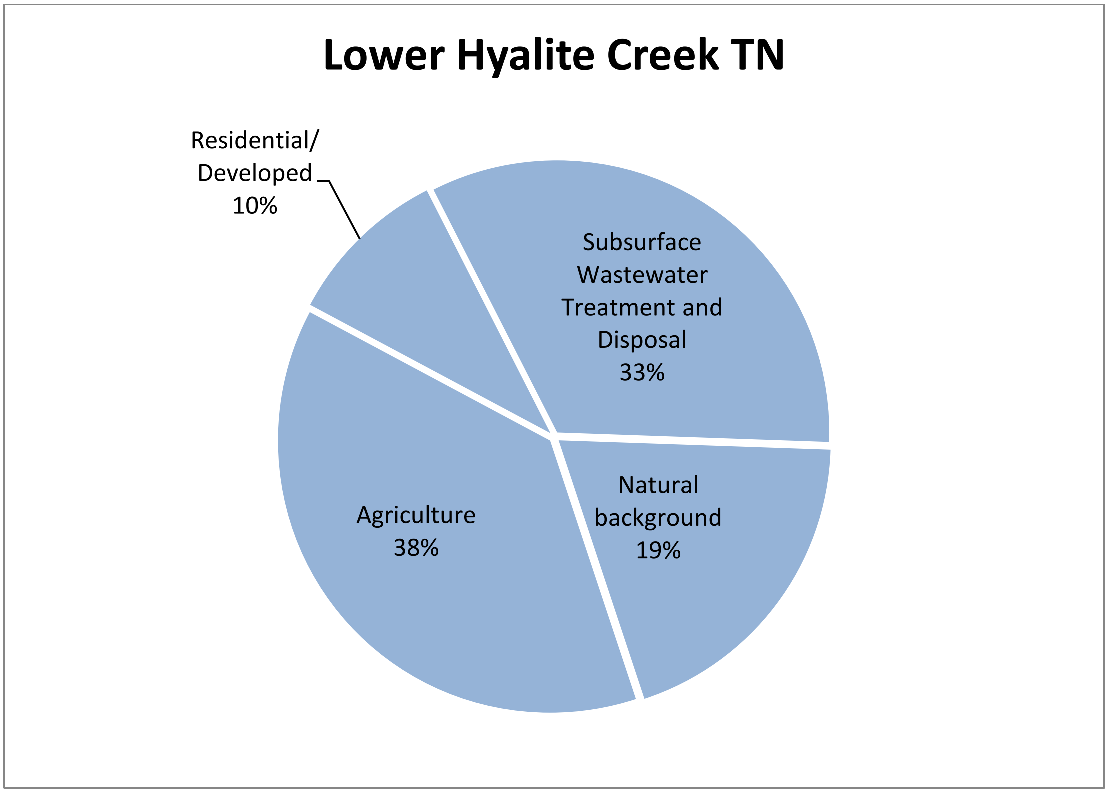

Figure 6-12. Existing TN sources for Lower Hyalite Creek

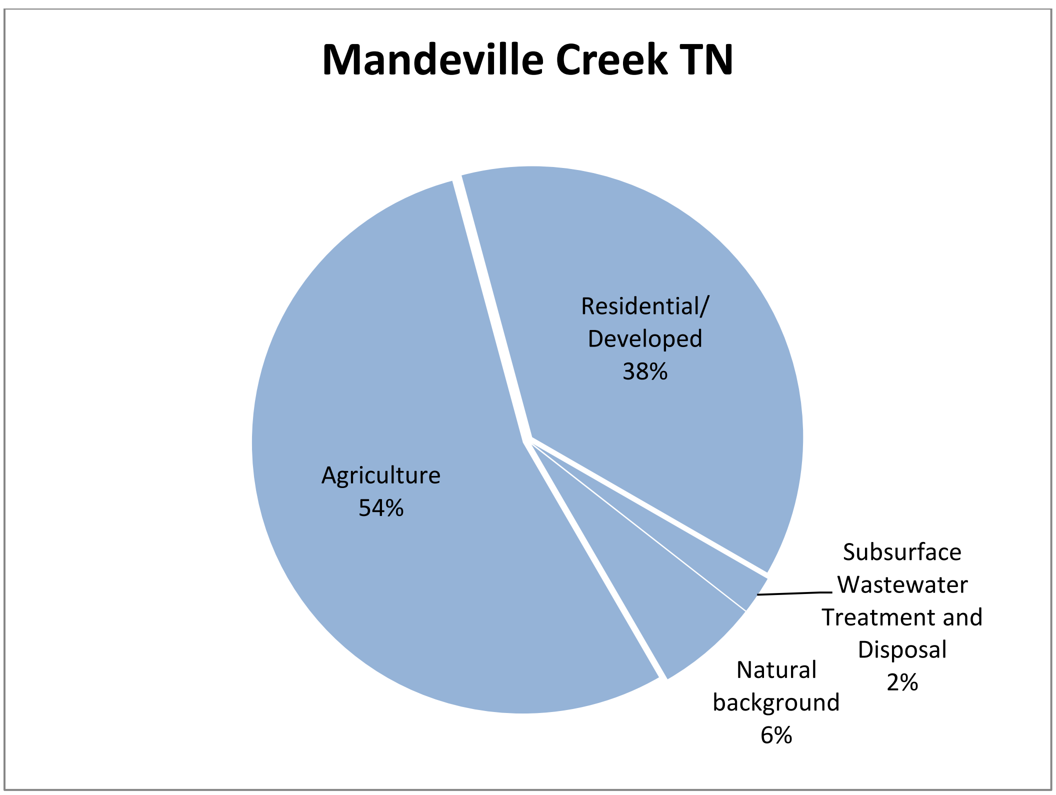

Figure 6-13. Existing TN sources for Mandeville Creek

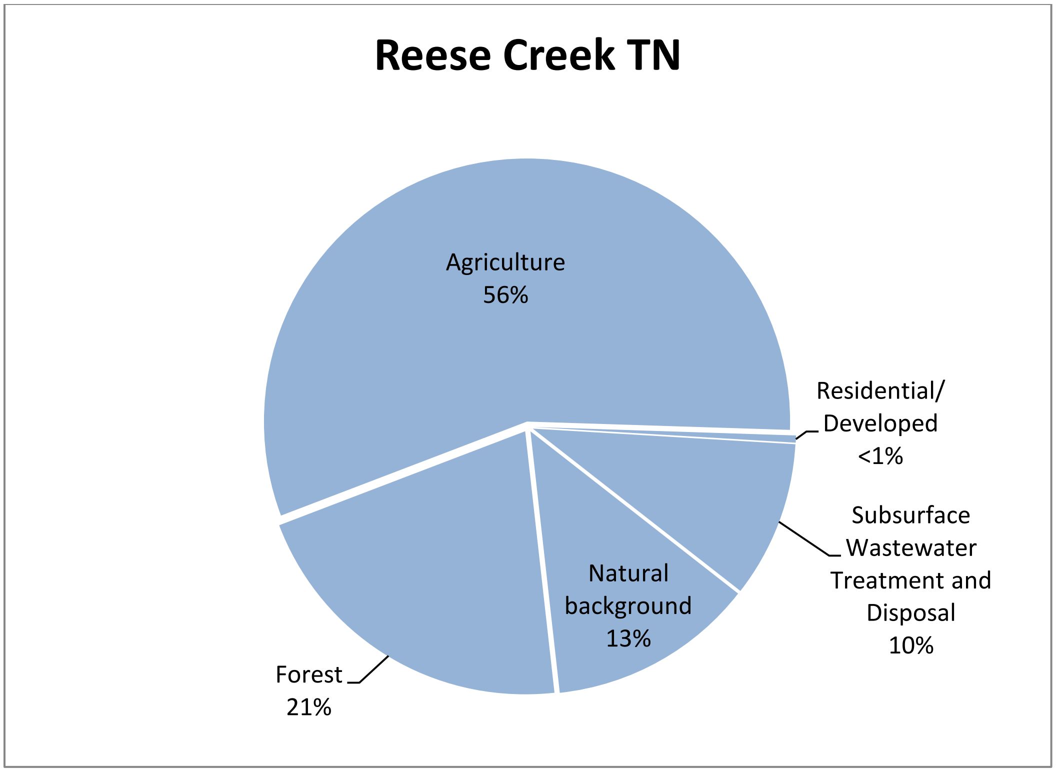

Figure 6-14. Existing TN sources for Reese Creek

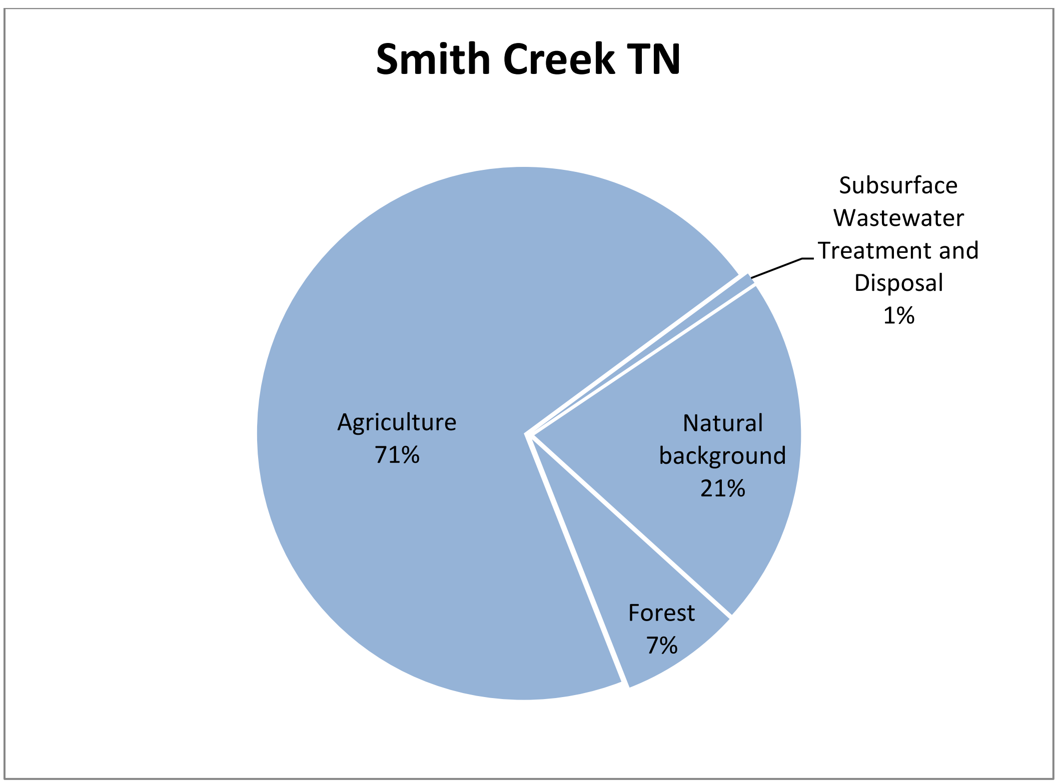

Figure 6-15. Existing TN sources for Smith Creek

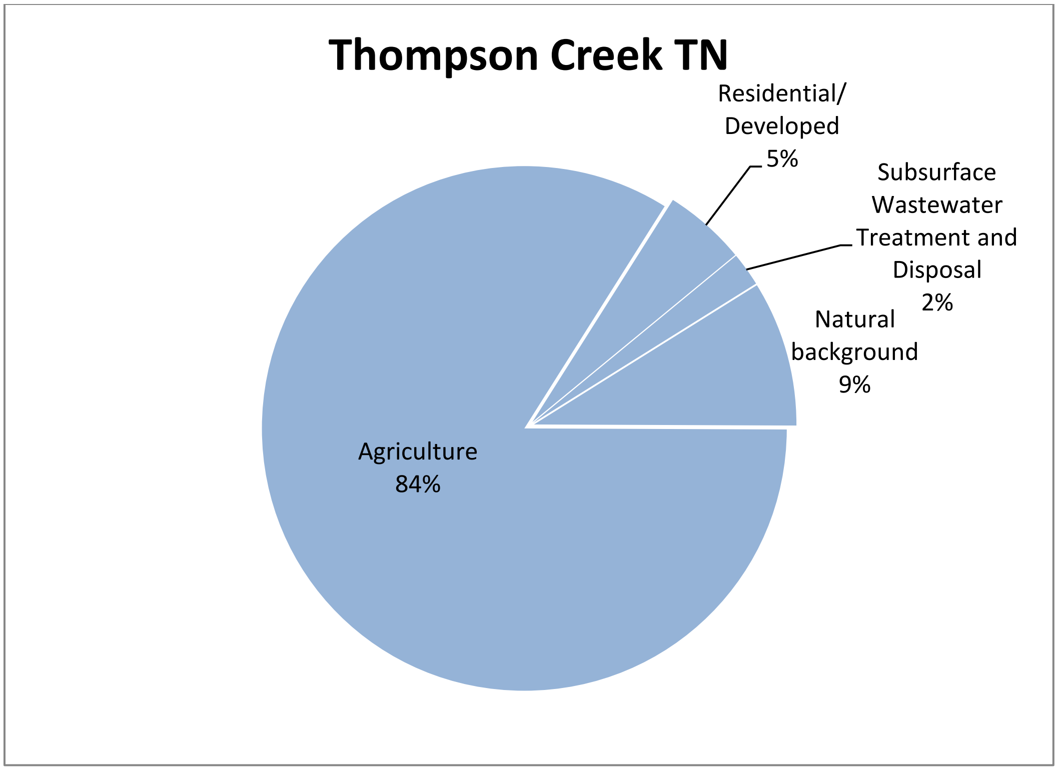

Figure 6-16. Existing TN sources for Thompson Creek

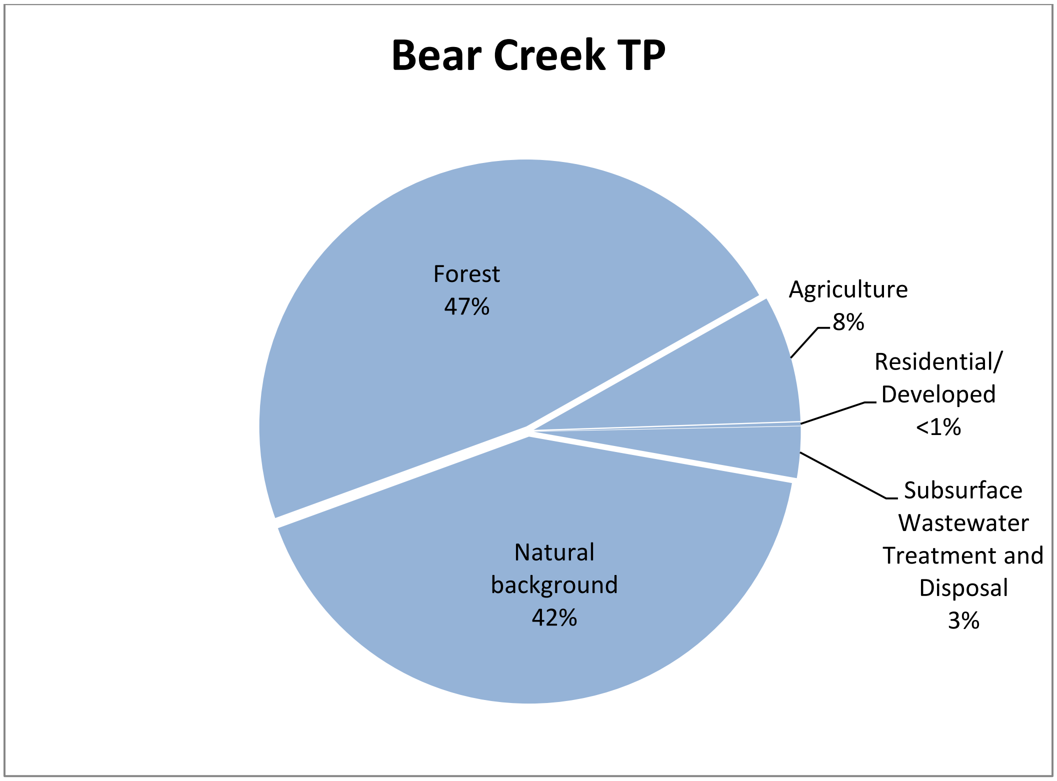

Figure 6-17. Existing TP sources for Bear Creek

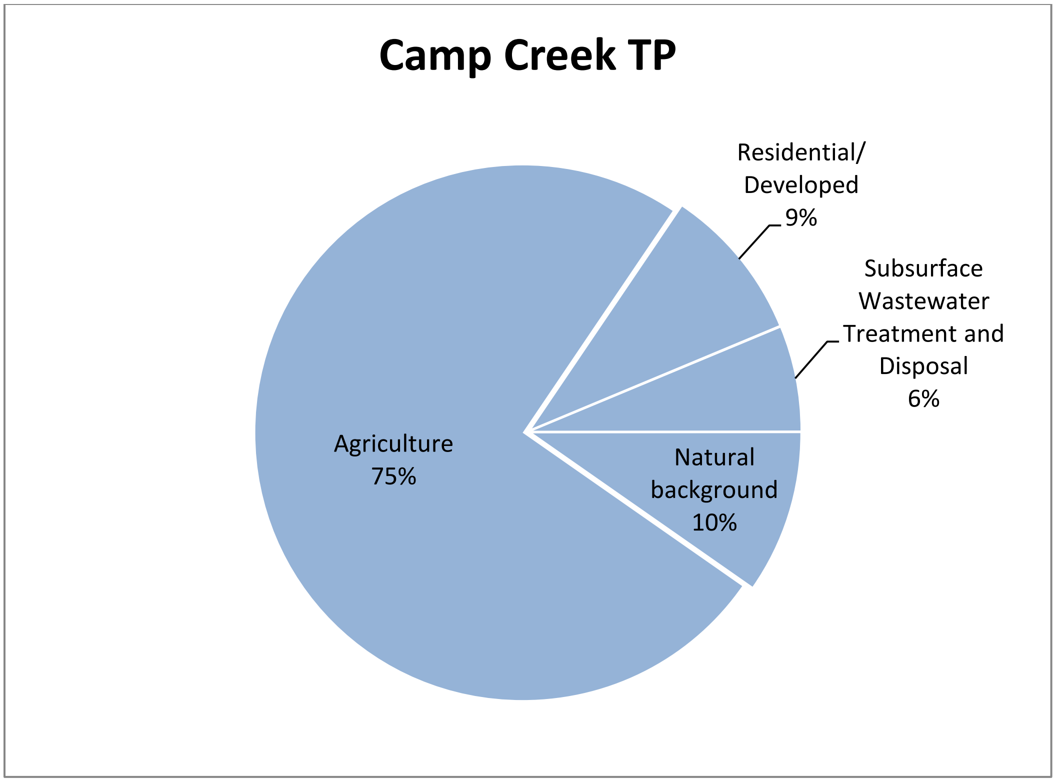

Figure 6-18. Existing TP sources for Camp Creek

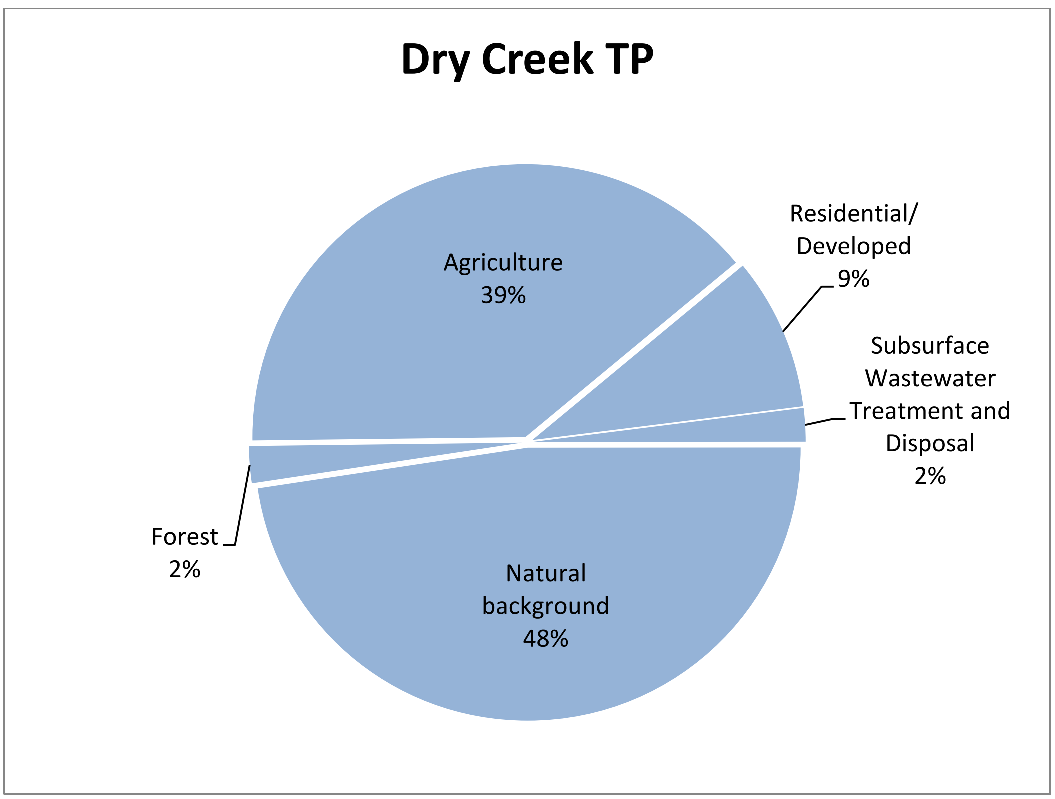

Figure 6-19. Existing TP sources for Dry Creek

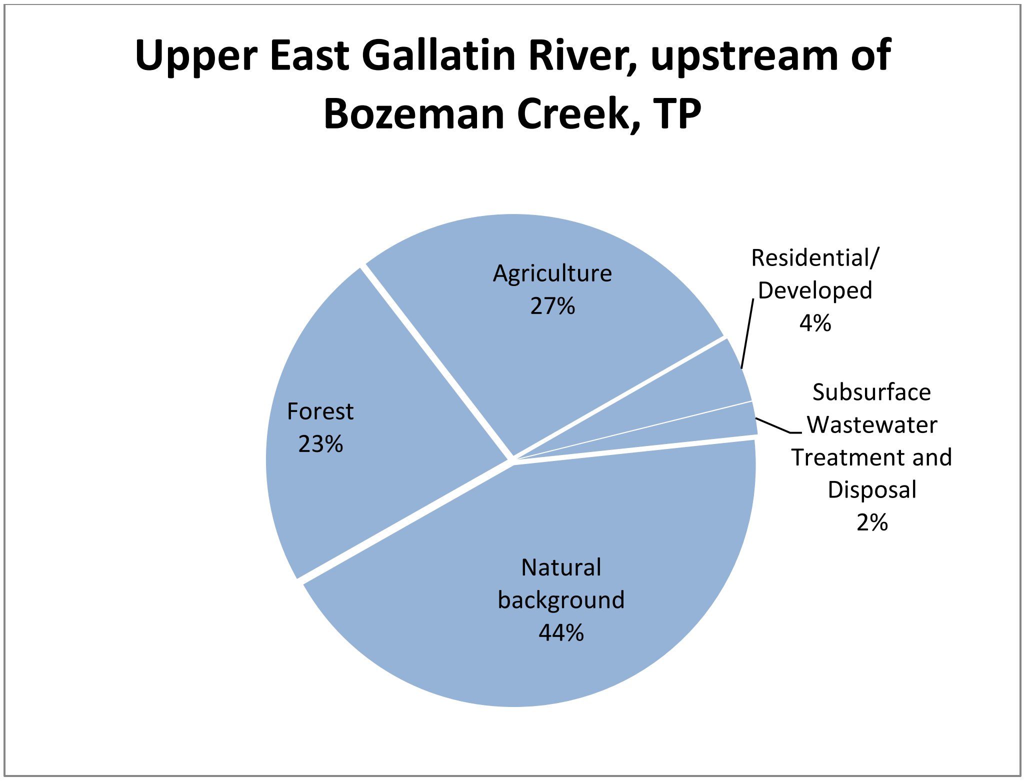

Figure 6-20. Existing TP sources for Upper East Gallatin River upstream of Bozeman Creek

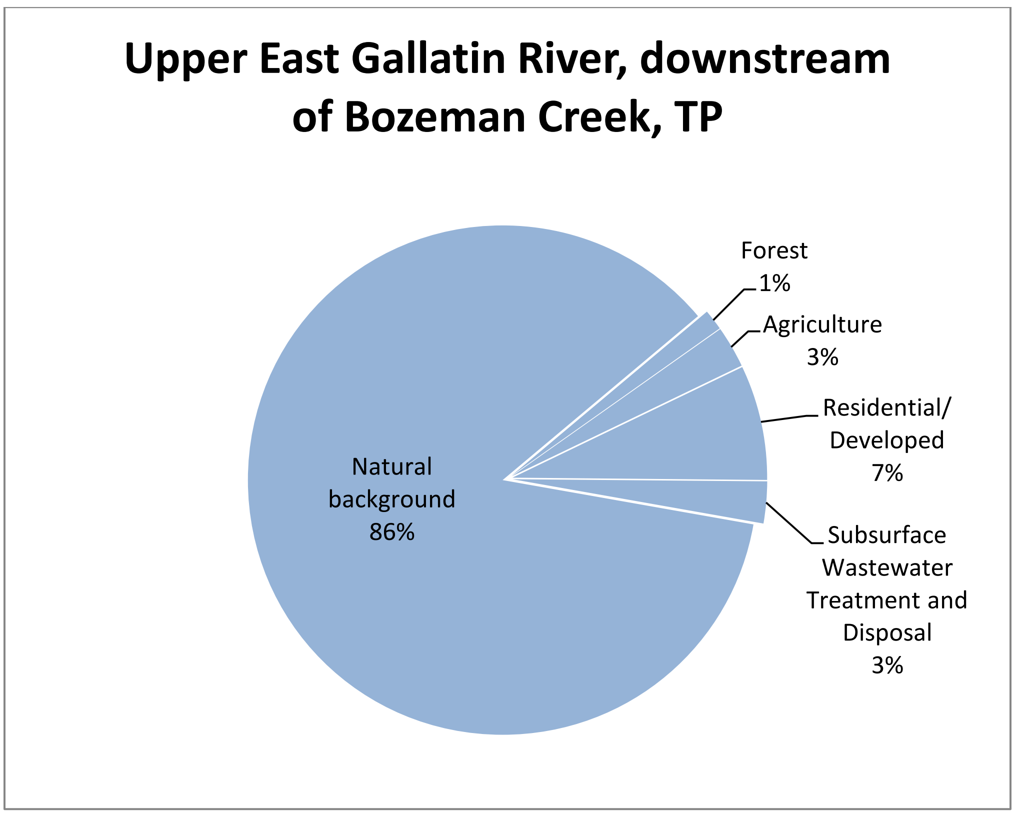

Figure 6-21. Existing TP sources for Upper East Gallatin River downstream of Bozeman Creek

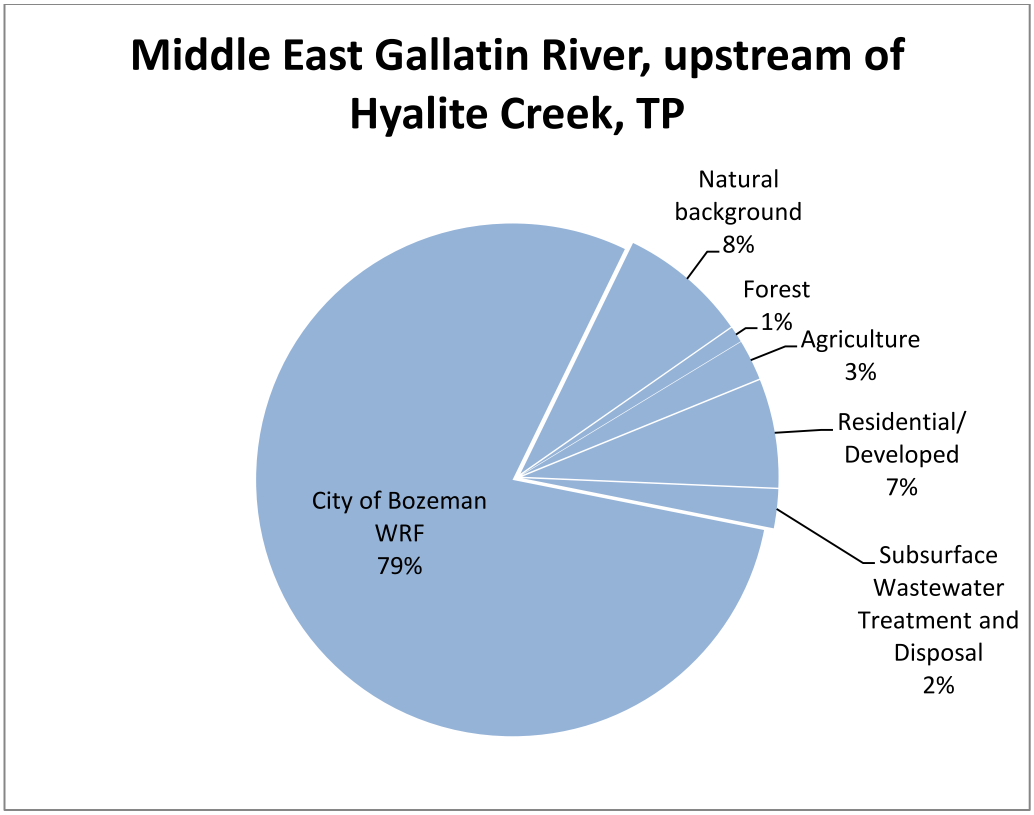

Figure 6-22. Existing TP sources for Middle East Gallatin River upstream of Hyalite Creek

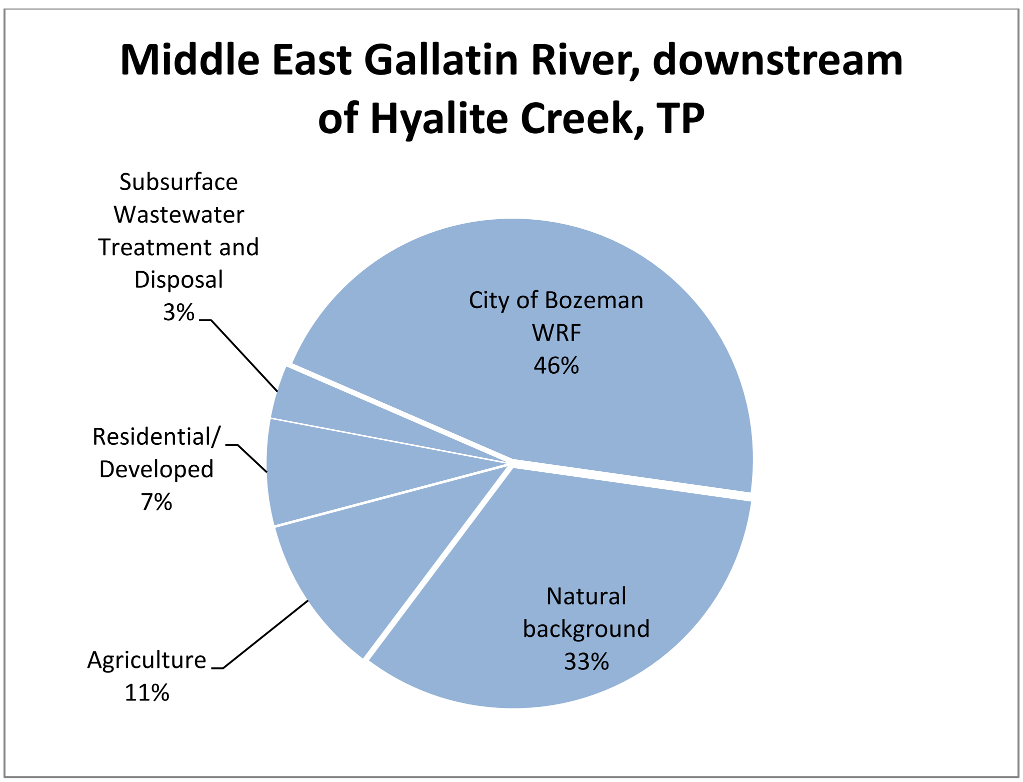

Figure 6-23. Existing TP sources for Middle East Gallatin River downstream of Hyalite Creek

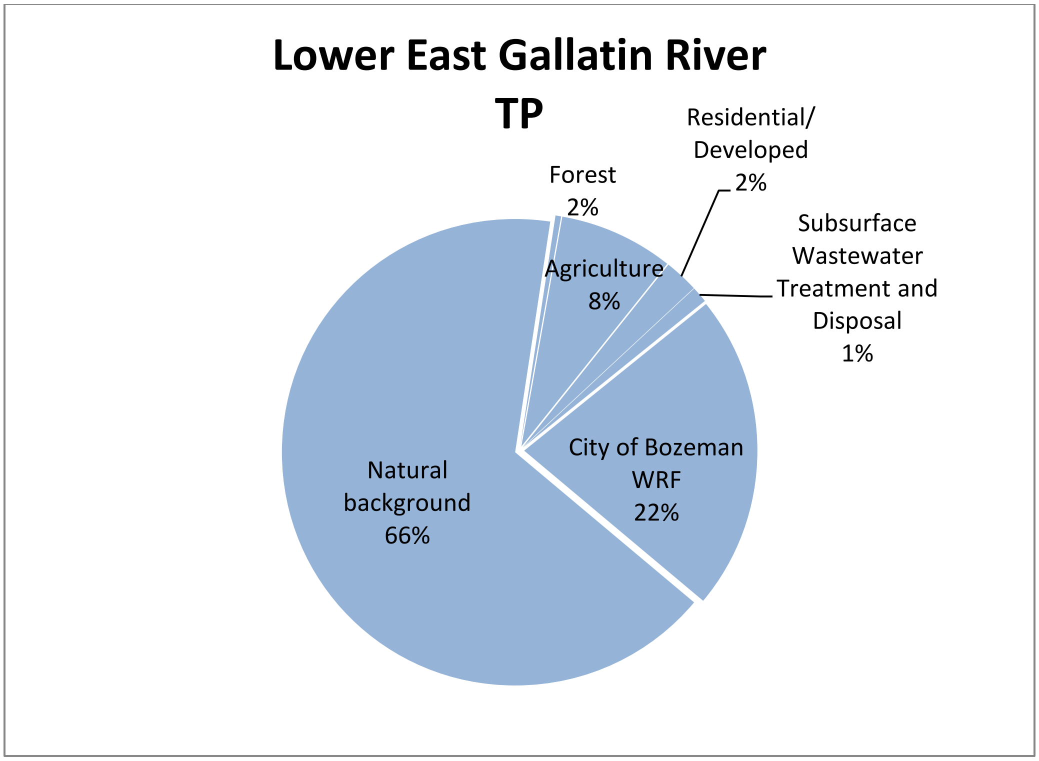

Figure 6-24. Existing TP sources for Lower East Gallatin River

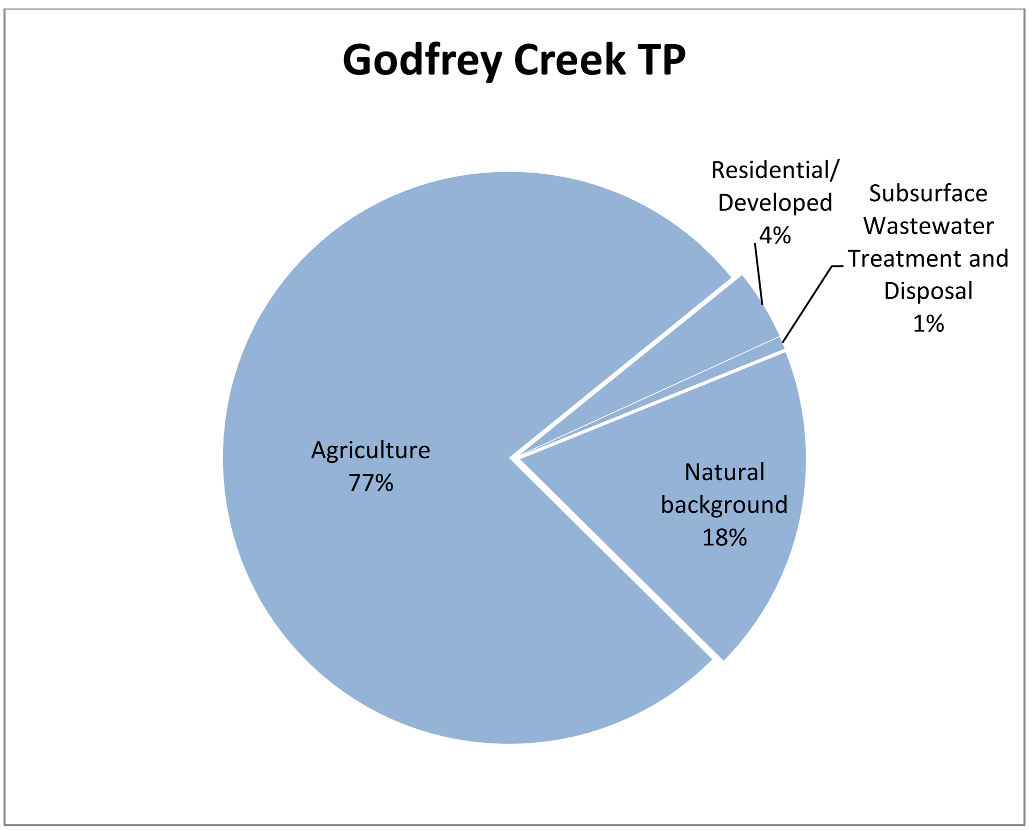

Figure 6-25. Existing TP sources for Godfrey Creek

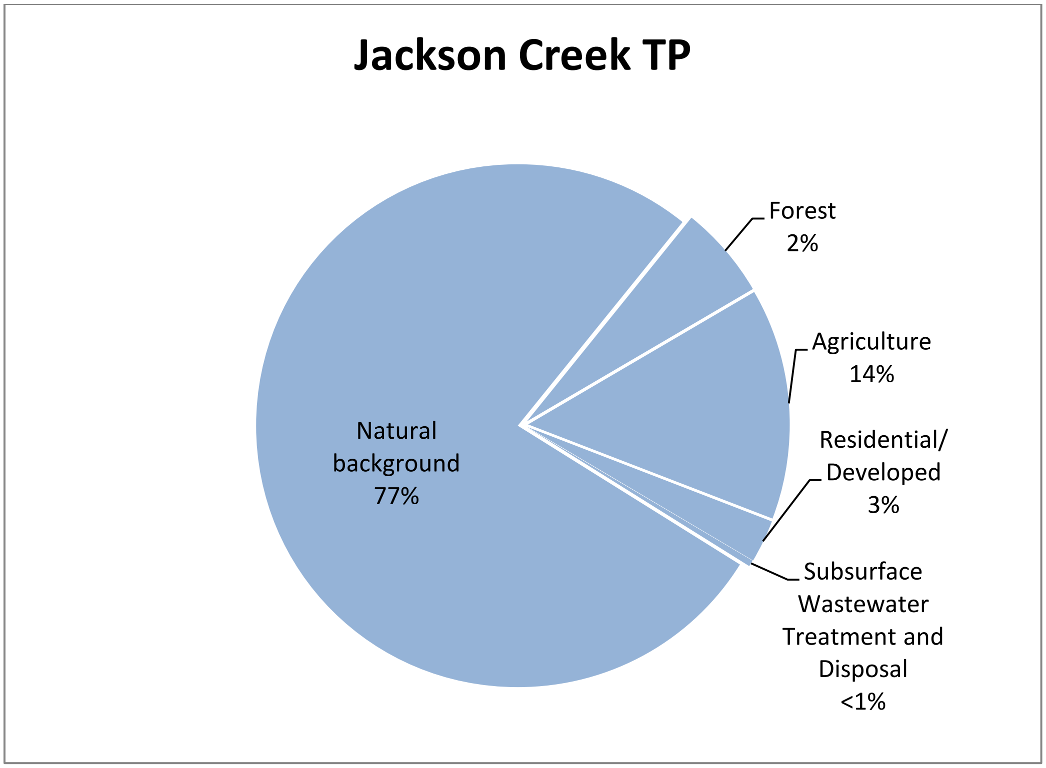

Figure 6-26. Existing TP sources for Jackson Creek

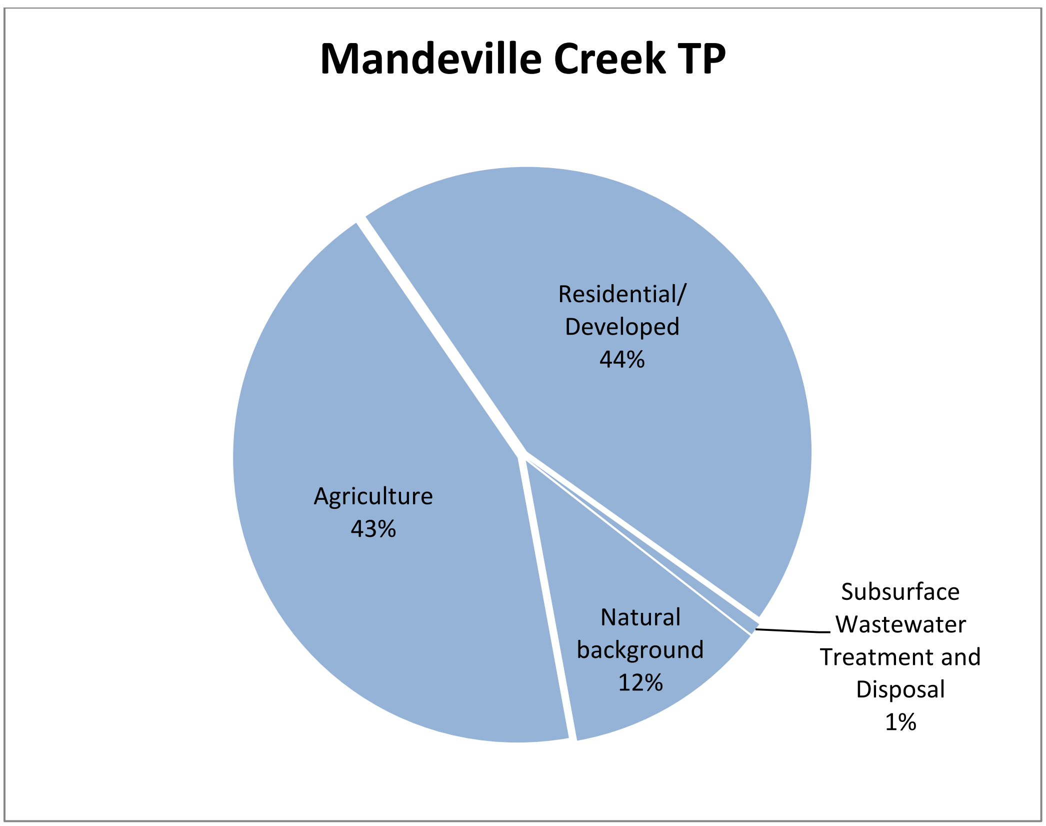

Figure 6-27. Existing TP sources for Mandeville Creek

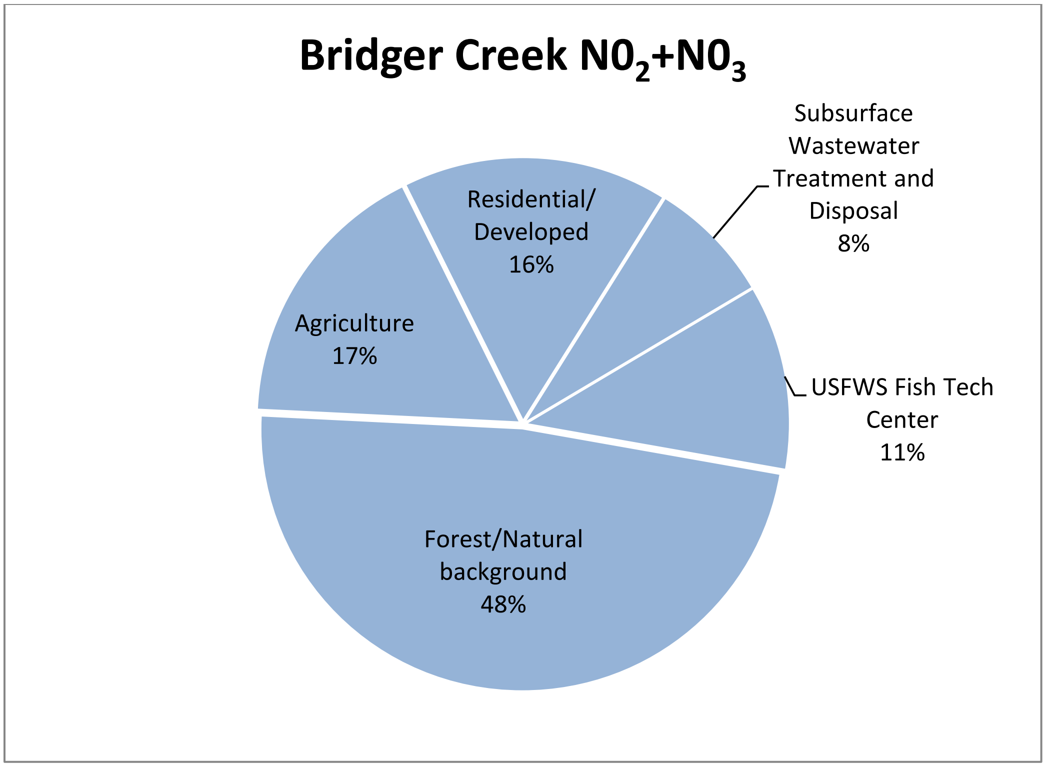

Figure 6-28. Existing N02+N03 sources for Bridger Creek

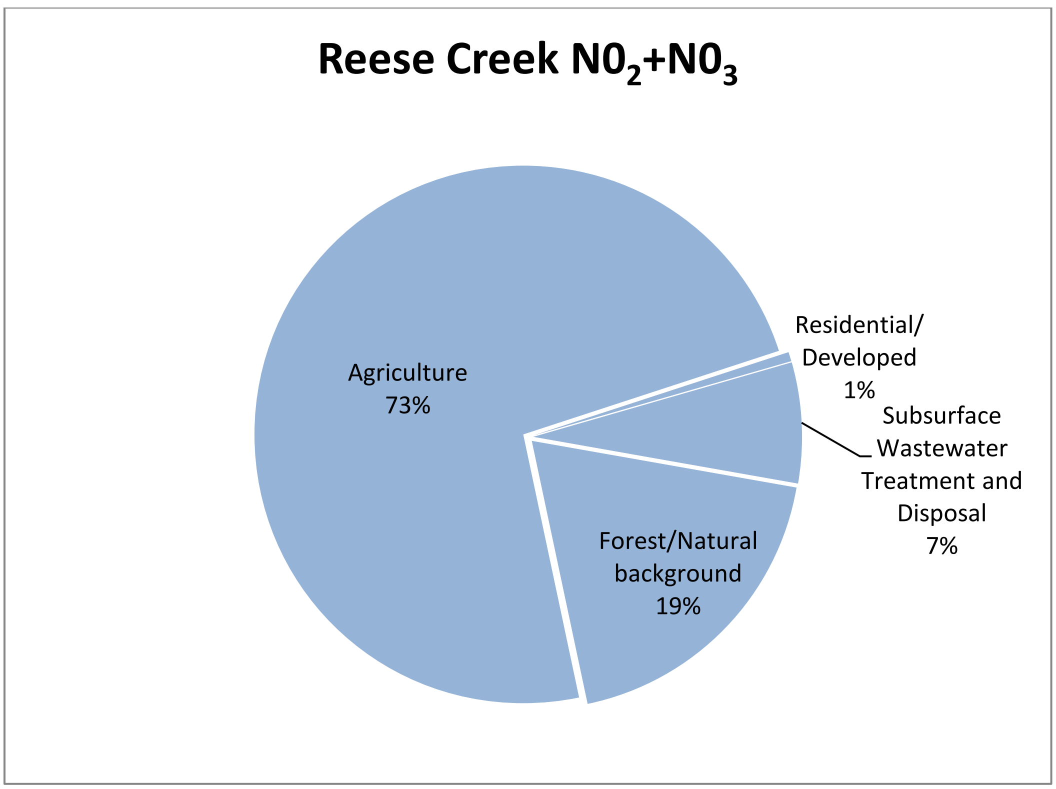

Figure 6-29. Existing NO_2+NO_3 sources for Reese Creek NO_2+NO_3

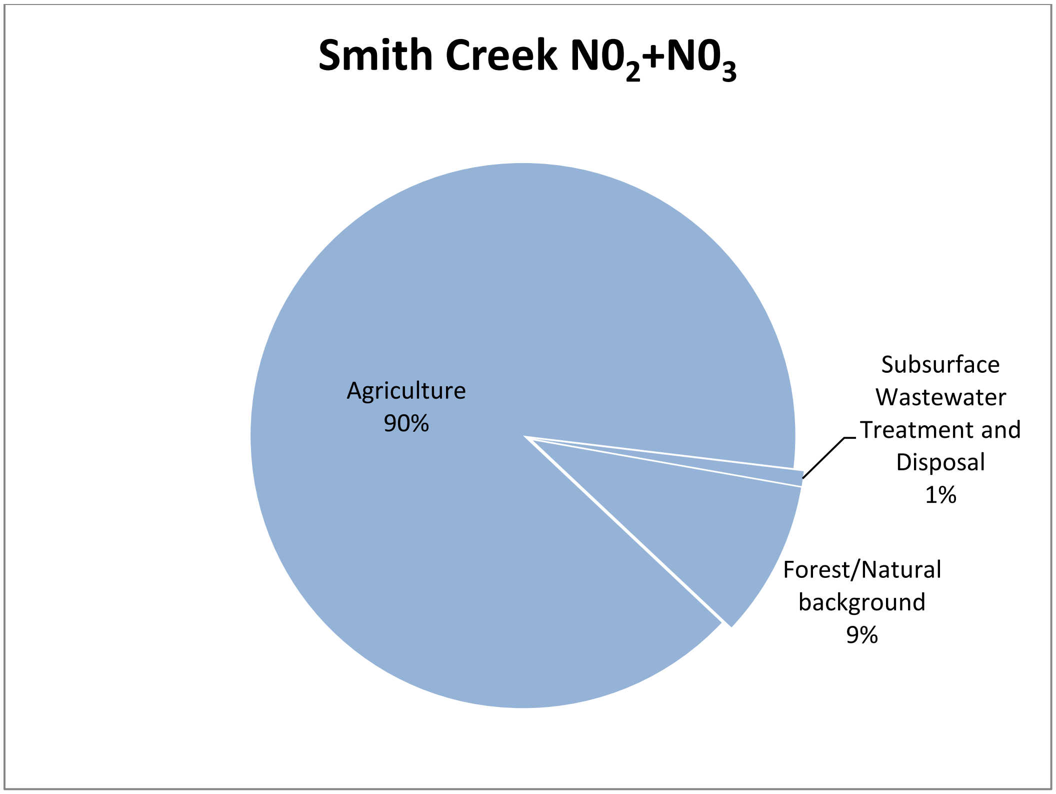

Figure 6-30. Existing N0$_2$+N0$_3$ sources for Smith Creek N0$_2$+N0$_3$

6.6 Nutrient TMDLs

Nutrient TMDLs will be developed for the nutrient pollutant causes identified for each waterbody in **Table 6-38**. The TMDL equation for each nutrient form is based on flow and the nutrient targets and is provided in **Equations 6-1** through **6-3**. Target values are identified in **Tables 6-2 and 6-3**. The nutrient TMDLs protect all designated beneficial uses. Future conditions will be deemed as meeting the TMDL if there is less than a 20% exceedance rate, as long as exceedances are spatially and temporally random during the summer months with no chlorophyll-*a* or ash-free dry weight (AFDW) target exceedances. This exceedance rate allows for natural variability yet should protect against nutrient conditions that affect any use of the water. The TMDLs are applied only to the summer growing season (July 1–Sept. 30). Because of the influence of the Absaroka-Gallatin-Volcanics Level IV ecoregion in the Lower Gallatin, there is not a single TN or TP water quality target applicable to the entire project area. However, the water quality target for NO_3+NO_2 is the same throughout the project area (≤0.1 mg/L).

Equation 6-1.
Total Nitrogen TMDL (lbs/day) = CFS*5.38*Water Quality Target (WQT)
Where: CFS = Average daily discharge in cubic feet per second; 5.38 = conversion factor; WQT = water quality target for total nitrogen in mg/L (**Table 6-2** and **6-3**)

Equation 6-2.
Nitrate+Nitrite TMDL (lbs/day) = CFS*5.38*0.1mg/L
Where: CFS = Average daily discharge in cubic feet per second; 5.38 = conversion factor; 0.1 = NO_3+NO_2 water quality target (**Table 6-2**)

Equation 6-3.
Total Phosphorus TMDL (lbs/day) = CFS*5.38*WQT
Where: CFS = Average daily discharge in cubic feet per second; 5.38 = conversion factor; WQT = water quality target for total phosphorus in mg/L (**Table 6-2** and **6-3**)

TMDL examples are provided for each waterbody segment using sample data from the growing season. The examples show the maximum and minimum for the measured existing load based on the sample data, as well as the load based on the 80th percentile of the data. The TMDL can be displayed as a line graph of allowable loading with increasing flow. **Figure 6-31** is the graph of an example TMDL for TN for a water quality target of 0.3 mg/L and with a range of mean daily flows from zero to 75 cfs. The vertical dotted line intersects the graph at a streamflow value of 40 cfs. The horizontal dotted line, extending from the diagonal TMDL graph to the y-axis, identifies the maximum TN load allowed for this discharge. Therefore, with a target value of 0.30 mg/L TN and a discharge of 40 cfs the TMDL = 64.56 lbs TN/day.

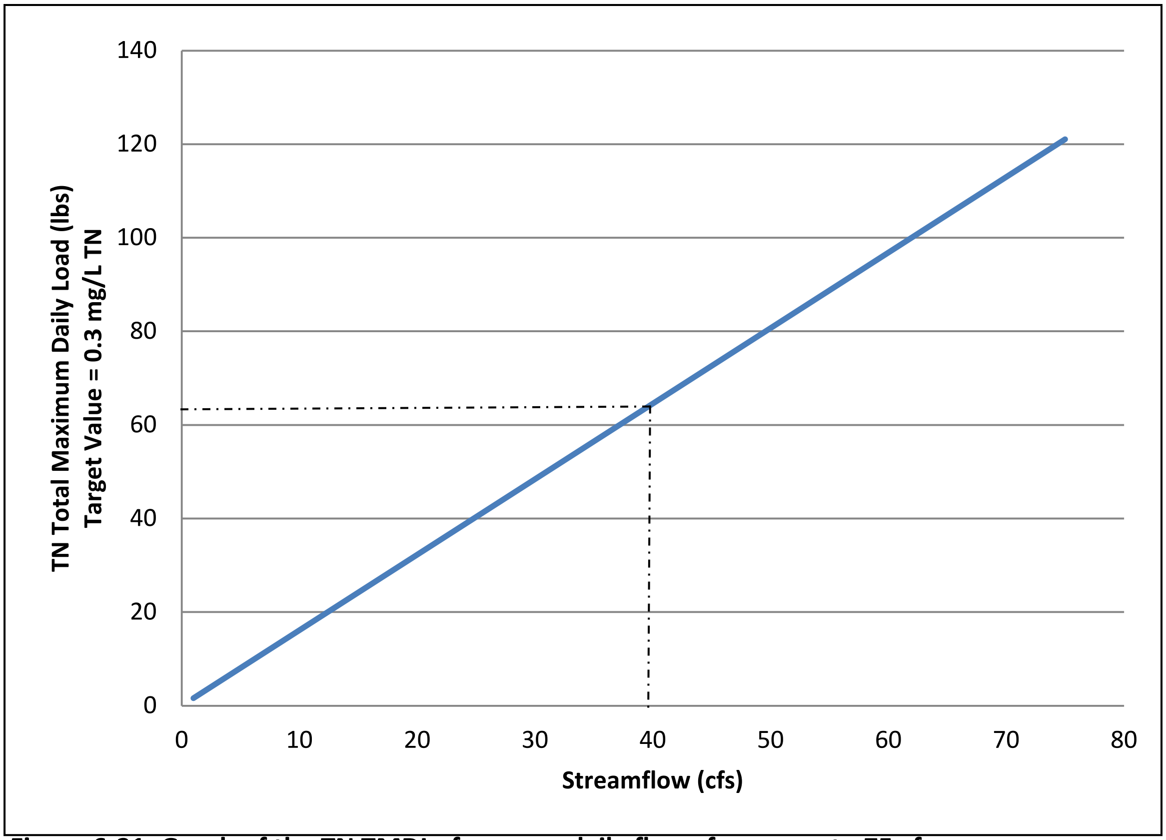

Figure 6-31. Graph of the TN TMDLs for mean daily flows from zero to 75 cfs.

6.6.1 Allocation Approach

Widespread improvements are needed to decrease nutrient loading and meet TMDLs in many streams. Necessary agricultural BMPs may include, but are not limited to, improved riparian buffers, rotational grazing, and fertilizer management. These efforts focus on the distribution, usage, and timing on the landscape. For instance, limiting livestock access to streams with fencing, providing alternate water sources, and/or installing hardened crossings will reduce direct nutrient inputs to streams, increase streambank stability, and improve the riparian buffer health. All of these factors will be essential for meeting both the nutrient and sediment TMDLs.

A combination of BMPs will help reduce nutrient loading, and the most appropriate BMPs will vary by site. Subsurface wastewater treatment and disposal loading is typically a fairly small portion of existing nutrient loading in most waterbody segments (**Figures 6-2 through 6-13**). In assessment units where subsurface wastewater treatment and disposal constitutes relatively large fractions of the nutrient load, long-term planning that recognizes the effects of developed areas on nutrient loading is warranted. This applies specifically to lower Hyalite Creek, Bozeman Creek and the East Gallatin River drainages. As part of this effort, BMPs are also needed to reduce nutrient loading from residential and urban areas to decrease the nutrient inputs from lawn maintenance, pet waste, and impervious surfaces.

Although the needed reductions (based on sample data) apply only to the growing season for nonpoint sources, DEQ anticipates that TMDL implementation will reduce nutrient loading year-round. This will address nutrients sources that tend to enter streams during runoff but which are stored in-channel, becoming available during the summer growing season.

Wasteload allocations (WLAs) were developed for the city of Bozeman WRF, the city of Bozeman MS4, and the USFWS Fish Technology Center. WLAs are relegated to the middle and lower segments of the East Gallatin River and Bridger Creek. For these assessment units, the TMDL will be the sum of the WLAs and load allocations (LAs). The WLA for the city of Bozeman MS4 is unique because during normal low flow conditions it equals zero for this point source. When the MS4 is activated, load reductions are based on the successful implementation of a stormwater management program. Therefore, since the system should not be actively discharging during typical summer low flow conditions which the TMDL represents, both the existing load and WLA are defined as 0 (zero).

Smith Creek and Lower Hyalite Creek, which receive flows from the East Gallatin River via irrigation canals, are affected by WLAs, although there is no WLA in their sub-basin. In these cases, two distinct sources are causing the nutrient impairment; the nonpoint nutrient sources in their respective watersheds and a separate source pathway comprised of the WRF discharge and other nonpoint sources that cross a watershed boundary to enter their basin. For Hyalite Creek, this pathway is Buster Gulch and for Smith Creek, the Dry Creek Irrigation Canal is the pathway from a different watershed. However, TMDL examples for Smith Creek and Hyalite Creek do not include the transported loads from the East Gallatin River as these loads and the necessary reductions are covered by TMDLs for the East Gallatin River.

TMDLs and necessary reductions will be presented first for those assessment units with WLAs. All nutrient TMDLs include an implicit margin of safety, which is based on conservative assumptions as described in **Section 6.6.4.2**.

6.6.1.1 City of Bozeman Water Reclamation Facility (MT0022608) WLA

The Bozeman Water Reclamation Facility (WRF) discharges directly into the East Gallatin River, which is impaired for TN and TP. Per Montana State Law (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. For a WRF and other permitted dischargers, this means that a discharge concentration must be less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the WRF discharge is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water.

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The draft numeric nutrient criteria provide the basis for the TMDL targets. The reach of the East Fork of the Gallatin River immediately upstream of the Bozeman WRF discharge is impaired for both TN and TP based on application of the TMDL targets and DEQ's nutrient assessment methodology. To ensure the Bozeman WRF discharge does not cause or contribute to a violation of water quality standards, the wasteload allocation (WLA) is based on a discharge concentration equal to the nutrient target concentrations for both TN and TP multiplied by the WRF discharge flow. Therefore, the resulting nutrient WLAs are based on the following equations:

Equation 1: TN WLA = TMDL TN Target Concentration X Discharge Flow = (0.300 mg/l) (Discharge Flow) x Conversion Factor

Equation 2: TP WLA = TMDL TP Target Concentration X Discharge Flow = (0.030 mg/l) (Discharge Flow) x Conversion Factor

For both Equation 1 and 2, the target concentrations are lower than current limits of technology for treatment of wastewater effluent.

The WLAs for TN and TP are represented in **Figure 6-32**, which identifies the allowable load to the East Gallatin River based on the discharge rate from the WRF. For reference, the summer period long-term mean discharge from the WRF is 8.34 cfs (5.39 MGD) and the design capacity for the facility is 21.5 cfs (13.9 MGD).

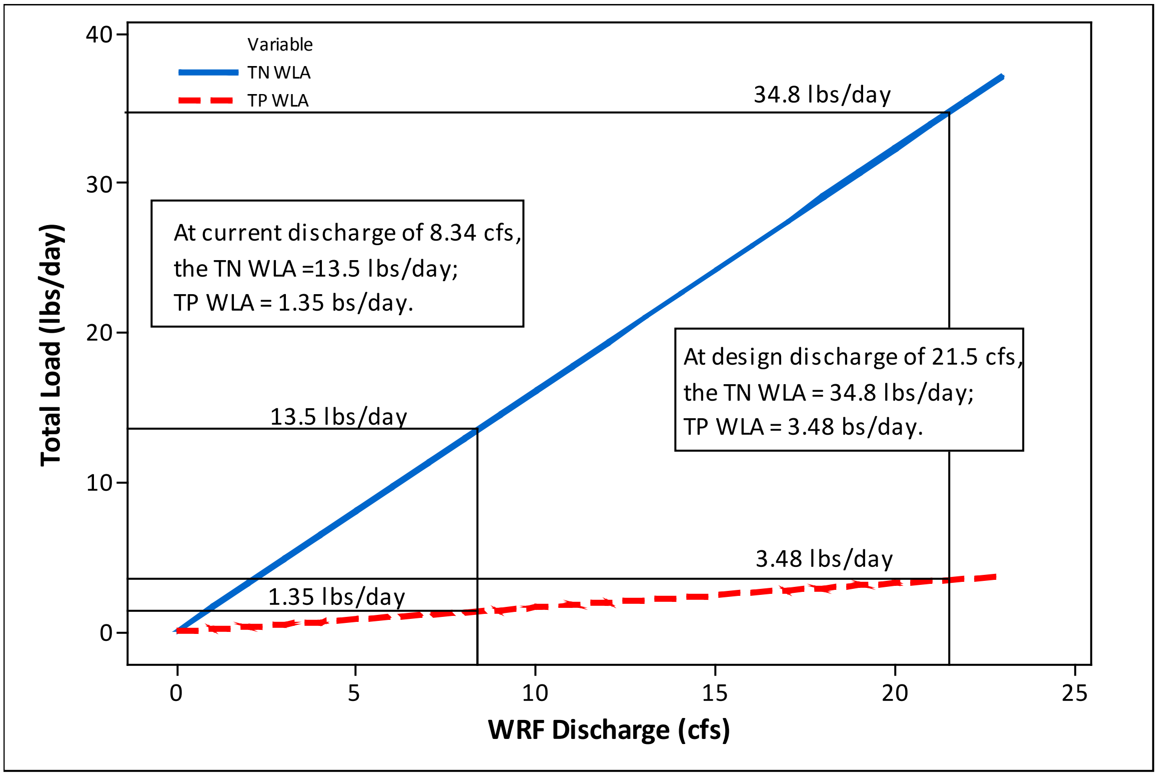

Figure 6-32. Wasteload allocation for Total Nitrogen and Total Phosphorus for the city of Bozeman WRF

At the design capacity discharge flow of 21.5 cfs, the TN WLA equates to 34.8 lbs/day per Equation 1 (discharge concentration of 0.300 mg/l), and the TP WLA equates to 3.48 lbs/day per Equation 2 (discharge concentration of 0.030 mg/l). When WRF discharge flows are lower than the design flow, the maximum TN concentrations of 0.300 mg/l and the maximum TP concentration of 0.030 mg/l must be met to satisfy the Equation 1 and Equation 2 WLA conditions, resulting in lower WLAs. For example, at existing WRF discharge flows of 8.34 cfs, the TN WLA equates to 13.5 lbs/day, and the TP WLA equates to 1.35 lbs/day. For all WRF discharge flows, WRF TN and TP loads will not cause or contribute to impairment as long as the discharge concentration is equal to or less than the TMDL target concentrations shown in Equations 1 and 2.

Mixing Zone Allowance

If water quality in the East Gallatin River in the reach immediately upstream of the Bozeman WRF discharge location improves to the point where either the TP or TN water quality target or adopted numeric nutrient standard is met, then the TN and/or TP WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July through September under 14Q5 flow conditions. For a given stream, 14Q5 refers to the 14 day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

Phased Implementation of Nutrient Wasteload Allocations

The TMDL targets represent concentrations below the current limits of treatment technology for TN and TP. MPDES permits provides a regulatory mechanism for implementing the TMDL via the variance process, once nutrient standards are adopted into rule, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 MCA) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing time enough to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for TN and TP for the Bozeman WRF defined in this TMDL allows phased implementation consistent with the variance process. There are two phased implementation scenarios based on whether numeric nutrient standards are adopted at the time a MPDES permit is renewed:

<u>Scenario 1: Numeric Nutrient Standards Adopted into Rule</u>

When the city of Bozeman renews its MPDES permit, it can apply for a variance as part of a phased implementation approach for one or both nutrient WLAs. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted.

<u>Scenario 2: Numeric Nutrient Standards Not Adopted into Rule</u>

- **Phased WLAs for Total Nitrogen (no numeric TN standard)**
  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TN in the 2017 permit will be based on the WRF discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility of 7.5 mg/L TN or (2) the long-term DMR average TN concentration after the 2011 facility upgrade. The WLA for TN in the

2022 permit will be based on the WRF discharge flow at that time multiplied by the then current limit of technology for TN. Regarding future permit cycles starting in 2017, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TN, then a specific plan to optimize TN treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TN concentration feasible at the facility. This concentration will be the basis for calculating the TN WLA using the WRF discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

Phased implementation will no longer be necessary once 1) the WRF is able to meet the WLA value defined by Equation 1 (i.e. discharge concentrations less than or equal to 0.300 mg/l), or 2) the East Gallatin River gains assimilative capacity and the WRF meets the mixing zone allowance requirements for TN treatment (defined above).

- **Phased WLAs for Total Phosphorus (no numeric TP standard)**
  No action is necessary until the next permit renewal scheduled for 2017. The WLA for TP in the 2017 permit will be based on the WRF discharge flow at that time multiplied by the lower of the two following concentrations: (1) the design performance at the facility of 1.0 mg/L TP or (2) the long-term DMR average TP concentration after the 2011 facility upgrade. The WLA for TP in the 2022 permit will be based on the WRF discharge flow at that time multiplied by the then current limit of technology for TP. Regarding future permit cycles starting in 2017, the TN limit of technology will be defined by DEQ in conjunction with the Nutrient Work Group. In 2022, if the plant is not capable of meeting the limit of technology for TP, then a specific plan to optimize TP treatment capabilities will be required for the 2022 permit renewal outlining specific measures and plant management protocols that will result in the lowest TP concentration feasible at the facility. This concentration will be the basis for calculating the TP WLA using the WRF discharge flow in 2022. The process outlined here for the 2022 permit cycle will be applied for all subsequent permits.

  Phased implementation will no longer be necessary once 1) the WRF is able to meet the WLA value defined by Equation 2 (i.e. discharge concentrations less than or equal to 0.030 mg/l), or 2) the East Gallatin River gains assimilative capacity and the WRF meets the mixing zone allowance requirements for TP treatment (defined above).

  Under Scenario 2, a timeline of how DEQ anticipates the phased implementation of the Bozeman WRF WLA to occur (**Figure 6-33**).

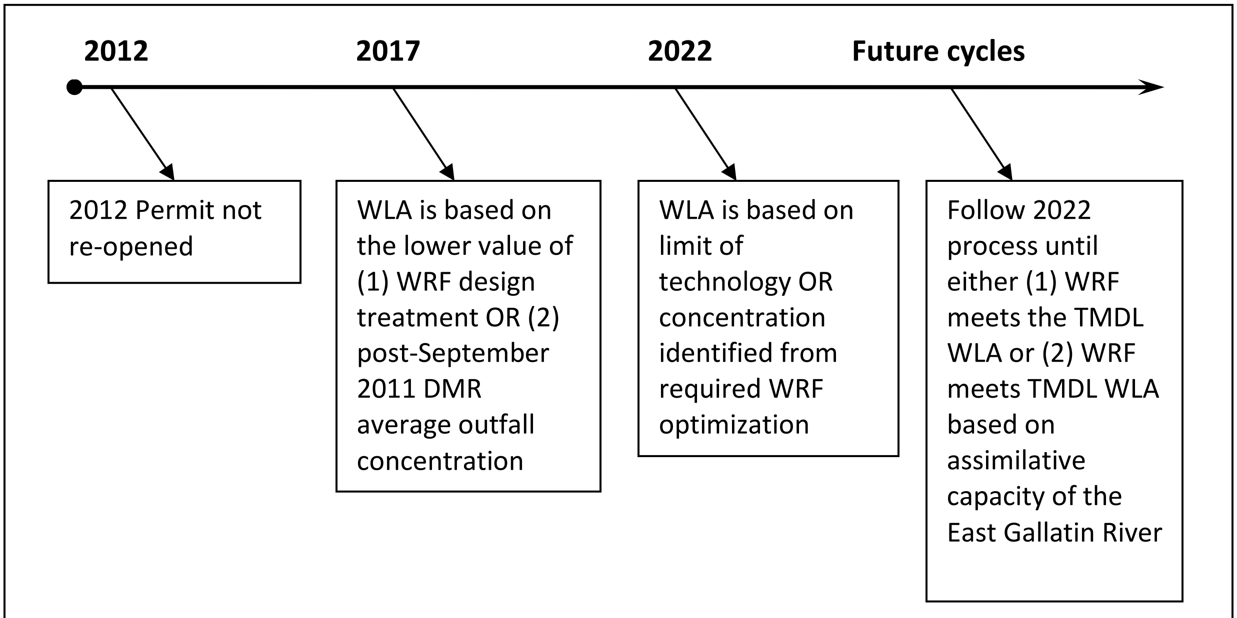

Figure 6-33. DEQ anticipated timeline of the phased implementation of the Bozeman WRF WLA

The Bozeman WRF permit was recently renewed in 2012, and the next renewal (after EPA approval of this TMDL) is scheduled for 2017. Because the Bozeman WRF is currently treating at levels approaching or consistent with the limits of technology for both TN and TP, and because these treatment levels are consistent with phased implementation as defined under both scenarios, the existing permit does not need to be reopened before 2017 to integrate the WLAs defined in this document.

During phased implementation, the total nitrogen and total phosphorus WLAs can be alternatively expressed as concentrations (versus loads) so that a concentration-based approach can be used for MPDES permit development using the phased implementation concentrations provided above. If a concentration based approach is not used for MPDES permit integration, then the WLA should be based on the phased implementation concentrations multiplied by the WRF discharge flow at that time (versus the design flow). This could create a loading cap until the next permit cycle when the WLA can be recalculated using an updated WRF average discharge flow.

Nutrient Trading

Montana is developing a nutrient trading program to allow point source dischargers to use trading as a cost-effective method of achieving the state’s numeric criteria for nutrients. Trading is a market-based approach in which a point source permittee purchases pollutant reduction credits from another point source or a nonpoint source in the applicable trading region. These credits are used to offset the source’s pollutant discharge obligations. Nothing in this TMDL document prevents nutrient trading as long as it is consistent with Montana’s nutrient trading program.

6.6.1.2 City of Bozeman MS4 Storm Water System (MTR040002) WLA

Per Part III.A. of the General Permit (MTR040000), the city’s, MSU’s and MDT’s Storm Water Management Program must address the pollutants of concern for which the receiving waterbodies are included on the state’s 303(d) list. This discussion must specifically address best management practices that will address the pollutants of concern.

Per EPA requirements at the federal level, NPDES-regulated stormwater discharges (MS4-permitted discharges) must be addressed by the wasteload allocation (WLA) of a TMDL (40 Code of Federal Regulations (C.F.R.) 130.2(h) & (i).). EPA requires a numeric WLA but allows a state permitting authority to apply best management practices to satisfy the WLA of a TMDL. Where appropriate, surrogate pollutant parameters (e.g., impervious cover) are acceptable for use as TMDL endpoints or other appropriate measures (40 C.F.R. 130(2)(i)).

At the state level, ARM 17.30.1111(5) requires MS4 permittees to develop, implement, and enforce a Storm Water Management Program (SWMP) to reduce the discharge of pollutants to the maximum extent practicable.

ARM 17.30.1111(5)(a) also states, "For the purposes of this rule, narrative effluent limitations requiring the implementation of BMPs are the most appropriate form of effluent limitations when designed to satisfy technology requirements (including reductions of pollutants to the maximum extent practicable) and to protect water quality. Implementation of BMPs consistent with the provisions of the SWMP required pursuant to this rule and the provisions of the permit shall constitute compliance with the standard of reducing pollutants to the 'maximum extent practicable.'"

The MS4 will be assigned a wasteload allocation of zero when the stormwater system is not activated. As required by the general permit, an illicit discharge detection and elimination program is necessary to achieve this WLA, which requires the permittees to regularly update the storm sewer system map, showing the location and number of all outfalls. Storm Water Ordinance 1763, adopted by the city of Bozeman in 2010, establishes legal authority to prohibit illicit discharges in the MS4. These measures will achieve the WLA when the system should not be producing flow. The illicit discharge detection and elimination program is critical for reducing chronic exceedances of water quality targets in the receiving waterbodies.

As discussed in the TMDL targets **Section 6.4**, there are two primary methods for evaluating target compliance based on nutrient concentrations. These include the exact binomial and student t-tests. Normally both tests are satisfied by setting the TMDL such that loading levels satisfy the target concentration values. This approach works in most watersheds in Montana because the best management practices (BMPs) required to meet the nutrient TMDLs during low flows are either somewhat independent of flow (e.g., septic systems) or will also limit elevated nutrient loading during stormwater events (e.g., grazing management). For streams that receive significant stormwater flows from MS4 permitted areas, an additional percent-load reduction WLA is developed for the MS4 to ensure compliance with the t-test and provide a margin of safety to help ensure compliance with the additional biology targets.

During and after precipitation, loading from the MS4 to the receiving waterbodies will be reduced by implementing ARM's (17.30.1111) "maximum extent practicable" and by monitoring stormwater BMPs within the MS4 boundaries. In addition to an active stormwater management program, these measures should achieve reductions in nutrient loads to the receiving waterbodies. Based on literature pollutant removal efficiencies, the maximum-extent-practicable level of treatment varies among BMPs for TN and TP. The International Storm Water Best Management Practices (BMPs) Database, published in 2010 for nutrients, lists retention ponds (59% decrease in concentration (DIC)), wetland basins (33% DIC), media filters (47% DIC), and wetland channels (22% DIC) as the BMPs that consistently reduced TP concentrations in stormwater. For TN, bioretention (12% DIC), retention ponds (27% DIC), and filter strips (13% DIC) BMPs consistently reduced TN concentrations in stormwater. For nitrogen, BMPs must target the type of nitrogen, since organic nitrogen is reduced differently than inorganic forms. Limited data from the city of Bozeman MS4 indicate that inorganic nitrogen comprises a larger proportion of TN than organic forms.

In order to maintain loading from the MS4 following implementation of the control measures, minimizing loading from new development, or redevelopment, projects greater than 1 acre will be important. Low-impact development BMPs minimize direct runoff to streams and use onsite or regional retention and infiltration to effectively remove direct discharge of stormwater to streams. The permit requires that projects that fit the above parameters infiltrate, evapotranspire, or capture for reuse the runoff generated from the first 0.5 inch of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation. This process was to be in place by January 1, 2012.

DEQ expects that by following the six minimum control measures outlined in the general permit, with particular attention to illicit discharge detection and elimination and stormwater BMPs, TN and TP loads to the receiving waterbodies will be reduced by 22% and 46%, respectively. These percent reductions are based on audit information of the City of Bozeman MS4 program and system and reductions possible from the available, applicable stormwater BMPs identified by USEPA that specifically target TN and TP.

Table 6-48. July 1–Sept 30 SWMM model results and anticipated reductions with BMP implementation for the city of Bozeman MS4

	TN Load (lbs/summer) SWMM model	TN Load (lbs/summer) Under BMP scenario	TP Load (lbs/summer) SWMM model	TP Load (lbs/summer) Under BMP scenario
Bozeman Creek	980.52	764.81	167.22	90.30
Bridger Creek	27.88	21.75	5.69	3.07
East Gallatin	4678.69	3649.38	747.03	403.40

Table 6-48 provides the estimated loads to each waterbody when the percent reductions are applied by watershed. As discussed above, the values and associated percent reductions are based on modeling results using characteristics of the MS4 and using literature estimates for the type of BMP loading reductions that could occur via a stormwater protection program, like the one required by the General MS4 permit. Therefore, the allocations can be satisfied by adhering to all of the requirements of the General MS4 permit. Further, it is unnecessary to include the TN and/or TP WLA values in **Table 6-48** as permit conditions will change in response to changes in WRF discharge. This is the most feasible approach for meeting WLAs, assuming that over time monitoring and other permit requirements will help provide the type of information that can be used to implement an adaptive management approach to meeting the applicable TMDLs and water quality protection goals and requirements.

Even when the MS4 meets the percent reduction WLA requirement, receiving waterbodies could occasionally have concentrations above the target concentrations presented in **Section 6.4.2** because of stormwater flows and pollutant concentrations. This is not an issue for compliance with targets and water quality standards since these excursions will be less than 20% of the summer growing season (July 1–September 30) and will be randomly spaced throughout that period. Where target exceedances do exist, but are less than 20%, it is desirable to have a somewhat random spacing of such exceedances similar to what would be anticipated from the city of Bozeman's MS4 stormwater system (Suplee et al., 2008a).

Ultimately, when the MS4 is activated, load reductions are based on the successful implementation of a stormwater management program. Therefore, since the system should not be actively discharging during typical summer low flow conditions, both the existing load and WLA are defined as 0 (zero).

6.6.1.3 USFWS Bozeman Fish Tech Center (MTG130006) WLA

Extensive water quality sampling on Bridger Creek indicates that the NO_3+NO_2 impairment is primarily limited to the stream reach below the Lyman Creek confluence downstream of the Fish Technology Center. Paired sampling above and below the Lyman Creek confluence from 2008 to 2011 observed water quality exceedances in 4 of 12 samples ~1.5 miles downstream of the Lyman Creek confluence near the mouth of Bridger Creek and none of 11 samples taken ~9 miles upstream of where Lyman Creek flows into Bridger Creek. NO_3+NO_2 was below the reporting limit for the only sample (collected on August 8, 2005) available for Bridger Creek immediately upstream of the center. The reporting limit was 0.05 mg/L for this sample. The NO_3+NO_2 impaired reach downstream of the center starts at the Lyman Creek confluence and is the result of downstream elevated controllable nitrate sources predominantly linked to land-use practices. Additional monitoring will be a requirement of the Fish Technology Center's WLA to ensure that the conditions upon which the WLA is based are maintained. Therefore, the TMDL for NO_3+NO_2 for Bridger Creek will focus on obtaining load reductions for the reach below the Lyman Creek confluence and maintaining existing water quality in the reaches above the Lyman Creek confluence (**Figure 6-34**).

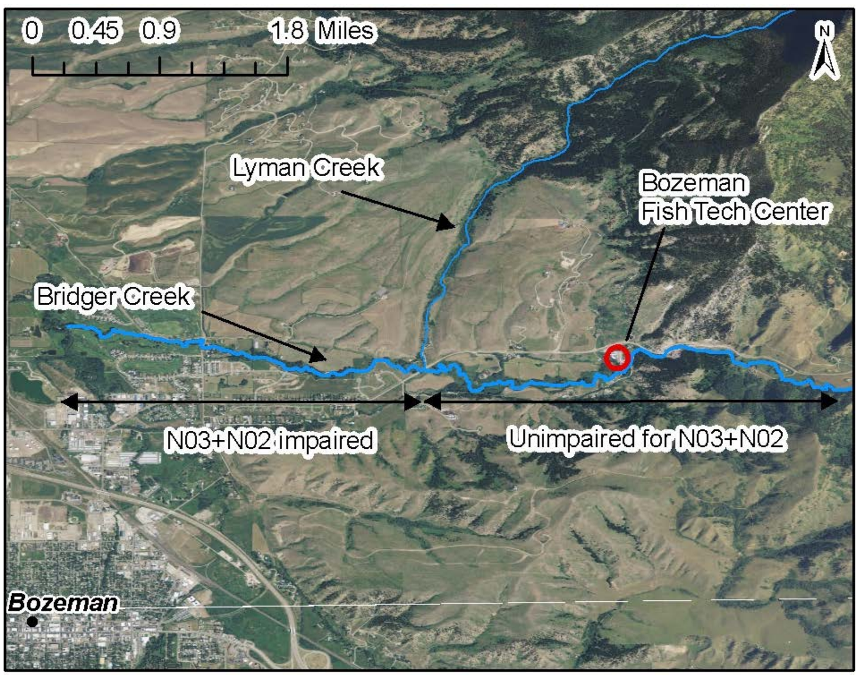

Figure 6-34. Delineation of segments above and below the Lyman Creek confluence in the Bridger Creek watershed

Because the Fish Technology Center discharge is not entering an impaired reach of Bridger Creek, and is contributing only 4% of the total inorganic nitrogen load to the creek below the Lyman Creek confluence, a WLA of 0.777 lb/day, equal to the current discharge load, will be given to the facility. Operations at the research facility must not exceed the existing load. Conservative estimates of TN loading from the facility do not cause a water quality impairment in Bridger Creek for TN in the reach where the discharge occurs. The facility will be encouraged to implement nutrient sampling for TN, TP, and NO_3+NO_2 of the hatchery discharge and in Bridger Creek below the mixing zone.

6.6.2 Meeting Allocations

The first critical step toward meeting the nutrient allocations involves applying and/or maintaining the land management practices or BMPs that will reduce nutrient loading. Once these actions have been completed, the landowner/manager will have taken action consistent with the intent of the nutrient allocation for that site. For many nonpoint source activities, it may be several years before full load reduction is achieved, even though all BMPs are in effect. For example, riparian areas may take several years to fully recover and decrease nutrient loading after implementing grazing BMPs. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased nutrient loading.

Progress toward achieving TMDLs and individual allocations can be gauged by BMP implementation and improvement in, or attainment of, water quality targets defined in **Section 6.4.2**. Any effort to calculate loads and percent reductions for comparing with TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented here.

6.6.3 TMDLs and Allocations by Waterbody

TMDLs for impaired waterbodies are presented in the following sections. Example TMDLs and load allocations are presented in the following sections. How the tables were calculated and presented to the reader is explained in **Tables 6-49** and **6-50**. It is important to note that the TMDLs are presented as example tables based on water quality and flow statistics. The TMDL is always the sum of the LAs and WLAs for a given waterbody.

Table 6-49. Example TMDL table and explanation of calculations

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Includes all nonpoint and point sources in a given watershed (i.e. agriculture, forest, WWTP). If not listed, no load was attributed to that (i.e. no forest sources in Camp Creek drainage).	Per each source, an existing load was calculated based on the results of the source assessment. The total load was calculated using the observed median flow and concentration in a given assessment unit.	% reduction multiplied by existing load	% reduction multiplied by existing load	Sum of LAs + WLAs	Necessary reduction per category to meet the TMDL

*This applies to all assessment units except for the middle and lower segments of the East Gallatin River where a different approach was used and is explained in those sections.

Unless otherwise noted, % reductions were determined by assuming a 0% reduction for natural background and subsurface wastewater treatment and disposal and requiring uniform reductions for all other nonpoint sources.

Table 6-50. Explanation of load allocation calculations

Source	Load Allocations (%)*
Includes all nonpoint and point sources in a given watershed (i.e. agriculture, forest, WWTP). If not listed, no load was attributed to that category (i.e. no forest sources in Camp Creek drainage).	Calculated as allocation divided by TMDL in TMDL table

*If load reductions were not necessary, load was uniformly distributed among all identified nonpoint source categories.

The upper, middle and lower segments of the East Gallatin River, Bozeman Creek, Mandeville Creek and Bridger Creek have TMDLs that include wasteload allocations (WLAs). The Lower Gallatin TPA includes multiple irrigation ditch networks that cross sub-basin divides. On Hyalite Creek and Smith Creek—tributaries to the East Gallatin River—irrigation diversions on the East Gallatin River transport East Gallatin River flows to nutrient-impaired stream segments on Hyalite and Smith Creeks. All other streams are not under the influence of a WLA. Following are the nutrient TMDLs for each waterbody segment in the Lower Gallatin planning area.

6.6.3.1 Bridger Creek

The extensive water quality data available for Bridger Creek suggests that the NO_3+NO_2 impairment is limited to the lower reaches near the mouth and below the canyon. Therefore, the TMDL will focus on achieving reductions in the area of the basin downstream of the canyon mouth and below the Fish Technology Center discharge point.

As described in **Section 6.6.1.3**, extensive water quality sampling on Bridger Creek indicates that the NO_3+NO_2 impairment is primarily limited to the stream reach below the Lyman Creek confluence downstream of the Fish Technology Center. The USFWS Fish Tech Center has a wasteload allocation of 0.777 lb NO_3+NO_2 /day from the center. The WLA for the Fish Tech Center does not change with flow. Downstream of Bridger Canyon, documented inorganic nitrogen from springs comprise a large natural background/forest load to the assessment unit. Montana Fish, Wildlife & Parks (FWP) lists Bridger Creek below the canyon as chronically dewatered (i.e., in almost all years, dewatering is a significant problem).

The USFWS Fish Tech Center is 6% of the TMDL at the median flow rate of 25.33 cfs. Using median statistics for flow and concentrations from samples collected downstream of the Lyman Creek confluence, the TMDL for NO_3+NO_2 is currently being met (**Table 6-51**). Bridger Creek load allocations may be found in **Table 6-52**.

Table 6-51. Bridger Creek NO_3+NO_2 load and TMDL below canyon

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background/Forest	3.27	6.96			0.0%
Agriculture	1.15	2.45			0.0%
Residential/Developed	1.11	2.36			0.0%
Subsurface Wastewater Treatment and Disposal	0.52	1.10			0.0%
USFWS Fish Tech Center (MTG130006)	0.77		0.77		0.0%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	6.81			13.63	0.0%

* Based on a median flow of 25.3 cfs downstream of the Lyman Creek confluence; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

Table 6-52. Bridger Creek NO_3+NO_2 TMDL allocations

Source	Load Allocations (%)*
Natural Background/Forest	51.1%
Agriculture	17.9%
Residential/Developed	17.3%
Subsurface Wastewater Treatment and Disposal	8.1%
USFWS Fish Tech Center (MTG130006)	5.7%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a median flow of 25.3 cfs downstream of the Lyman Creek confluence; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

6.6.3.2 East Gallatin River, City of Bozeman Water Reclamation Facility

The city of Bozeman Water Reclamation Facility (WRF) completed an extensive upgrade in fall 2011, in addition to a smaller upgrade completed in November 2007. As part of this upgrade the outfall was moved several hundred feet upstream and closer to the physical location of the treatment facility. Because the plant is the most significant nutrient point source on the middle and lower segments of the East Gallatin River, a concentration based model was developed to determine the changes in WRF contributions to total concentrations at distances downstream of the WRF on the East Gallatin River. Given the available data for the system, there was not sufficient information about river biology, mass transfer functions, or other state-variables to implement a sophisticated mass-balance modeling approach. Synoptic sampling events from 2005 and 2009 were used to calibrate the concentration based model and to determine the relative contribution from all other sources. Estimated nutrient loads at points downstream of the WRF discharge were based on an East Gallatin River low flow analysis, design performance for the post-October 2011 facility and long term summer period mean discharge for the WRF. The model is presented and discussed in **Appendix G**.

Significant irrigation diversions on the East Gallatin River transport water to two impaired waterbodies addressed in this document. Buster Gulch diverts flow from the East Gallatin River about 2.8 miles downstream of the WRF discharge. Buster Gulch flows 6.2 miles to the lower segment of Hyalite Creek north of Airport Road about 1.5 miles upstream of where Hyalite Creek flows into the East Gallatin River. Approximately 9 miles downstream of the WRF discharge, the Dry Creek Irrigation Canal transports East Gallatin water north to Smith Creek.

6.6.3.3 East Gallatin, Middle Segment

The middle segment of the East Gallatin River has two different water quality standards for TN and TP because of the Level IV ecoregion Absaroka-Gallatin-Volcanics in the headwaters of Hyalite Creek, which flows into the East Gallatin River northeast of Belgrade (**Figure 6-35**). The TN and TP water quality criteria for the East Gallatin River below Bridger Canyon and above the confluence with Hyalite Creek is 0.3 mg/L TN and 0.03 mg/L TP. Below the Hyalite Creek confluence down to the Gallatin River, the targets are 0.29 mg/L TN and 0.06 mg/L TP. For this reason TMDLs and percent-load reductions are different for the two reaches (Reach 1 and Reach 2).

The TN WLA for Bozeman's WRF requires a reduction in TN loading of 91% from current discharge loads into the East Gallatin River. This reduction is based on meeting the end-of-pipe water quality targets for TN in comparison with the current facility discharge load to the East Gallatin River. An 89% reduction in loading agriculture and residential/developed area sources is required to achieve the TN TMDL (**Table 6-53 and 6-54**).

Tables 6-53 and **6-54** are example TMDL tables that used the estimated 14Q5 flows and modeled TN concentrations at sampling site EG07 located downstream of the WRF discharge location and upstream of the Buster Gulch diversion and the Hyalite Creek confluence.

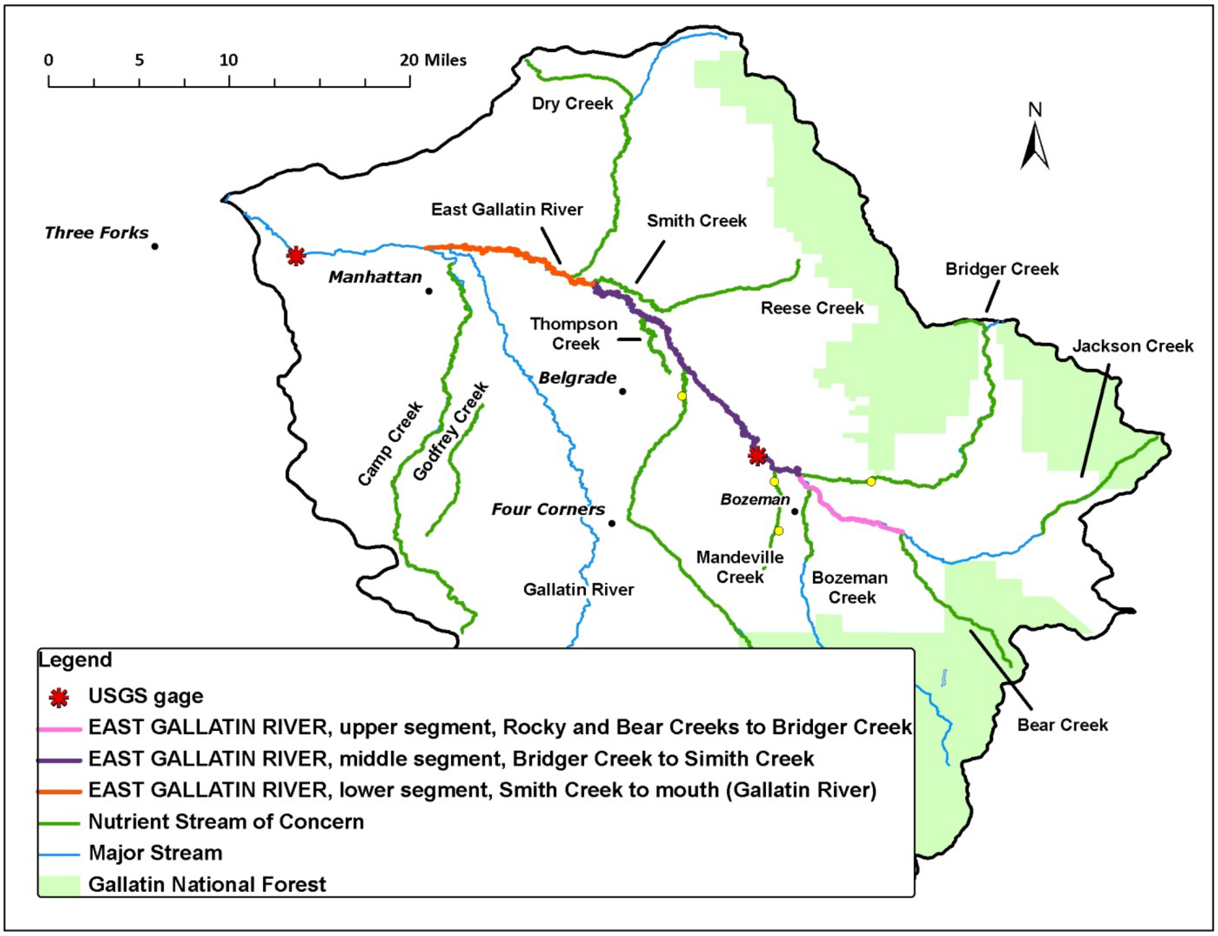

Figure 6-35. Map of East Gallatin River upper, middle and lower assessment units.

TN and TP TMDLs and Allocations for Reach 1 of the middle segment

Table 6-53. East Gallatin River TN load and TMDL between Bridger Creek and Hyalite Creek confluences

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural background	19.25	19.25			0.0%
Forest	4.10	4.10			0.0%
Agriculture	39.33	4.22			89.3%
Residential/Developed	55.59	5.96			89.3%
Subsurface Wastewater Treatment and Disposal	13.31	13.31			0.0%
USFWS Fish Tech Center (MTG130006)	0.34		0.34		0.0%
City of Bozeman WRF (MT0022608)	148.97		13.62***		90.9%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	280.89			60.80	78.4%

Table 6-54. East Gallatin River TN TMDL allocations between Bridger Creek and Hyalite Creek confluences

Source	Load Allocations (%)*
Natural background	31.7%
Forest	6.7%
Agriculture	11.1%
Residential/Developed	15.6%
Subsurface Wastewater Treatment and Disposal	21.9%
USFWS Fish Tech Center (MTG130006)	0.6%
City of Bozeman WRF (MT0022608)	12.4%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 37.6 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

The TP WLA for Bozeman's WRF requires a reduction in TN loading of 97% from current discharge loads into the East Gallatin River. This reduction is based on meeting the end-of-pipe water quality targets for TP in comparison with the current facility design load to the East Gallatin River. This reduction in loading from the WRF would achieve the TMDL as the WRF is most significant TP source in this segment (**Table 6-55 and 6-55**).

Table 6-55. East Gallatin River TP load and TMDL between Bridger Creek and Hyalite Creek confluences

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural background	2.03	2.03			0.0%
Forest	0.25	0.25			0.0%
Agriculture	0.64	0.71			0.0%
Residential/Developed	1.71	1.88			0.0%
Subsurface Wastewater Treatment and Disposal	0.62	0.62			0.0%
City of Bozeman WRF (MT0022608)	19.88		0.60***		97.0%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	25.13			6.08	75.8%

* Based on a flow of 37.6 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time; *** Based on discharge of 8.34 cfs at 0.030 mg/L TP, the value represents the modeled WRF concentration 0.5 miles downstream of the discharge location; the target of 0.030 mg/L TP is below the current limit of technology for treatment of wastewater effluent.

Table 6-56. East Gallatin River TP TMDL allocations between Bridger Creek and Hyalite Creek confluences

Source	Load Allocations (% of TMDL)*
Natural background	33.3%
Forest	4.2%
Agriculture	11.6%
Residential/Developed	30.9%
Subsurface Wastewater Treatment and Disposal	10.1%
City of Bozeman WRF (MT0022608)	9.8%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a median flow of 37.6 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

TN and TP TMDLs and Allocations for Reach 2 of the middle segment

In the middle segment of the East Gallatin River below the Hyalite Creek confluence and above the Smith Creek confluence, the TN TMDL requires a 93% reduction in loading from all agriculture and residential/developed area nonpoint sources (LAs) (**Table 6-57 and 6-58**) in addition to a 95% reduction from the WRF. A 20% reduction in loading from subsurface wastewater treatment and disposal is also needed to meet the TMDL. The Hyalite Creek watershed is the primary source of TN in this reach and brings TN loads from agriculture/residential developed sources and subsurface wastewater disposal and treatment. In reach 2, a WLA for the USFWS Fish Tech Center (MTG130006) is no longer provided due to dilution and assumed uptake rates the load is no longer measurable.

Table 6-57. East Gallatin River TN load and TMDL between Hyalite Creek and Smith Creek confluences

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural background	29.12	29.12			0.0%
Forest	3.34	3.34			0.0%
Agriculture	109.74	7.32			93.3%
Residential/Developed	17.62	1.18			93.3%
Subsurface Wastewater Treatment and Disposal	55.09	44.07			20.0%
City of Bozeman WRF (MT0022608)	156.25		7.77***		95.0%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	371.15			92.79	75.0%

* Based on a flow of 59.5 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time; *** Based on discharge of 8.34 cfs at 0.300 mg/L TN, the value represents the modeled WRF concentration 10.8 miles downstream of the discharge location; the target of 0.300 mg/L TN is below the current limit of technology for treatment of wastewater effluent.

Table 6-58. East Gallatin River TN TMDL allocations between Hyalite Creek and Smith Creek confluences

Source	Load Allocations (%)*
Natural background	31.4%
Forest	3.6%
Agriculture	7.9%
Residential/Developed	1.3%
Subsurface Wastewater Treatment and Disposal	47.5%
City of Bozeman WRF (MT0022608)	8.4%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 59.5 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

Of all the assessment units in the Lower Gallatin watershed, reach 2 of the middle segment of the East Gallatin River from the Hyalite Creek confluence to the Smith Creek confluence is the most complicated. Numerous sources contribute to the reach including the WRF discharge and the large TN load from Hyalite Creek. The Hyalite Creek drainage includes areas of high septic density and large acreages of irrigated agriculture. Additionally, the lower segment of Hyalite Creek has been identified by FWP as being chronically dewatered reducing its ability to assimilate nutrient loads. This area of the East Gallatin River is also a significant groundwater recharge area and likely receives nutrient loads via medium and long distance groundwater flow paths. Significant reductions from multiple sources are needed in order to meet the TMDL.

It is critical to reaffirm that the above example for reach 2 of the middle segment is a worst-case scenario using the 14Q5 flow in the East Gallatin River. At these low flows, the influence from groundwater and point sources become more significant contributors to the total load than at higher flows. At higher flows, assimilative capacity of the waterbody increases and the TMDL is more likely to be achieved.

A 20% reduction in subsurface wastewater treatment and disposal is necessary to achieve the TMDL. Long-term strategies to meet this reduction may include retiring existing septic systems by providing sewer connections to existing wastewater treatment plants or Level 2 treatment system requirements for new or replacement septic systems. Although sewer hookups could increase loading to the East Gallatin River based on nutrient treatment from the septic system versus existing WRF treatment, the fact that the WRF WLA is ultimately set to obtain standards at the discharge location (**Section 6.6.1.1**) means that this approach will ultimately decrease TN (nitrate) loading to the East Gallatin River while still eventually satisfying all TMDL requirements once phased implementation of the city of Bozeman WRF WLA is complete. If the basin continues to be developed for residences, long-term planning is needed for subsurface wastewater treatment and disposal; as this load increases with the increase in residences and loss of agriculture.

Better study of the influence from groundwater nitrogen loading to Hyalite Creek and the East Gallatin River is recommended to more accurately quantify the nutrient loads from subsurface wastewater treatment and disposal and from agriculture.

The TP WLA for Bozeman's WRF requires a reduction in TP loading of 96% from current discharge loads into the East Gallatin River. This reduction is based on meeting the end-of-pipe water quality targets for TP in comparison with the current facility performance design load to the East Gallatin River. This reduction in loading from the WRF would achieve the TMDL as the WRF is most significant TP source in this segment (**Table 6-59 and 6-60**).

Table 6-59. East Gallatin River TP load and TMDL between Hyalite Creek and Smith Creek confluences

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural background	8.64	8.64			0.0%
Forest	0.00	0.16			0.0%
Agriculture	2.78	3.66			0.0%
Residential/Developed	1.85	2.79			0.0%
Subsurface Wastewater Treatment and Disposal	0.93	3.46			0.0%
City of Bozeman WRF (MT0022608)	11.95		0.48***		95.9%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	26.15			19.20	26.6%

* Based on a flow of 59.5 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time; *** Based on discharge of 8.34 cfs at 0.030 mg/L TP, the value represents the modeled WRF concentration 10.8 miles downstream of the discharge location; the target of 0.030 mg/L TP is below the current limit of technology for treatment of wastewater effluent.

Table 6-60. East Gallatin River TP TMDL allocations between Hyalite Creek and Smith Creek confluences

Source	Load Allocations (%)*
Natural background	45.0%
Forest	0.8%
Agriculture	19.1%
Residential/Developed	14.5%
Subsurface Wastewater Treatment and Disposal	18.0%
City of Bozeman WRF (MT0022608)	2.5%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 59.5 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

6.6.3.4 East Gallatin River, Lower Segment

The water quality targets for TN and TP in the lower segment are 0.300 mg/L TN and 0.030 mg/L TP. Downstream of the Smith Creek confluence the influence of the Level IV ecoregion Absaroka-Gallatin-Volcanics on the East Gallatin River has become negligible given the sum of additional inflows from multiple tributaries downstream of the Hyalite Creek confluence. In addition to the WRF reduction of 95%, the TMDL for the lower segment requires a 59% reduction in loading from agriculture and residential/developed nonpoint sources for TN (**Table 6-61 and 6-62**).

Table 6-61. East Gallatin River TN load and TMDL between Smith Creek confluence and the Gallatin River

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	74.20	74.20			0.0%
Forest	3.72	3.72			0.0%
Agriculture	239.60	99.35			58.5%
Residential/Developed	39.52	16.39			58.5%
Subsurface Wastewater Treatment and Disposal	36.69	36.69			0.0%
City of Bozeman WRF (MT0022608)	78.18		3.98***		94.9%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	471.91			234.32	50.3%

* Based on a flow of 145.2 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time; *** Based on discharge of 8.34 cfs at 0.300 mg/L TN, the value represents the modeled WRF concentration 26.6 miles downstream of the discharge location; the target of 0.300 mg/L TN is below the current limit of technology for treatment of wastewater effluent.

Table 6-62. East Gallatin River TN TMDL allocations between Smith Creek confluence and the Gallatin River

Source	Load Allocations (%)*
Natural background	31.7%
Forest	1.6%
Agriculture	42.4%
Residential/Developed	7.0%
Subsurface Wastewater Treatment and Disposal	15.7%
City of Bozeman WRF (MT0022608)	1.7%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 145.2 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

The lower segment of the East Gallatin River downstream of the Smith Creek confluence is currently meeting the TMDL for TP (**Table 6-63 and 6-64**). The WLA for the Bozeman WRF also applies to this segment and will reduce the existing TP load.

Table 6-63. East Gallatin River TP load and TMDL between Smith Creek confluence and the Gallatin River

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	7.81	7.81			0.0%
Forest	0.05	0.52			0.0%
Agriculture	0.93	10.40			0.0%
Residential/Developed	0.28	3.12			0.0%
Subsurface Wastewater Treatment and Disposal	0.13	1.48			0.0%
City of Bozeman WRF (MT0022608)	2.58		0.10***		96.0%
City of Bozeman MS4 (MTR040002)**	0.00		0.00		0.0%
Total	11.78			23.43	0.0%

* Based on a flow of 145.2 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time; *** Based on discharge of 8.34 cfs at 0.030 mg/L TP, the value represents the modeled WRF concentration 26.6 miles downstream of the discharge location; the target of 0.030 mg/L TP is below the current limit of technology for treatment of wastewater effluent.

Table 6-64. East Gallatin River TP TMDL allocations between Smith Creek confluence and the Gallatin River

Source	Load Allocations (%)*
Natural background	33.3%
Forest	2.2%
Agriculture	44.4%
Residential/Developed	13.3%
Subsurface Wastewater Treatment and Disposal	6.3%
City of Bozeman WRF (MT0022608)	0.4%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 145.2 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time.

6.6.3.5 Lower Hyalite Creek

The TN TMDL for lower Hyalite Creek does not include the TN load transported to Hyalite Creek from the East Gallatin River via Buster Gulch. This load is addressed by the TN TMDL for the middle segment of the East Gallatin River (**Section 6.6.3.3**).

Reductions necessary to achieve the TN TMDL for waters originating in the Hyalite Creek basin are outlined in **Table 6-65**. Allocations may be found in **Table 6-66**. These reductions need to come from two primary nonpoint source s in the basin: agriculture (cropping and pasture/rangeland) and residential /developed. In Lower Hyalite Creek, agriculture and residential/developed nonpoint sources will need to be reduced 84% to meet the TMDL.

Additional study is likely needed to determine appropriate strategies for reducing the TN loading from subsurface wastewater treatment and disposal. If the basin continues to be developed, long-term planning is needed for subsurface wastewater treatment and disposal as this load will increase with the increase in houses and loss of agriculture. Therefore, SWTD loading to Hyalite Creek should be limited pending further investigation into the timing and delivery of SWTD loads to Hyalite Creek. For this TMDL, the 0% reduction LA for SWTD load can be interpreted as a 0% increase in this load through time.

It is important to note that chronic dewatering of Hyalite Creek downstream of the forest boundary decreases dilution and exacerbates the effects of nonpoint source nutrient additions. Montana FWP identifies Hyalite Creek below the forest boundary as chronically dewatered (i.e., in almost all years, dewatering is a significant problem). As outlined in the source assessment in **Appendix F,** the upper portion of the 21-mile long assessment unit was not considered a source area as the stream is chronically dewatered in the lower reaches and flows (and therefore nutrient loads) from the upper portion are diverted at multiple locations through the assessment unit. Therefore, forest was not considered a source of TN in the lower Hyalite Creek drainage.

Table 6-65. Lower Hyalite Creek TN load and TMDL for Lower Hyalite Creek.

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	19.87	19.87		0.0%
Agriculture	38.92	6.12		84.3%
Residential/Developed	9.94	1.56		84.3%
Subsurface Wastewater Treatment and Disposal	33.95	33.95		0.0%
Total	102.68		61.50	40.1%

*Based on flow of 44.0 cfs

Table 6-66. Lower Hyalite Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	32.3%
Agriculture	9.9%
Residential/Developed	2.5%
Subsurface Wastewater Treatment and Disposal	55.2%
Total	100.0%

*Based on flow of 44.0 cfs

6.6.3.6 Smith Creek

There are three main sources of nutrients on Smith Creek: the Smith Creek watershed below the confluence of Reese Creek and Ross Creeks/Dry Creek Irrigation Canal (39.7%), the Ross Creek watershed (22.5%), and the East Gallatin River (37.8%). The Dry Creek Irrigation Canal diverts up to 32.5 cfs from the East Gallatin River approximately 4 miles downstream of the Hyalite Creek confluence and 9 miles downstream of the Bozeman WRF discharge point. That portion of the load that is attributed to the East Gallatin River is not included in **Tables 6-67** and **6-68** as it has been previously addressed by a TN TMDL. **Tables 6-67** and **6-68** identify the existing nutrient loads and the necessary reductions from all sources to meet the TMDL.

The Dry Creek Irrigation Canal flows northward from the East Gallatin River and intersects Ross Creek (**Figure 6-36**). At this point, flows from the canal and Ross Creek continue northward in the same channel. Ross Creek originally continued northeastward to its confluence with Smith Creek but is now channelized along a private road to where it meets Reese Creek. At this intersection of flow, Ross Creek/Dry Creek Irrigation Canal flow from the south and join Reese Creek from the east. The Dry Creek Irrigation Canal continues northward. The confluence marks the start of Smith Creek, which flows westward to the East Gallatin River. Because there is no headgate or diversion that separates flows at this intersection, water quality analyses assumed that during the summer period Reese Creek flows are forced into the Dry Creek Irrigation Canal, which flows northward with a mix of Ross Creek, Reese Creek, and East Gallatin River flows. Smith Creek flows westward with a mixture of Ross Creek and East Gallatin River flow. Under this assumption, the Reese Creek watershed is not a source of nutrient impairments on Smith Creek during the summer period when the irrigation canal is flowing.

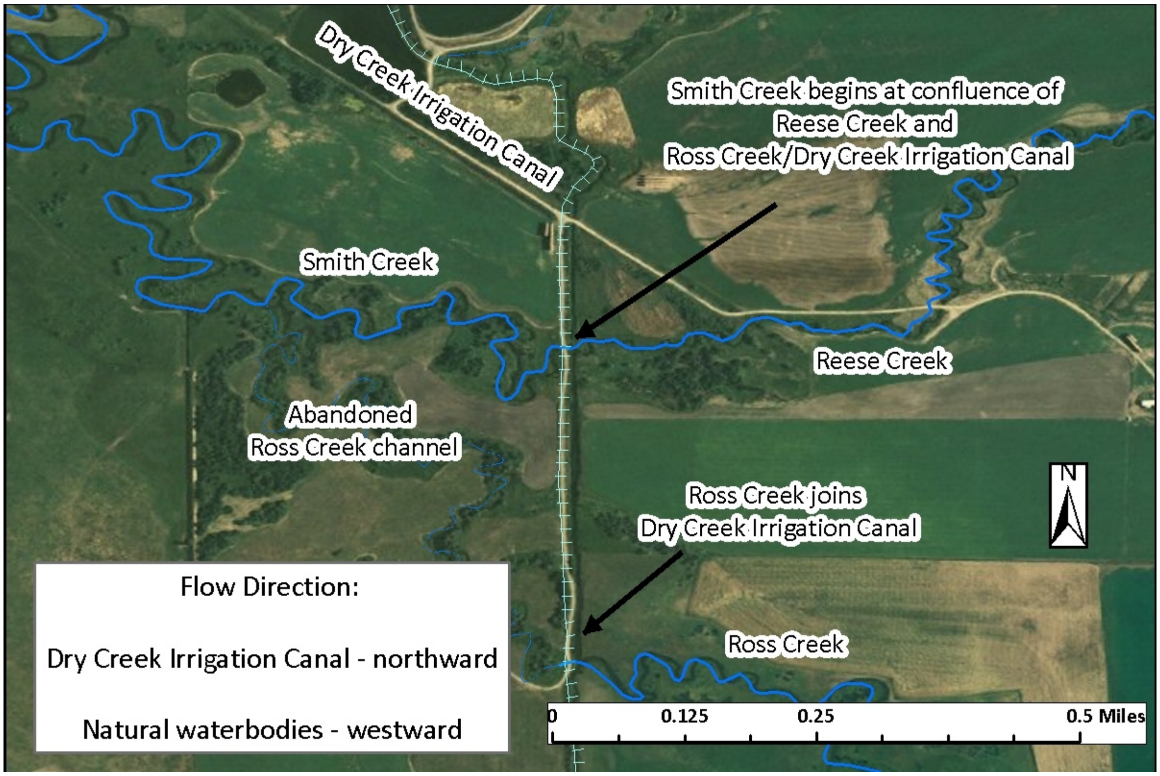

Figure 6-36. Confluence of Ross, Reese, and Smith Creeks and influence of Dry Creek Irrigation Canal

If the East Gallatin River TMDL is achieved, a further reduction of 33% is necessary in the Smith Creek watershed to meet the TMDL for TN. Allowing a 0% reduction in natural background and forest and agricultural sources need to be reduced 42% to meet the TMDL for TN. For the NO_3+NO_2 TMDL, a 78% reduction in loading is needed (**Table 6-69**). Allocations are in **Table 6-70**. Allowing a 0% reduction in SWTD, natural background/forest and agricultural sources need to be reduced 79% to meet the TMDL for NO_3+NO_2. Differences in necessary reductions are due to the NO_3+NO_2 target value (0.1 mg/L) being much lower than the TN target value (0.3 mg/L).

Because East Gallatin flow is transported by an irrigation canal, a WLA is not assigned to the Smith Creek TMDLs for TN or NO_3+NO_2.

Table 6-67. Smith Creek TN load and TMDL for Smith Creek

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	16.16	16.16		0.0%
Forest	5.55	3.20		42.3%
Agriculture	53.98	31.15		42.3%
Subsurface Wastewater Treatment and Disposal	0.52	0.52		0.0%
Total	76.21		51.03	33.0%

*Based on flow of 31.6 cfs

Table 6-68. Smith Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Forest	6.3%
Agriculture	61.0%
Residential/Developed	0.0%
Subsurface Wastewater Treatment and Disposal	1.0%
Total	100.0%

*Based on flow of 31.6 cfs

Table 6-69. Smith Creek NO_3+NO_2 load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background/Forest	7.10	1.52		78.5%
Agriculture	69.04	14.82		78.5%
Subsurface Wastewater Treatment and Disposal	0.67	0.67		0.0%
Total	76.80		17.01	77.9%

*Based on flow of 31.6 cfs

Table 6-70. Smith Creek NO_3+NO_2 TMDL allocations

Source	Load Allocations (%)*
Natural Background/Forest	9.0%
Agriculture	87.1%
Subsurface Wastewater Treatment and Disposal	3.9%
Total	100.0%

*Based on flow of 31.6 cfs

6.6.3.7 Bear Creek

For the entire assessment unit, Bear Creek is currently meeting the TMDL for TP (**Table 6-71**). It has not been delisted because it has not met the minimum sample size necessary for a full assessment. However, there were a few exceedances of the water quality target for TP above the forest boundary. Water quality exceedances are likely event-driven, which delivers or re-suspends sediment in the channel. Fine-grained erosive soils in the canyon are at a higher risk of reaching the stream channel. Allocations are located in **Table 6-72**.

Table 6-71. Bear Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.15	0.15		0.0%
Forest	0.17	0.24		0.0%
Agriculture	0.03	0.04		0.0%
Residential/Developed	0.001	0.002		0.0%
Subsurface Wastewater Treatment and Disposal	0.01	0.02		0.0%
Total	0.36		0.45	0.0%

*Based on flow of 2.8 cfs

Table 6-72. Bear Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Forest	52.8%
Agriculture	8.1%
Residential/Developed	0.5%
Subsurface Wastewater Treatment and Disposal	5.3%
Total	100.0%

*Based on flow of 2.8 cfs

6.6.3.8 Bozeman Creek

To meet the TMDL in Bozeman Creek, the TN load must be reduced by 63% (**Table 6-73**). Tributaries to Bozeman Creek, Matthew Bird Creek and Nash Spring Creek contribute large TN loads to the stream. Bozeman Creek has several different sources of TN, including agriculture (27%), development (40%), and loading from subsurface wastewater disposal and treatment systems (20%). There is a 10% reduction for the subsurface wastewater treatment and disposal. This reduction over time is considered practical given the ability to retire existing septic systems by providing sewer connection to the Bozeman WRF through time. Although for some septic systems this could increase loading to the East Gallatin River based on nutrient treatment from the septic system versus existing WRF treatment, the fact that the WRF WLA is ultimately set to obtain standards at the discharge location (**Section 6.6.1.1**) means that this approach will ultimately decrease TN (nitrate) loading to Bozeman Creek while still eventually satisfying all TMDL requirements once phased implementation of the Bozeman WRF WLA is complete. In addition to sewer connections, other septic load reduction options in addition to or instead of sewer hookup. For example, another septic load reduction option can include Level 2 treatment system requirements for new or replacement septic systems. Source allocations are located in **Table 6-74**.

If the basin continues to be developed for residences, long-term planning is needed for subsurface wastewater treatment and disposal as this load increases with the increase in residences and loss of agriculture. In Bozeman Creek, even with a 10% reduction in TN loading from subsurface wastewater treatment and disposal, all other nonpoint sources will need to be reduced 89% to meet the TMDL. Additional study is likely needed to determine the appropriate strategies for reducing the TN loading from these sources, in particular for subsurface wastewater treatment and disposal.

Table 6-73. Bozeman Creek TN load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	10.95	10.95		0.0%
Forest	1.88	0.20		89.3%
Agriculture	25.07	2.69		89.3%
Residential/Developed	37.35	4.01		89.3%
Subsurface Wastewater Treatment and Disposal	18.81	16.93		10.0%
City of Bozeman MS4 (MTR040002)**	0.00		0.00	0.0%
Total	94.06		34.79	63.0%

* Based on a flow of 23.95 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

Table 6-74. Bozeman Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.5%
Forest	0.6%
Agriculture	7.7%
Residential/Developed	11.5%
Subsurface Wastewater Treatment and Disposal	48.7%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 23.95 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

6.6.3.9 Camp Creek

Because natural background and SWTD have 0% load reductions, other TN sources will need to be reduced 95% to achieve the TMDL (**Table 6-75**). The basin is dominated by irrigated and dryland cropping, although the data do suggest subsurface wastewater treatment and disposal are contributing a TN load. Elevated nitrogen in the form of nitrate in groundwater is likely the result of irrigated agriculture combined with fertilizer transport. Dryland farming in the upper reaches is contributing nitrate to the stream as well as soil nitrogen, since a large increase in load was observed where dryland cropping transitioned to irrigated agriculture. The largest TN source allocation is for subsurface wastewater treatment and disposal (**Table 6-76**).

The TMDL for TP requires a reduction of 84% from agricultural and residential/developed sources (**Table 6-77**). Existing data suggest this is a spring-fed system augmented by irrigation return flows. TP source allocations are found in **Table 6-78**.

The Amsterdam-Churchill WWTP is leaking about 85,000 gpd to groundwater relatively close to the creek. Improving the load from the Amsterdam-Churchill WWTP to design standards could decrease the needed TN reduction by 19% and the TP reduction by 7%.

Table 6-75. Camp Creek TN load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	2.61	2.61		0.0%
Agriculture	25.32	1.38		94.6%
Residential/Developed	3.49	0.19		94.6%
Subsurface Wastewater Treatment and Disposal	4.08	4.08		0.0%
Total	35.50		8.26	76.7%

* Based on a flow of 5.1 cfs

Table 6-76. Camp Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Agriculture	16.7%
Residential/Developed	2.3%
Subsurface Wastewater Treatment and Disposal	49.4%
Total	100.0%

* Based on a flow of 5.1 cfs

Table 6-77. Camp Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.28	0.28		0.0%
Agriculture	2.12	0.33		84.4%
Residential/Developed	0.26	0.04		84.4%
Subsurface Wastewater Treatment and Disposal	0.18	0.18		0.0%
Total	2.83		0.83	70.9%

* Based on a flow of 5.1 cfs

Table 6-78. Camp Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Agriculture	40.1%
Residential/Developed	5.0%
Subsurface Wastewater Treatment and Disposal	21.6%
Total	100.0%

* Based on a flow of 5.1 cfs

6.6.3.10 Dry Creek

The TN TMDL for Dry Creek identified the Pass Creek drainage as the most significant source area of TN in the watershed (**Table 6-79**). Pass Creek is the largest tributary to Dry Creek in the Dry Creek watershed and flows westward from the Bridger Range to Dry Creek. This is attributed to the crop fallow and irrigated agriculture in the Pass Creek catchment as well as to the natural background/forest load from the Bridger Range. Influence of agriculture is supported by limited groundwater quality data in the basin. A total reduction from all nonpoint sources of 42% is needed to achieve the TMDL for TN, allowing for a 0% reduction in natural background, forest, and SWTD. TN allocations are in **Table 6-80**.

Table 6-79. Dry Creek TN load and TMDL for Dry Creek

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	3.86	3.86		0.0%
Forest	0.65	0.65		0.0%
Agriculture	11.24	6.50		42.2%
Residential/Developed	0.32	0.18		42.2%
Subsurface Wastewater Treatment and Disposal	1.00	1.00		0.0%
Total	17.07		12.19	28.6%

* Based on a flow of 7.6 cfs

Table 6-80. Dry Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Forest	5.3%
Agriculture	53.3%
Residential/Developed	1.5%
Subsurface Wastewater Treatment and Disposal	8.2%
Total	100.0%

* Based on a flow of 7.6 cfs

Based on limited sampling data, Dry Creek is currently meeting the TMDL for TP, since there have been no exceedances of the water quality standard (**Table 6-81**). The stream has remained listed for a TP impairment because it has not met the minimum sample size required to conduct a full assessment. Also, there is no biological data available for the stream. While no reduction is required, efforts should be made to not increase the TP load. TP source allocations may be found in **Table 6-82**.

Table 6-81. Dry Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.41	0.41		0.0%
Forest	0.02	0.03		0.0%
Agriculture	0.33	0.61		0.0%
Residential/Developed	0.08	0.14		0.0%
Subsurface Wastewater Treatment and Disposal	0.02	0.03		0.0%
Total	0.85		1.22	0.0%

* Based on a flow of 7.6 cfs

Table 6-82. Dry Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Forest	2.8%
Agriculture	49.9%
Residential/Developed	11.5%
Subsurface Wastewater Treatment and Disposal	2.5%
Total	100.0%

* Based on a flow of 7.6 cfs

6.6.3.11 East Gallatin River, Upper Segment

Because of the Level IV ecoregion Absaroka-Gallatin-Volcanics in the headwaters of Bozeman Creek, the TN water quality criteria for the segment of the Upper East Gallatin River above the confluence with Bozeman Creek is 0.30 mg/L; below it is 0.27 mg/L (**Figure 6-37**). For TP, the target above the Bozeman Creek confluence is 0.03 mg/L; below it is 0.05 mg/L. For this reason TMDLs and percent-load reductions are different for the two reaches (Reach 1 and Reach 2).

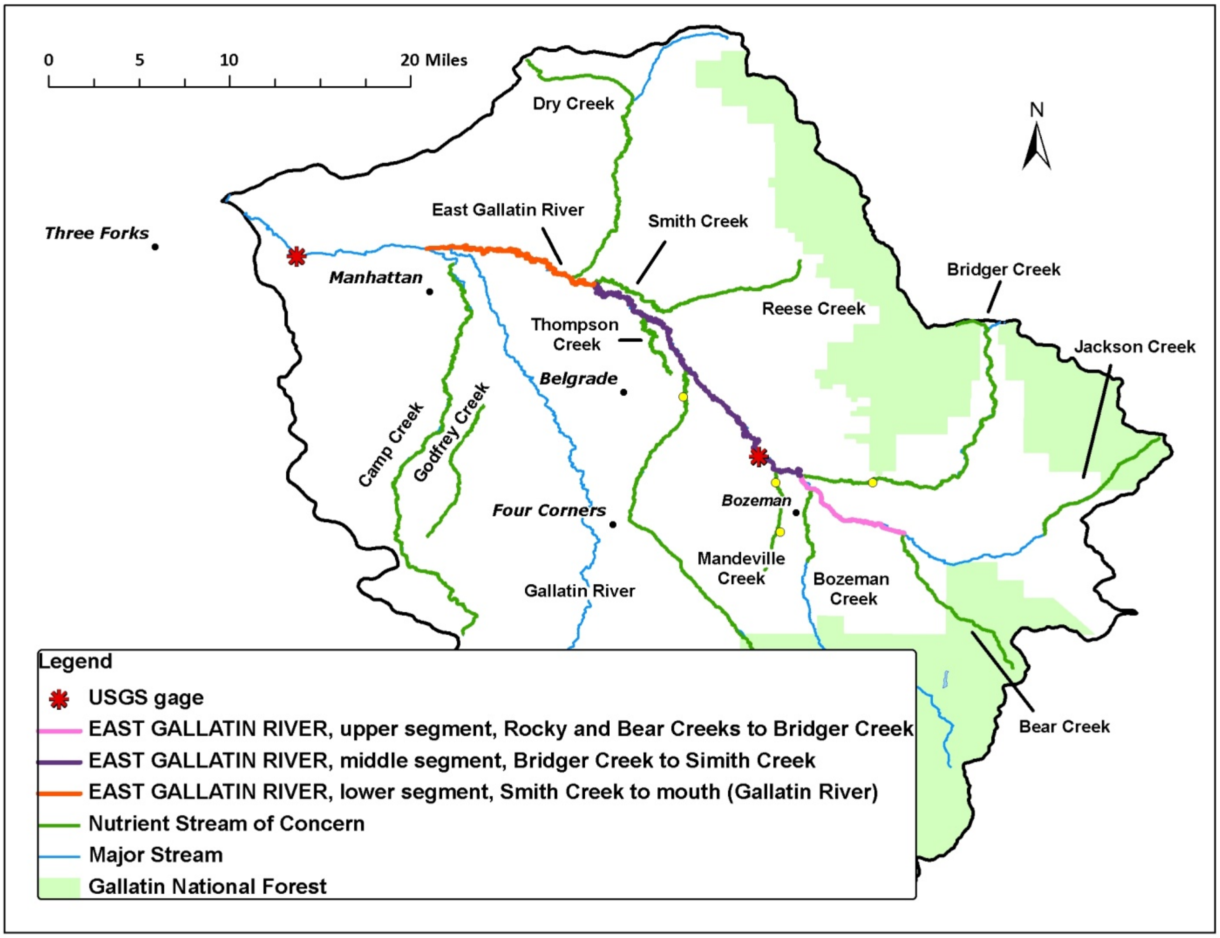

Figure 6-37. Map of East Gallatin River upper, middle and lower assessment units.

TN and TP TMDLs and Allocations for Reach 1 of the upper segment

For both TN and TP, the TMDLs are currently being met above the Bozeman Creek confluence (**Tables 6-83** and **6-85**). Allocations for TN and TP in this segment are found in **Tables 6-84 and 6-85** respectively. The nutrient-impaired reach is limited to the segment of the upper East Gallatin River between the Bozeman Creek confluence and the Bridger Creek confluence.

Table 6-83. East Gallatin River TN load and TMDL upstream of Bozeman Creek confluence

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	10.89	10.89		0.0%
Forest	0.67	0.89		0.0%
Agriculture	9.72	12.85		0.0%
Residential/Developed	3.02	4.00		0.0%
Subsurface Wastewater Treatment and Disposal	4.36	5.76		0.0%
Total	28.66		34.39	0.0%

* Based on a flow of 21.31 cfs

Table 6-84. East Gallatin River TN TMDL allocations upstream of Bozeman Creek confluence

Source	Load Allocations (%)*
Natural background	31.7%
Forest	2.6%
Agriculture	37.4%
Residential/Developed	11.6%
Subsurface Wastewater Treatment and Disposal	16.8%
Total	100.0%

* Based on a flow of 21.31 cfs

Table 6-85. East Gallatin River TP load and TMDL upstream of Bozeman Creek confluence

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	1.15	1.15		0.0%
Forest	0.60	0.92		0.0%
Agriculture	0.72	1.10		0.0%
Residential/Developed	0.12	0.18		0.0%
Subsurface Wastewater Treatment and Disposal	0.06	0.09		0.0%
Total	2.64		3.44	0.0%

* Based on a flow of 21.31 cfs

Table 6-86. East Gallatin River TP TMDL allocations upstream of Bozeman Creek confluence

Source	Load Allocations (%)*
Natural background	33.3%
Forest	26.9%
Agriculture	32.1%
Residential/Developed	5.2%
Subsurface Wastewater Treatment and Disposal	2.6%
Total	100.0%

* Based on a flow of 21.31 cfs

TN and TP TMDLs and Allocations for Reach 2 of the upper segment

A 17% reduction in TN is necessary to achieve the TMDL in the East Gallatin River between the Bozeman Creek confluence and the Bridger Creek confluence (**Table 6-87**). Allowing a 0% reduction in natural background and SWTD, a 30% reduction in agriculture and residential/developed area sources is needed. Because the Bozeman Creek watershed is the primary source of TN to this segment, if Bozeman Creek achieves its TMDL for TN, the TMDL for total nitrogen in this segment will be met as well. TN source allocations are found in **Table 6-88**.

Table 6-87. East Gallatin River TN load and TMDL between Bozeman Creek confluence and Bridger Creek confluence

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	24.25	24.25		0.0%
Forest	2.21	2.21		0.0%
Agriculture	24.49	16.98		30.6%
Residential/Developed	27.67	19.19		30.6%
Subsurface Wastewater Treatment and Disposal	14.63	14.63		0.0%
Total	93.25		77.27	17.1%

* Based on a flow of 49.5 cfs

Table 6-88. East Gallatin River TN TMDL allocations between the Bozeman Creek confluence and the Bridger Creek confluence

Source	Load Allocations (%)*
Natural background	31.4%
Forest	2.9%
Agriculture	22.0%
Residential/Developed	24.8%
Subsurface Wastewater Treatment and Disposal	18.9%
Total	100.0%

* Based on a flow of 49.5 cfs

For TP, the segment is currently meeting the TMDL (**Table 6-89**). TP source allocations are found in **Table 6-90**.

Table 6-89. East Gallatin River TP load and TMDL between Bozeman Creek confluence and Bridger Creek confluence

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	8.26	8.26		0.0%
Forest	0.13	0.48		0.0%
Agriculture	0.25	0.96		0.0%
Residential/Developed	0.70	2.65		0.0%
Subsurface Wastewater Treatment and Disposal	0.25	0.96		0.0%
Total	9.59		13.32	0.0%

* Based on a flow of 49.5 cfs

Table 6-90. East Gallatin River TP TMDL allocations between the Bozeman Creek confluence and the Bridger Creek confluence

Source	Load Allocations (%)*
Natural background	62.0%
Forest	3.6%
Agriculture	7.2%
Residential/Developed	19.9%
Subsurface Wastewater Treatment and Disposal	7.2%
Total	100.0%

* Based on a flow of 49.5 cfs

6.6.3.12 Godfrey Creek

Based on water quality data, Godfrey Creek is most heavily impaired for nutrients in the upper portion of the watershed. Water quality improves downstream of Churchill, MT. Multiple irrigation diversions and returns and agricultural land uses, combined with marginal or nonexistent riparian buffers along the stream corridor, are the main sources of nutrient impairment in Godfrey Creek. Allowing a 0% reduction of natural background and SWTD loads, the agriculture/residential loads need to be reduced by 86% for TN and by 55% for TP to achieve the TMDLs (**Table 6-91** and **6-93**). Existing data suggest this is a spring-fed system augmented by irrigation return flows. TN and TP allocations may be found in **Table 6-92 and Table 6-94** respectively.

Available groundwater data in the basin has elevated nitrogen and phosphorus concentrations, suggesting groundwater in addition to overland runoff are modes of nutrient deposition to the stream.

Table 6-91. Godfrey Creek TN load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	1.27	1.27		0.0%
Agriculture	16.95	2.32		86.3%
Residential/Developed	0.20	0.03		86.3%
Subsurface Wastewater Treatment and Disposal	0.39	0.39		0.0%
Total	18.81		4.00	78.7%

* Based on a flow of 2.5 cfs

Table 6-92. Godfrey Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Agriculture	57.8%
Residential/Developed	0.7%
Subsurface Wastewater Treatment and Disposal	9.8%
Total	100.0%

* Based on a flow of 2.5 cfs

Table 6-93. Godfrey Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.13	0.13		0.0%
Agriculture	0.55	0.25		55.0%
Residential/Developed	0.03	0.01		55.0%
Subsurface Wastewater Treatment and Disposal	0.01	0.01		0.0%
Total	0.72		0.40	44.4%

* Based on a flow of 2.5 cfs

Table 6-94. Godfrey Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Agriculture	62.2%
Residential/Developed	3.2%
Subsurface Wastewater Treatment and Disposal	1.3%
Total	100.0%

* Based on a flow of 2.5 cfs

6.6.3.13 Jackson Creek

Based on limited sampling data, Jackson Creek is currently meeting the TMDL for TP, since there have been no exceedances of the water quality standard (**Table 6-95**). The stream has remained listed for a TP impairment because it has not met the minimum sample size required to conduct a full assessment. Also there is limited biological data available for the stream.

There are few anthropogenic sources along the stream, and the data suggest that most of the load originates above the forest boundary. In the last 10 years, the Forest Service has made extensive road closures in the drainage. While no reduction is required, efforts should be made to not increase the TP load. TP source allocations may be found in **Table 6-96**.

Table 6-95. Jackson Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.12	0.12		0.0%
Forest	0.01	0.06		0.0%
Agriculture	0.02	0.15		0.0%
Residential/Developed	0.004	0.03		0.0%
Subsurface Wastewater Treatment and Disposal	0.001	0.004		0.0%
Total	0.16		0.36	0.0%

* Based on a flow of 2.3 cfs

Table 6-96. Jackson Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Forest	16.6%
Agriculture	41.3%
Residential/Developed	7.6%
Subsurface Wastewater Treatment and Disposal	1.2%
Total	100.0%

* Based on a flow of 2.3 cfs

6.6.3.14 Mandeville Creek

Mandeville Creek receives flows from Farmers Canal in the lower reaches of Mandeville Creek, where the canal terminates. This creates two different sources of impairment for the creek, including nutrient loading from lands that lie outside of the Mandeville Creek basin but which flow to the Farmers Canal. Farmers Canal diverts flow from the Gallatin River. Primary sources include residential development and agriculture. Allowing a 0% reduction of natural background and SWTD, the TN load needs to be reduced 88% and the TP load by 75% from agriculture and residential/developed area nonpoint sources to achieve the TMDL (**Table 6-97** and **6-99**). Existing data suggest this is a spring-fed system augmented by irrigation return flows. TN and TP allocations may be found in **Table 6-98 and Table 6-100** respectively.

Table 6-97. Mandeville Creek TN load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.69	0.69			0.0%
Agriculture	6.15	0.73			88.1%
Residential/Developed	4.26	0.50			88.1%
Subsurface Wastewater Treatment and Disposal	0.26	0.26			0.0%
City of Bozeman MS4 (MTR040002)**	0.0		0.0		0.0%
Total	11.35			2.18	81.4%

* Based on a flow of 1.35 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

Table 6-98. Mandeville Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Agriculture	33.5%
Residential/Developed	23.2%
Subsurface Wastewater Treatment and Disposal	11.7%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 1.35 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

Table 6-99. Mandeville Creek TP load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	WLA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	0.07	0.07			0.0%
Agriculture	0.27	0.07			74.5%
Residential/Developed	0.28	0.07			74.5%
Subsurface Wastewater Treatment and Disposal	0.004	0.004			0.0%
City of Bozeman MS4 (MTR040002)**	0.0		0.0		0.0%
Total	0.63			0.22	65.3%

* Based on a flow of 1.35 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

Table 6-100. Mandeville Creek TP TMDL allocations

Source	Load Allocations (%)*
Natural background	33.3%
Agriculture	31.9%
Residential/Developed	32.7%
Subsurface Wastewater Treatment and Disposal	2.0%
City of Bozeman MS4 (MTR040002)**	0.0%
Total	100.0%

* Based on a flow of 1.35 cfs; **MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

6.6.3.15 Reese Creek

Agriculture is the dominant land use in the Reese Creek watershed, but there is a large nitrogen load from above the forest boundary in the Bridger Range. It was not possible to differentiate natural background from forest land uses for this drainage. To achieve the TMDL for TN, a 77% reduction is needed from forest, agriculture, and residential/developed area sources (**Table 6-101**). TN source allocations may be found in **Table 6-102**. For the TMDL for NO_3+NO_2, an 88% reduction in load is needed to meet the TMDL from agriculture and residential/developed sources (**Table 6-103**). The forest/natural background load needs to be reduced by 50% as well. Existing data suggest this is a spring-fed system augmented by irrigation return flows. NO_3+NO_2 allocations are in **Table 6-104**.

Table 6-101. Reese Creek TN Allocations and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	3.69	3.69		0.0%
Forest	6.10	1.39		77.2%
Agriculture	16.40	3.74		77.2%
Residential/Developed	0.13	0.03		77.2%
Subsurface Wastewater Treatment and Disposal	2.80	2.80		0.0%
Total	29.11		11.65	60.0%

* Based on a flow of 7.2 cfs

Table 6-102. Reese Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background	31.7%
Forest	12.0%
Agriculture	32.1%
Residential/Developed	0.2%
Subsurface Wastewater Treatment and Disposal	24.0%
Total	100.0%

* Based on a flow of 7.2 cfs

Table 6-103. Reese Creek NO_3+NO_2 load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background/Forest	4.21	1.26		70.0%
Agriculture	16.36	0.99		93.9%
Residential/Developed	0.12	0.01		93.9%
Subsurface Wastewater Treatment and Disposal	1.62	1.62		0.0%
Total	22.32		3.88	82.6%

* Based on a flow of 7.2 cfs

Table 6-104. Reese Creek NO_3+NO_2 TMDL allocations

Source	Load Allocations (%)*
Natural background/Forest	32.6%
Agriculture	25.6%
Residential/Developed	0.2%
Subsurface Wastewater Treatment and Disposal	41.6%
Total	100.0%

* Based on a flow of 7.2 cfs

6.6.3.16 Thompson Creek

Thompson Creek is a spring creek that lies in an extensive groundwater discharge area in the Lower Gallatin watershed. In order to meet the TMDL for TN, a load reduction of 81% is needed from agriculture/residential sources, allowing a 0% reduction for natural background and SWTD (**Table 6-105**). Because Thompson Creek is a groundwater-fed system, many of the load reductions necessary to achieve the TMDL should occur as part of other TMDL efforts, such as in lower Hyalite Creek. TN source allocations are in **Table 6-106**.

Table 6-105. Thompson Creek TN load and TMDL

Source	Existing Load (lbs/day)*	LA (lbs/day)	TMDL (lbs/day)	% Reduction
Natural Background	6.04	6.04		0.0%
Agriculture	56.55	10.98		80.6%
Residential/Developed	3.41	0.66		80.6%
Subsurface Wastewater Treatment and Disposal	1.40	1.40		0.0%
Total	67.41		19.08	71.7%

* Based on a flow of 11.8 cfs

Table 6-106. Thompson Creek TN TMDL allocations

Source	Load Allocations (%)*
Natural background/Forest	31.7%
Agriculture	57.5%
Residential/Developed	3.5%
Subsurface Wastewater Treatment and Disposal	7.3%
Total	100.0%

* Based on a flow of 11.8 cfs

6.6.4 Seasonality, Margin of Safety, and Uncertainty and Adaptive Management

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, as well as to ensure (to the degree practicable) the TMDL components and requirements sufficiently protect water quality and beneficial uses. This section describes seasonality and margin of safety in developing nutrient TMDLs for the Lower Gallatin watershed.

6.6.4.1 Seasonality

Addressing seasonal variations is an important and required component of TMDL development, and throughout this plan seasonality is an integral consideration. Water quality, and particularly nitrogen concentrations, have seasonal cycles. Specific examples of how seasonality has been addressed within this document:

- Water quality targets and subsequent allocations are applicable for the summertime growing season (July1–Sept. 30) to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads was collected during the summertime period to coincide with applicable nutrient targets.

6.6.4.2 Margin of Safety

A margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a).

This plan addresses MOS implicitly in a variety of ways. Static nutrient target values (i.e., 0.030 mg/L TP, 0.100 mg/L NO_3+NO_2, 0.300 mg/L TN in Middle Rockies Level IV ecoregion) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets (see **Section 6.4.3**) were not incorporated into the calculation of allowable loads, thereby adding an MOS to established allocations. Target values were developed to err on the conservative side of protecting beneficial uses. Seasonality and variability in nutrient loading was also considered.

DEQ developed scenarios to be reasonable and achievable, and the scenarios estimate greater than necessary reductions for nutrients in most streams. Loading reductions are shown for the growing season when nutrient targets apply, but practices will be implemented year-round, resulting in even greater reductions in nutrient loading. And finally, DEQ also used an adaptive management approach to evaluate target attainment and to allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

6.6.4.3 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through an adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static but rather processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in both the water quality-based and source area modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

Water Quality Conditions

DEQ assumed that sampling data for each waterbody segment represents conditions in each segment. Most segments have less than the desired 12 samples, which increases the uncertainty of the representativeness of the data. Exceptions to this were Bozeman Creek, Bridger Creek, lower Hyalite Creek, and Mandeville Creek, where DEQ sampling efforts were significantly augmented with volunteer stream monitoring by the Greater Gallatin Watershed Council. Additionally, water quality conditions in the East Gallatin River were modeled to account for facility upgrades in 2007 and 2011.

Furthermore, macroinvertebrate data are a supplementary indicator, and many waterbody segments have little to no macroinvertebrate data. Particularly in situations where nutrient and algal data indicate borderline impairment, additional macroinvertebrate data may help decrease the uncertainty. Data for most waterbody segments with a nutrient TMDL clearly indicated that targets are not being attained. Exceptions to this include the TP impairments on Bear Creek, Dry Creek and Jackson Creek. Future monitoring, as discussed in **Section 10.0**, should help reduce the uncertainty of data representativeness, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

DEQ assumed that background concentrations are less than the target values, and based on sample data upstream of known sources, this appears to be true. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed.

Source Assessment

One other area of uncertainty is the contribution from septic systems. Based on the age of septic systems within the watershed, there are probably some failing systems. Depending on their proximity or connectivity to surface water, they could be point sources of nutrient loading. However, a completely failing system has obvious symptoms and will be addressed quickly. A partially failing system will likely result in similar loading as a functioning system, unless it's close to surface water.

This source could be investigated further, particularly in segments with nearby septic systems and elevated nutrient concentrations that cannot be explained by other sources; however, based on the low septic density within the watershed and conservative loading estimates used, even with this uncertainty, septic systems will typically be a minor source of nutrient loading. There are some notable exceptions: for the TMDLs for TN on Bozeman Creek below the Limestone Creek confluence, lower Hyalite Creek, and middle segment of the East Gallatin River downstream of the Hyalite Creek confluence loading from subsurface wastewater treatment and disposal comprise a relatively large fraction of the existing load. For these stream segments, DEQ recommends that long-term planning include the consideration of stream health in designing future residential development and sanitary sewer improvements and/or expansions in these areas.

Despite the uncertainty associated with the loading contributions from the various nonpoint sources in the watershed, based on the modeling, literature, and field observations, there is a fairly high level of certainty that improvements in land management practices discussed in this document will reduce nutrient loading sufficiently to meet the TMDLs.

7.0 *ESCHERICHIA COLI (E. COLI)*

This portion of the document focuses on *Escherichia coli* (*E. coli*) and fecal coliform as causes of water quality impairments in the Lower Gallatin TPA. It addresses:

- Beneficial use impacts
- Stream segments of concern
- Water quality data sources
- Water quality targets and comparison to existing conditions
- *E. coli* source assessment
- *E. coli* total maximum daily loads
- *E. coli* source load allocations
- Seasonality and margin of safety

7.1 IMPACTS TO BENEFICIAL USES

Elevated instream concentrations of pathogenic pollutants put humans at risk for contracting water-borne illnesses and can lead to impairments to a waterbody's contact recreation beneficial use. *E. coli* and fecal coliform are nonpathogenic indicator bacteria that are usually associated with pathogens transmitted by fecal contamination. While their presence does not always prove or disprove the presence of pathogenic bacteria, viruses, or protozoans, *E. coli* correlates highly with the presence of fecal contamination (United States Environmental Protection Agency, 2001) and is an indicator that other pathogenic bacteria are likely present. EPA recommends the use of *E. coli* as the preferred indicator organism for pathogenic bacteria forms due to its strong correlation with swimming-related gastroenteritis. Consequently, in 2006 Montana DEQ adopted *E. coli* water quality criteria (**Table 7-3**) for the protection of recreational beneficial uses, replacing the previous fecal coliform water quality criteria.

7.2 STREAM SEGMENTS OF CONCERN

Five streams are listed as impaired for *E. coli* (**Table 7-1**) on the 2012 303(d) List.

Table 7-1. Waterbody segments in the Lower Gallatin TMDL Planning Area with bacteria pollutant listings on the 2012 303(d) List

Waterbody	Waterbody Segment ID	Impairment Cause
Camp Creek	MT41H002_010	*Escherichia coli*
Godfrey Creek	MT41H002_020	*Escherichia coli*
Reese Creek	MT41H003_070	*Escherichia coli*
Smith Creek	MT41H003_060	*Escherichia coli*
Bozeman Creek	MT41H003_040	*Escherichia coli*

Camp Creek, Godfrey Creek, Reese Creek and Smith Creek were listed as impaired due to fecal coliform prior to adoption of *E. coli* water quality criteria in 2006. Water quality data (bacterial) collected prior to 2006 consists primarily of Fecal Streptococcus Group Bacteria (collected in 1976-77), which formed the basis for fecal-coliform impairment listings on Camp, Godfrey, Reese and Smith Creeks. The *E. coli* impairment listing on Bozeman Creek was based on *E. coli* data collected on Bozeman Creek in the summer of 2004.

7.3 Water Quality Data Sources

In order to evaluate attainment of the newly adopted *E. coli* water quality criteria, *E. coli* data was collected by DEQ on all five streams multiple times during the summer of 2008 and 2009 (**Figure 7-1**). This data (**Table 7-2**) forms the primary data set used for evaluation of *E. coli* water quality criteria, source assessment and loading analyses in support of *E. coli* TMDL development.

Table 7-2. 2008-2009 *E. coli* data collection

Waterbody	Number of *E. coli* Samples
Bozeman Creek	17
Camp Creek	15
Godfrey Creek	11
Smith Creek	7
Reese Creek	6

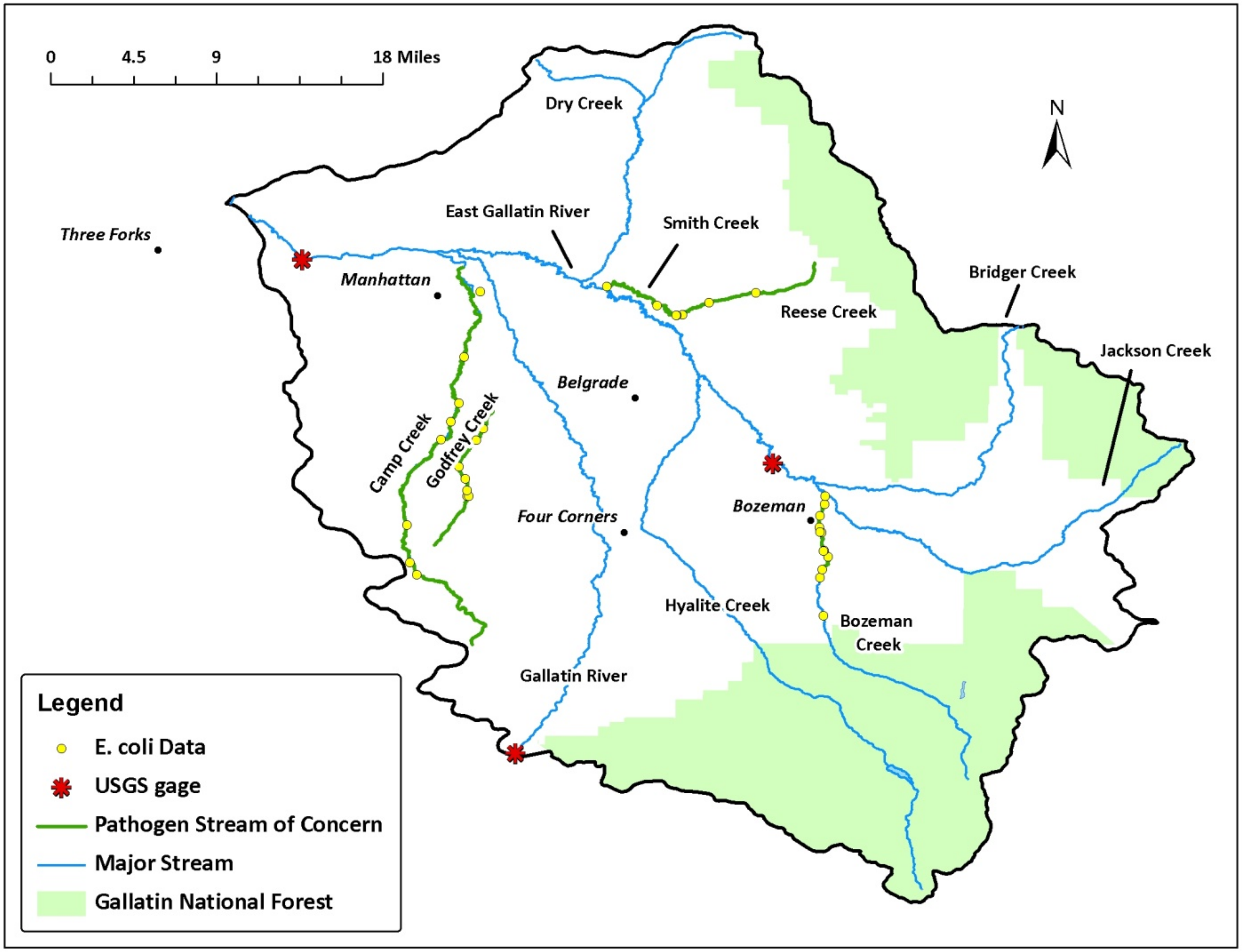

Figure 7-1. *E. coli* sampling sites for pathogen streams of concern

7.4 *E. coli* Water Quality Targets and Comparison to Existing Conditions

TMDL water quality targets are numeric indicator values used to evaluate attainment of water quality standards. The following section presents *E. coli* water quality targets, and compares those target values to recently collected *E. coli* data. TMDLs are developed for those streams where data shows that *E. coli* targets are not being met.

7.4.1 *E. coli* Water Quality Targets

The Montana instream numeric water quality criteria (the Standard) for *Escherichia coli* are adopted as the *E. coli* target for streams in the Lower Gallatin TMDL Planning Area. The Montana *E. coli* standard for B-1 waterbodies specifies:

> *The geometric mean number of E. coli may not exceed 126 cfu/100mL and 10% of the total samples may not exceed 252 cfu/100mL during any 30-day period between April 1 through October 31 [ARM 17.30.623 (2)(i)]* (**Table 7-3**)*. From November 1 through March 31, the geometric mean number of E. coli may not exceed 630 cfu/100mL and 10% of the samples may not exceed 1,260 cfu/100mL during any 30-day period [ARM 17.30.623 (2)(ii)]. The E. coli bacteria standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period that are analyzed by the most probable number (MPN) or equivalent membrane filter method [ARM 17.30.620(2)]. The geometric mean is the value obtained by taking the Nth root of the product of the measured values where values below the detection limit are taken to be the detection limit [ARM 17.30.602(13)].*

Table 7-3. Montana Water Quality Criteria for *E. coli* for B-1 Waterbodies

Applicable Period	Standard	Geometric mean of 5 samples collected over a 30-day time period	No more than 10% of the samples shall exceed:
Apr 1 – Oct 31 ("summer")	The geometric mean number of *E. coli* may not exceed 126 colony forming units per 100 milliliters and 10% of the total samples may not exceed 252 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(i)).	<126 cfu/100mL	252 cfu/100mL
Nov 1 – Mar 31 ("winter")	The geometric mean number of *E. coli* may not exceed 630 colony forming units per 100 milliliters and 10% of the samples may not exceed 1,260 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(ii)).	<630 cfu/100mL	1,260 cfu/100mL

Evaluation of target compliance is done by comparing existing water quality conditions to the established water quality target (in this case, the *E. coli* water quality criteria provided in **Table 7-3**).

TMDLs establish a maximum allowable daily pollutant load that will result in the attainment and maintenance of water quality standards. In order to ensure that daily maximum allowable loads do not result in an exceedance of the 30-day geometric mean *E. coli* criteria, values of 126 cfu/100ml and 630 cfu/100ml , are used for the calculation of seasonal *E. coli* TMDLs and allocations (**Section 7.7**).

7.4.2 Existing Conditions and Comparison to Water Quality Targets

DEQ evaluated attainment of *E. coli* water quality targets for each stream segment of concern. Water quality data was collected in both 2008 and 2009, however only *E. coli* results from 2008 are used to evaluate attainment of *E. coli* targets; only the 2008 dataset met the criteria of a '*minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period.'* The results of this target evaluation and a summary of *E. coli* data is provided below.

7.4.2.1 Bozeman Creek

The lower segment of Bozeman Creek flows 4.9 miles from the confluence with Limestone Creek to the mouth (East Gallatin River). Bozeman Creek originates in the Gallatin Range and flows out of Sourdough Canyon above the forest boundary. The total length of the stream is 14 miles from the confluence of North Fork and South Fork to the mouth (East Gallatin River).The segment flows primarily through residential and urban areas of the city of Bozeman although there are large acreages in agriculture in the drainage between the forest boundary and the Limestone Creek confluence and in the headwaters of tributaries that flow to Bozeman Creek including Nash Spring Creek and Matthew Bird Creek. *E. coli* sources appear to be primarily related to residential and recreational land uses within the developed lands within the city of Bozeman.

Bozeman Creek is listed as impaired for *E. coli* on the 2012 303(d) List based on *E. coli* water quality results from sampling conducted in 2004. Additional *E. coli* water quality data was collected on Bozeman Creek by DEQ in 2008 and 2009. *E. coli* results from the 2008 sampling effort were used to evaluate attainment of the *E. coli* water quality standard (**Table 7-3**). Results of this waterbody evaluation for *E. coli* are summarized in **Table 7-4**.

Table 7-4. Bozeman Creek *E. coli* target evaluation summary

Waterbody	Station	Date	*E. coli* Result (cfu/100mL)	Geometric Mean	10% of samples > 252?	GeoMean > 126?	Assessment Decision
Bozeman Creek	SD01	8/20/08	308	157	YES	YES	***E. coli* criteria/ target exceeded**
	GD03	9/2/08	1730				
	GD01	9/9/08	133				
	GD03	9/15/08	1990				
	GD01	9/17/08	93				

E. coli results on Bozeman Creek exceeded water quality targets. The geometric mean *E. coli* concentration of 157 cfu/100ml exceeded the target value of 126 cfu/100ml, and >10% of samples were >252 cfu/100ml.

7.4.2.2 Camp Creek

Camp Creek flows 29.6 miles from the headwaters on the Madison Plateau (Camp Creek Hills) through the town of Amsterdam to the mouth (Gallatin River) northeast of Manhattan. Land uses along Camp Creek are primarily agricultural, with open rangeland in the upper reaches and livestock, hay, pasture and small grain operations in its middle and lower reaches. Irrigation networks along Camp Creek influence flow. Summer baseflow in Camp Creek are typically variable and range from 3 to 15 cfs in its middle reaches near the town of Amsterdam. In its lower reaches, Camp Creek flows are significantly augmented by groundwater and spring inputs from the Gallatin River floodplain.

Camp Creek is listed as impaired for *Escherichia coli* on the 2012 303(d) List based on *Fecal Streptococcus* water quality results from 1976-1977 and *E. coli* water quality data from 2008 and 2009. *E. coli* results from the 2008 sampling effort were used to evaluate compliance with the *E. coli* water quality standard (**Table 7-3).** Results of this waterbody evaluation for *E. coli* are summarized in **Table 7-5**.

Table 7-5. Camp Creek *E. coli* target evaluation summary

Waterbody	Station	Date	*E. coli* Result (cfu/100mL)	Geometric Mean	10% of samples > 252?	GeoMean > 126?	Assessment Decision
Camp Creek	CP03	8/26/08	816	441	YES	YES	***E. coli* criteria/ target exceeded**
	GD03	9/2/08	1730				
	GD01	9/9/08	133				
	GD03	9/15/08	1990				
	GD01	9/17/08	93				

E. coli results on Camp Creek exceeded water quality targets. The geometric mean *E. coli* concentration of 441cfu/100ml exceeded the target value of 126 cfu/100ml, and 80% of samples were >252 cfu/100ml.

7.4.2.3 Godfrey Creek

Godfrey Creek flows 9 miles from the headwaters on the Madison Plateau (Camp Creek Hills) through the town of Churchill to the mouth where is flows into Moreland Ditch, an irrigation canal. Historic alterations to Godfrey Creek's watercourse and adjacent irrigation infrastructure have changed flow patterns so that Godfrey Creek no longer maintains a natural channel in its lower reaches. Godfrey Creek water is distributed to a series of irrigation ditches (Moreland Ditch, White Ditch, and Lewis Ditch) which intersect Camp Creek north of Amsterdam. Summer baseflow in Godfrey Creek are typically less than 5 cfs, but streamflows can be significantly influenced by irrigation withdrawals and returns throughout the summer growing season.

Godfrey Creek is listed as impaired for *Escherichia coli* on the 2012 303(d) List based on *Fecal Streptococcus* water quality results from 1976-1977 and *E. coli* water quality data from 2008 and 2009. *E. coli* results from this sampling effort were used to evaluate attainment of the *E. coli* criteria (**Table 7-3**). Results of this waterbody evaluation for *E. coli* are summarized in **Table 7-6**.

Table 7-6. Godfrey Creek *E. coli* target evaluation summary

Waterbody	Station	Date	*E. coli* Result (cfu/100mL)	Geometric Mean	10% of samples > 252?	GeoMean > 126?	Assessment Decision
Godfrey Creek	GD01	8/26/08	162	370	YES	YES	***E. coli* criteria/ target exceeded**
	GD03	9/2/08	1730				
	GD01	9/9/08	133				
	GD03	9/15/08	1990				
	GD01	9/17/08	93				

E. coli results on Godfrey Creek exceeded water quality targets. The geometric mean *E. coli* concentration of 370cfu/100ml exceeded the target value of 126 cfu/100ml, and 40% of samples (2/5) exceeded 252 cfu/100ml criteria.

7.4.2.4 Reese Creek

Reese Creek flows 8.3 miles from the headwaters in the Bridger Range to the mouth (Smith Creek). It flows through agricultural lands and rural residential areas to its confluence with Smith Creek upstream of Dry Creek Road. Summer baseflow in Reese Creek are typically less than 10 cfs, but streamflows can be influenced by irrigation withdrawals and returns throughout the summer growing season. *E. coli* sources consist primarily of livestock, which have periodic access along the length of Reese Creek.

Reese is listed as impaired for *Escherichia coli* on the 2012 303(d) List based on *Fecal Streptococcus* water quality results from 1976-1977 and *E. coli* water quality data from 2008 and 2009. *E. coli* results from the 2008 sampling effort were used to evaluate attainment of the *E. coli* water quality standard (**Table 7-3**). Results of this waterbody evaluation for *E. coli* are summarized in **Table 7-7**.

Table 7-7. Reese Creek *E. coli* target evaluation summary

Waterbody	Station	Date	*E. coli* Result (cfu/100mL)	Geometric Mean	10% of samples > 252?	GeoMean > 126?	Assessment Decision
Reese Creek	RS02	9/15/08	34.5	55.9	NO	NO	Not enough data
	RS02	9/3/08	90.8				

There were too few *E. coli* results on Reese Creek to meet the requirements of *ARM 17.30.620(2)* to complete a full assessment. However, there were 4 additional samples collected on 9/17/2009 on Reese Creek. One sample was 411 cfu/100mL which exceeded the water quality target of <10% of samples < 252 cfu/100mL. The limited dataset for Reese Creek does indicate impairment.

7.4.2.5 Smith Creek

Smith Creek flows 6 miles from the confluence of Ross and Reese Creeks to the mouth (East Gallatin River). It flows through agricultural bottom lands and rural residential areas. *E. coli* sources consist primarily of livestock usage on both Smith Creek and tributary, Ross Creek.

Smith Creek is listed as impaired for *Escherichia coli* on the 2012 303(d) List based on *Fecal Streptococcus* water quality results from 1976-1977 and *E. coli* water quality data from 2008 and 2009. Because only 4 samples (rather than the minimum 5 samples) were collected on Smith Creek in 2008, an evaluation of compliance with the *E. coli* water quality standard could not completed. Results of this waterbody evaluation for *E. coli* are summarized in **Table 7-8**.

Table 7-8. Smith Creek *E. coli* target evaluation summary

Waterbody	Station	Date	*E. coli* Result (cfu/100mL)	Geometric Mean	10% of samples > 252?	GeoMean > 126?	Assessment Decision
Smith Creek	SM02	8/21/08	124	155	NO	NO	Not enough data
	SM01	9/3/08	108				
	RS01	9/8/08	435				
	SM02	9/17/08	76.8				

There were too few *E. coli* results on Smith Creek to meet the requirements of *ARM 17.30.620(2)* to complete a full assessment. However, there were 2 additional samples collected on 9/17/2009 on Smith Creek. One sample was 291 cfu/100mL which exceeded the water quality target of <10% of samples <252 cfu/100mL. The limited dataset for Smith Creek does indicate impairment.

7.4.3 *E. Coli* Target Compliance Summary

Water quality data collected in 2008 and 2009 verify that the *E. coli* water quality criteria were exceeded in Bozeman Creek, Camp Creek, Godfrey Creek, Reese Creek and Smith Creek. Although there were too few *E. coli* results on Reese Creek and Smith Creek to meet the requirements of *ARM 17.30.620(2)* to complete a full assessment, individual samples on these streams did exceed the criteria that <10% of all samples be <252 cfu/100mL. *E. coli* TMDLs will be written for all 5 stream segments (**Section 7.6**).

7.5 *E. Coli* Source Characterization and Assessment

Assessment of existing *E. coli* sources is necessary in order to develop load allocations to specific source categories. The following section characterizes sources contributing to *E. coli* loading and assesses *E. coli* contributions from individual source categories.

E. coli sampling conducted in 2008 and 2009 provides the most recent data for characterization of existing *E. coli* water quality conditions in the Lower Gallatin watershed. Over 50 samples were taken from 32 sampling sites with the objectives of 1) evaluating summer period (April 1 – October 31) attainment of *E. coli* water quality targets, and 2) assessing *E. coli* load contributions from sources within the Lower Gallatin River watershed.

As described in **Section 7.5**, data results show *E. coli* target exceedances in the Lower Gallatin River watershed and periodic exceedances of water quality targets on all streams with an *E. coli* impairment (**Figure 7-2**).

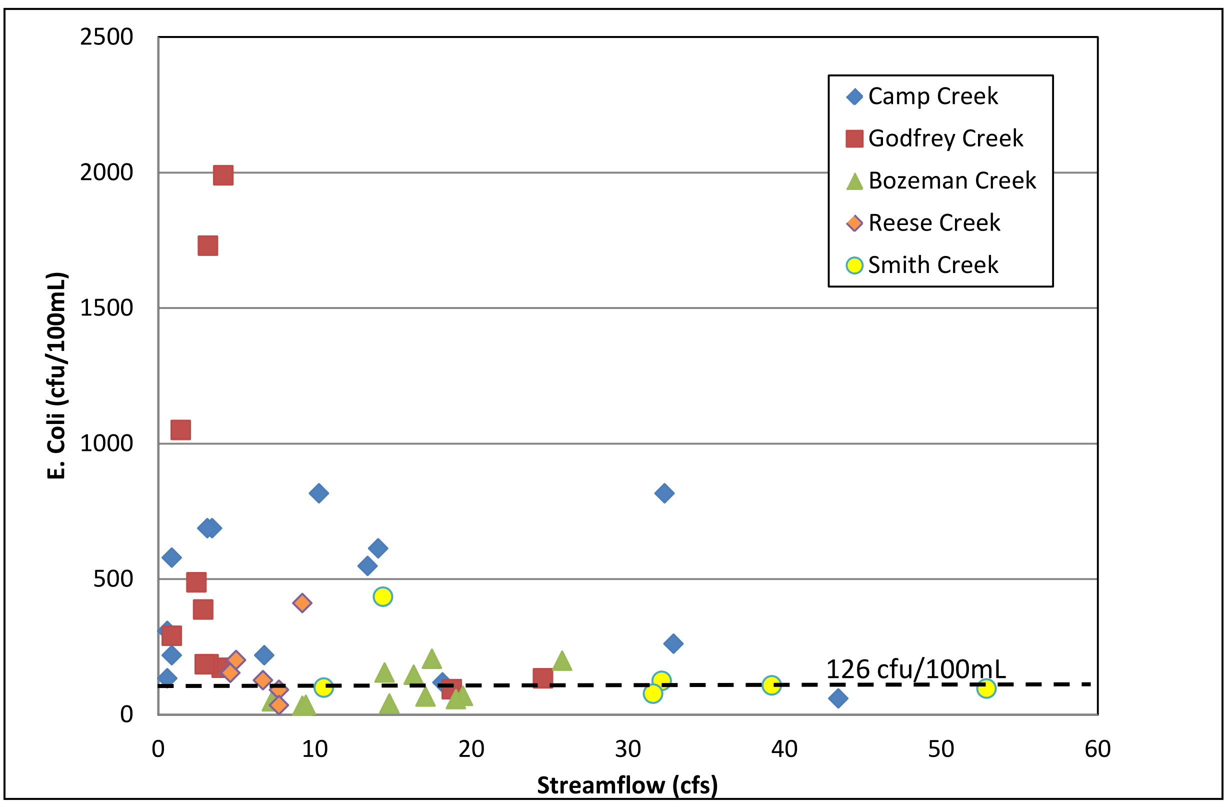

Figure 7-2. *E. coli* Concentrations in the Lower Gallatin Watershed, 2008-2009

Typically, anthropogenic *E. coli* sources in western watersheds consist of agricultural nonpoint sources and wastewater point sources. Agricultural nonpoint *E. coli* sources are typically significant during wet, high flow periods (United States Environmental Protection Agency, 2001) and may cause water quality impairments during these times if proper controls are not in place. Alternatively, point sources of *E. coli* are the most significant during the lowest flows when a stream's dilution capacity is at its lowest. *E. coli* source characterization therefore focuses on identifying and assessing sources that may contribute *E. coli* loads during the late summer and early fall low-flow season. *It is expected that practical pollutant controls designed to reduce loading from these summertime sources may apply to year-round E. coli source reductions.*

Land uses in *E. coli* impaired streams in the Lower Gallatin River watershed are primarily agricultural and residential. There is one permitted point source which discharges directly to an impaired waterbody. The City of Bozeman MS4 discharges to Bozeman Creek. *E. coli* sources in the Lower Gallatin watershed include agricultural sources associated with livestock operations, residential and natural sources.

7.5.1 Natural *E. coli* Sources

Natural background sources of *E. coli* are primarily from wildlife excrement, and may include moose, deer, beaver, waterfowl and other types of wildlife that utilize riparian and stream corridors. Estimates of natural background conditions for *E. coli* rely on historical data and, more importantly, collected reference data.

Historical/pre-development *E. coli* data with which to estimate natural background levels is limited for the Lower Gallatin River watershed. In developing pathogen TMDLs for *E. coli* in the West Fork Gallatin River Watershed, data collected on undeveloped or 'reference' areas was used to inform natural background *E. coli* conditions. During *E. coli* data collection in 2006-2008, several sampling sites were chosen in undeveloped areas in order to estimate natural background *E. coli* conditions. Sites include undeveloped areas of Swan Creek, Hellroaring Creek, Beehive Creek, the North Fork West Fork Gallatin River, and the South Fork West Fork Gallatin River. Late summer/fall *E. coli* concentrations averaged 24 cfu/100ml (**Table 7-9**).

Table 7-9. *E. coli* Reference Data and summary statistics

Site	Sample Date	*E. coli* (cfu/100ml)
BEHV01	08/18/06	29
BEHV01	11/17/06	6
BEHV01	08/27/08	19
NFWF01	08/18/06	91
NFWF01	11/17/06	20
SFTR01	08/27/08	5
HLRG01	08/27/08	3
SWAN03	08/27/08	23
	mean	24
	90th percentile	48
	max	91
	min	3

For purposes of estimating natural background concentrations for TMDL development, the 90th percentile reference value of 48 *E. coli* cfu/100ml is adopted as an estimate of nature background sources for calculation of daily load allocations in **Section 7.7**.

7.5.2 Anthropogenic Sources

7.5.2.1 Agricultural/Residential E. coli Sources

Anthropogenic *E. coli* sources in the watershed include a variety of nonpoint sources associated with agricultural and residential uses. These sources include a variety of lesser individual source categories that together may be categorized as recreational/residential sources and include:

Livestock

Horses, cattle, sheep and goats are raised in many of the basins in the Lower Gallatin watershed and include both small and large operations. Land ownership consists of smaller parcels in the Bozeman Creek drainage relative to the other *E. coli* impaired waterbodies in the Lower Gallatin watershed. Several of the drainages have significant livestock numbers such as Camp, Godfrey, and Reese Creeks. Smith Creek drains upland areas that have livestock operations.

Domestic pets

Animals associated with human residential and recreational lands are included as a component of 'recreational/residential' sources. Dogs are common in the residential areas of the Lower Gallatin watershed, and recreational stock (commercial trail and hobby horses) are maintained by individuals and businesses.

Stormwater runoff & sediment

Stormwater runoff from residential and commercial areas can carry a variety of contaminated refuse to receiving waterbodies and contaminating stream sediments. Re-suspension of *E. coli* in substrate sediments as a result of recreational usage (anglers, waders, dogs, etc) or disturbance may contribute to instream *E. coli* loads during the summer usage season. This is directly applicable to the Bozeman Creek drainage.

7.5.2.2 Wastewater E. coli Sources

Possible wastewater sources with the potential to contribute *E. coli* loads to surface waters include individual septic systems and sewer system main lines and residential service connections. Properly designed, installed and maintained, these systems pose no significant loading threat to surface waters. Failing systems or leaking pipes have the potential to contribute *E. coli* loads where they are in close proximity to surface waters.

Failing or malfunctioning septic systems

Failing and malfunctioning septic systems include individual wastewater systems that are not providing adequate treatment of bacterial contaminants before they reach surface waters. Typically such systems exhibit evidence of failure by surface ponding and routing of effluent. Malfunctioning systems may also include improperly installed systems or those that intercept groundwater or are susceptible to flooding. While no information is available regarding failing septic systems in the Lower Gallatin project area, the number of septic systems in close proximity to surface waters within the watershed is low and not expected to contribute significantly to *E. coli* loads. The exception to this is Bozeman Creek which does have medium to high densities of septic fields in its drainage.

Broken sewer lines or domestic service lines

Compromised underground sewer and service lines are not uncommon to sewer systems, and have the potential to contribute *E. coli* loads to nearby waterbodies. The significance of this source is unknown, but the proximity of sewer mainlines and residential service connections to Bozeman Creek may have an adverse effect on *E. coli* impairment (**Figure 7-3**). Maintenance of sewer and service lines is conducted routinely by the City of Bozeman.

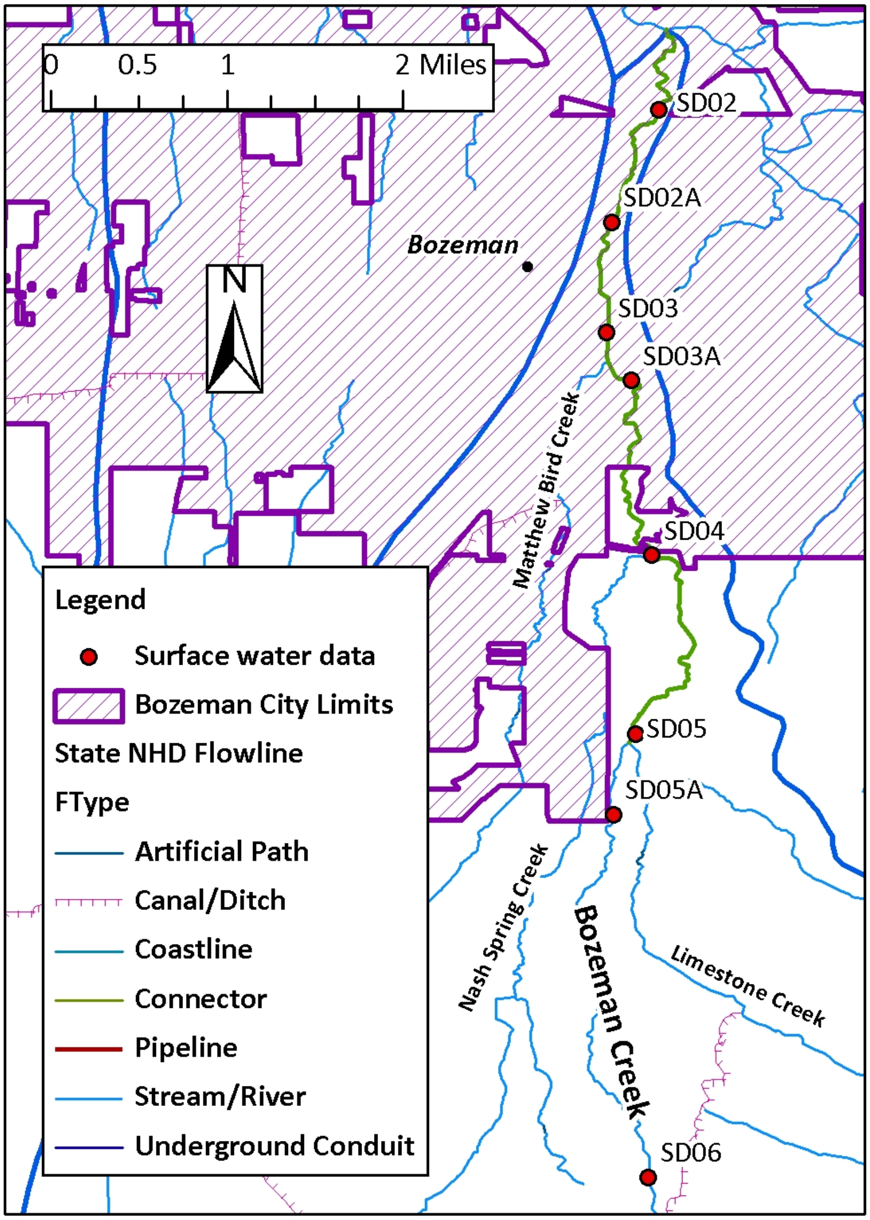

Figure 7-3. Bozeman city limits and sewered areas in relation to Bozeman Creek

Because of the diffuse nature of nonpoint source loads and the variability in *E. coli* results, identification and estimation of discrete of *E. coli* loads from specific sources is difficult to estimate. Synoptic sampling events conducted in 2009, while not adequate to unveil definitive source linkages, show the spatial and temporal variability in *E. coli* measurements throughout the watershed.

In general the higher *E. coli* concentrations were observed in the Camp and Godfrey Creek drainages which have the most intensive agricultural land uses of all the *E. coli* impaired waterbodies in the Lower

Gallatin watershed. In the absence of genetic microbial source tracking information, it is difficult to assign specific load estimations to individual agricultural, residential, and wastewater source categories. Consequently, numeric load estimations are not calculated for cumulative residential/recreational and wastewater *E. coli* sources. Rather, load allocations given in **Section 7.6** provide allowable *E. coli* loading levels to these source categories.

7.5.3 Point Sources

As of March 19, 2012, there were 81 Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within the Lower Gallatin TMDL Project Area (**Figure A-22**). These 81 MPDES permits include:

- City of Bozeman Water Reclamation Facility (WRF) (MT0022608)
- City of Bozeman Water Treatment Facility (MT0030155)
- City of Bozeman – Lyman Creek Reservoir (MT0031631)
- City of Bozeman MS-4 Storm Water System (MTR040002)
- Town of Manhattan Wastewater Treatment Facility (WWTF) (MT0021857)
- United States Fish & Wildlife Service (USFWS) Bozeman Fish Technology Center (MTG130006)
- One permit for petroleum cleanup (MTG790003)
- One permit for construction dewatering (MTG070687)
- Two permits for disinfected water (MTG770015 and MTG770018)
- Three permits for sand and gravel (MTG490019, MTG490024, and MTG490026)
- Four Concentrated Animal Feeding Operations (MTG010052, MTG010188, MTG010219, and MTG010225)
- Five permits for industrial activity stormwater (MTR000095, MTR000192, MTR000358, MTR000403, and MTR000483)
- Fifty-nine general permits for construction activity stormwater

Of the complete list of MPDES permits, only 1 has a direct discharge of a potential pathogen source to a pathogen impaired stream in the Lower Gallatin TPA. The City of Bozeman MS-4 sends stormwater flows to Bozeman Creek. To provide the required WLAs for permitted point sources, a source assessment was performed for the City of Bozeman MS-4 permit.

7.5.3.1 City of Bozeman MS4 Storm Water System (MTR040002)

E. coli Wasteload Allocations

The city of Bozeman MS4 Storm Water System falls under the General Permit For Storm Water Discharge Associated with Small Municipal Separate Storm Water Sewer System (MS4) (MTR04000). The most recent permit was issued by DEQ on February 22, 2010 to the following three co-permittees: the City of Bozeman (City), Montana State University – Bozeman (MSU), and the Montana Department of Transportation (MDT). This permit allows the discharge of stormwaters to the following surface waters:

- Spring Creek (for City)
- Bozeman Creek (for City and MDT)
- Bridger Creek (for City)
- East Gallatin River (for City and MDT)
- Farmers Canal (for City and MSU)
- Bear Creek (for City)
- Baxter Creek (for City and MDT)
- Maynard Border Ditch (for City and MDT)
- Mandeville Creek (for City and MSU)
- Middle Creek Ditch (for City and MSU)
- West Gallatin Canal (for MSU)
- Unnamed Ditch – West End MSU Boundary (for MSU)

In accordance with Part III.A. of the General Permit (MTR040000), the City's, MSU's and MDT's Storm Water Management Program (SWMP) must address the pollutants of concern for which the receiving waterbodies are listed on the State's 303(d) list. This discussion must specifically address Best Management Practices that will address the pollutants of concern.

Per EPA requirements at the federal level, NPDES-regulated stormwater discharges (MS4-permitted discharges) must be addressed by the wasteload allocation (WLA) of a TMDL (40 Code of Federal Regulations (C.F.R.) § 130.2(h) & (i).). EPA requires a numeric WLA but allows a state permitting authority to apply a BMP based approach to satisfy the WLA of a TMDL. Where appropriate, surrogate pollutant parameters (i.e. impervious cover) are acceptable for use as TMDL endpoints or other appropriate measures (see 40 C.F.R. §130(2)(i)).

At the state level, Administrative Rule of Montana (ARM) 17.30.1111(5) requires MS4 permittees to develop, implement and enforce a Storm Water Management Program (SWMP) designed to reduce the discharge of pollutants to the maximum extent practicable (MEP).

ARM 17.30.1111(5)(a) also states, 'For the purposes of this rule, narrative effluent limitations requiring the implementation of BMPs are the most appropriate form of effluent limitations when designed to satisfy technology requirements (including reductions of pollutants to the maximum extent practicable) and to protect water quality. Implementation of BMPs consistent with the provisions of the SWMP required pursuant to this rule and the provisions of the permit shall constitute compliance with the standard of reducing pollutants to the 'maximum extent practicable.'

The stormwater system is designed for the 10 year, 2 hour event of 0.41 inches. The MS4 area comprises 6% of the Bozeman Creek watershed and Bozeman Creek receives approximately 16% of the flow from the MS4. Based on 30 years of precipitation data (1980-2009), ≥0.05 inches of precipitation fall, on average, 18.6 days per summer period (July 1 – September 30). Activation of the MS4 is relatively infrequent during the summer period.

Limited *E. coli* data is available for the MS4 stormwater system. Flowing outfalls to Bozeman Creek were sampled for *E. coli* as part of a synoptic sampling event on 9/15/2009 **(Figure 7-4**). This sampling identified illicit discharges of *E. coli* to Bozeman Creek from the MS4 stormwater system (**Table 7-10**). The precipitation record at Montana State University (COOP ID 241044) observed no measurable precipitation from 9/2/2009 to 9/20/2009. Therefore, the observed flows from the outfalls to Bozeman Creek constituted illicit discharges.

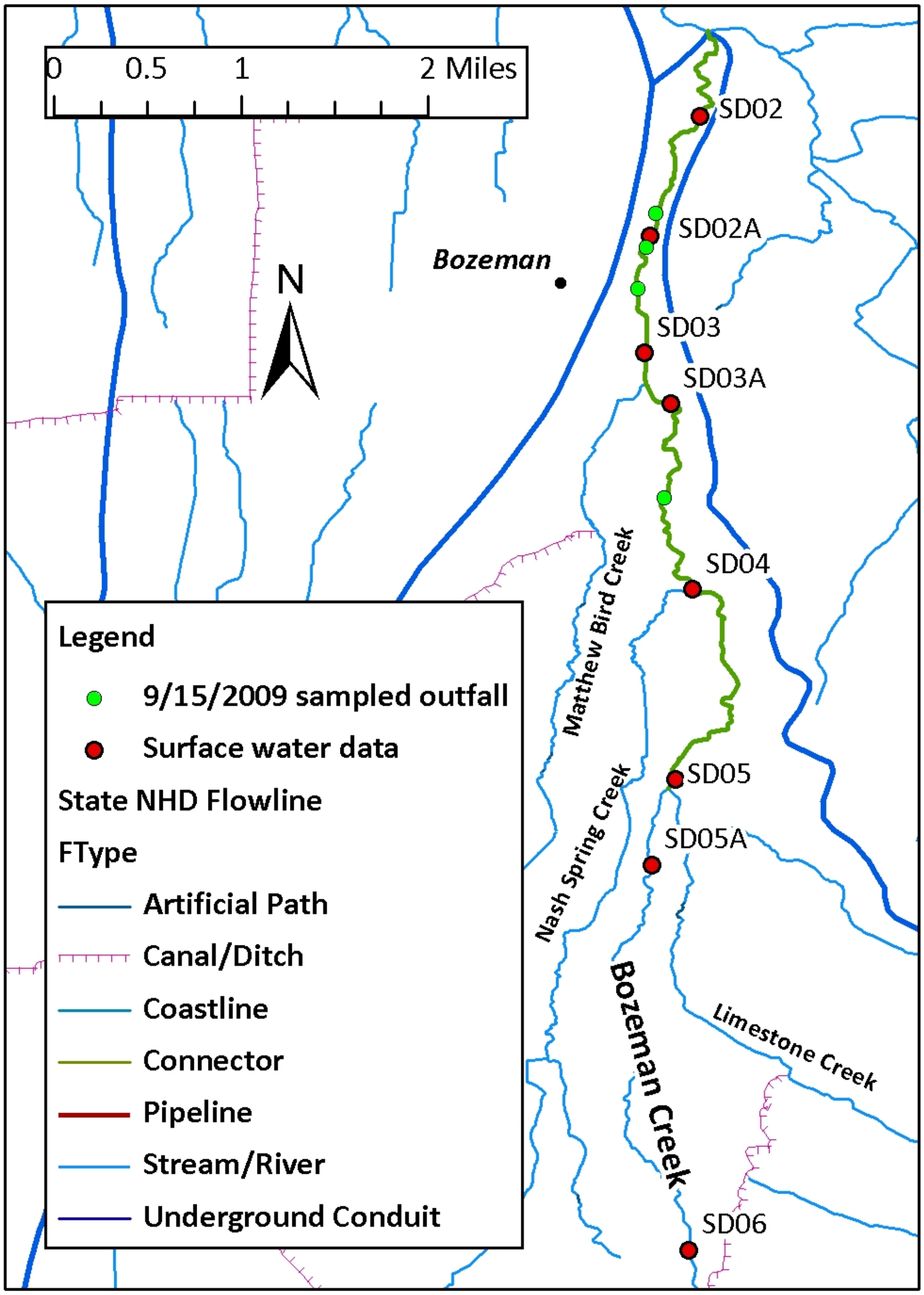

Figure 7-4. Location of sampled MS4 outfalls to Bozeman Creek, 9/15/2009

Table 7-10. 9/15/2009 *E. coli* loads to Bozeman Creek from MS4

Site ID	Discharge (cfs)	*E. coli* (cfu/100mL)	*E. Coli* Load (cfu/day)
SPD01	0.13	365	1178.92
SPD02	0.15	ND	NA
SPD03	0.10	2420	5862.28
SPD04	0.88	ND	NA

ND = not detected; NA = not applicable

On 9/15/2009, the *E. coli* load from the flowing storm drains constituted approximately 21% of the non-natural background *E. coli* load in Bozeman Creek. Not enough sampling data exist to determine the long-term average load from the MS4 to Bozeman Creek.

Stagnant waters within the MS4 stormwater system may act as a temporary breeding ground for *E. coli* bacteria which are then released to the receiving waterbody during storm events. Illicit discharges may be the result of groundwater flows entering the system or illegal discharges from homes and businesses to storm sewers or direct connections to the MS4 network. The MS4 will be assigned a wasteload allocation of 0 when the stormwater system is not activated. As required by the general permit, an illicit discharge detection and elimination (IDDE) program will be necessary to achieve this WLA. A continually updated storm sewer system map, showing the location and number of all outfalls must be developed and maintained by the permittees in order to successfully implement an IDDE program. Storm Water Ordinance 1763 adopted by the city of Bozeman in 2010 establishes legal authority to prohibit illicit discharges in the MS4. These measures will achieve the WLA when the system should not be producing flow. IDDE is critical to reduce chronic exceedances of water quality targets in the receiving waterbodies.

A review of stormwater BMPs for bacteria, found that the BMPs that resulted in the greatest reductions of bacteria loading were extended retention basins and sand filters which resulted in bacteria load reductions of 40% and 55% respectively (Barrett, 1999). Sand filters consist of basins that capture stormwater runoff and filter the runoff through a bed of sand to remove sediment and pollutants. Filtration of coliform bacteria and nutrients is by a mat of bacterial slime that develops from normal operations. Sand filters are highly adaptable as they can be used in areas with thin soils, high evaporation rates and low soil infiltration rates. They also do not need a large area for installation. During and following precipitation events, loading from the MS4 to the receiving waterbodies will be reduced via implementation to the '*maximum extent practicable'* and monitoring of stormwater Best Management Practices (BMPs) within the MS4 boundaries. In addition to an active stormwater management program (SWMP) as required by the general permit; these measures should achieve reductions in the *E. coli* loads to the receiving waterbodies. It is anticipated that if the conditions of the permit are met, the *E. coli* load from the MS4 to Bozeman Creek can be reduced by 21% when the system is activated. A successful program of IDDE and possible BMP implementation should reduce the *E. coli* load to 0 when the MS4 is not activated by a precipitation event. It is recommended that future discharge monitoring by the city of Bozeman include *E. coli* sampling. For this reason, during periods of low flow the MS4 is assigned a WLA=0 as it should not be discharging to the stream.

It is recognized that even when the MS4 meets the percent reduction WLA requirement, receiving waterbodies could occasionally have concentrations above the target concentrations presented in **Section 7.4.1** because of stormwater flows and pollutant concentrations. This is not considered an issue regarding compliance with targets and water quality standards since these excursions will be less than 20% of the summer growing season (July 1 – September 30) and will be randomly spaced throughout that period. Where target exceedances do exist, but are less than 20%, it is desirable to have a somewhat random spacing of such exceedances similar to what would be anticipated via the city of Bozeman MS4 stormwater system (Suplee et al., 2008a).

7.6 *E. Coli* Total Maximum Daily Loads

As established in **Section 7.5**, *E. coli* Total Maximum Daily Loads are presented herein for Bozeman Creek, Camp Creek, Godfrey Creek, Reese Creek and Smith Creek.

A Total Maximum Daily Load (TMDL) is a calculation of the maximum pollutant load a waterbody can receive while maintaining water quality standards. The total maximum daily load (cfu/day) of *E. coli* for streams in the Lower Gallatin watershed is calculated using seasonal *E. coli* target values. The total maximum daily *E. coli* load during the 'summer' season (Apr 1 – Oct 31) is based on an instream *E. coli* target value of 126 cfu/100ml, while the *E. coli* TMDL during the winter season (Nov 1 – March 31) is based on an instream *E. coli* target value of 630 cfu/100ml (**Figure 7-5**). TMDL calculations are based on the following calculation:

TMDL = (X) (Y) (2.44E+7)

TMDL= Total Maximum Daily Load in cfu/day
X= E. coli water quality target in cfu/100ml
Y= streamflow in cubic feet per second
(2.44E+7) = conversion factor

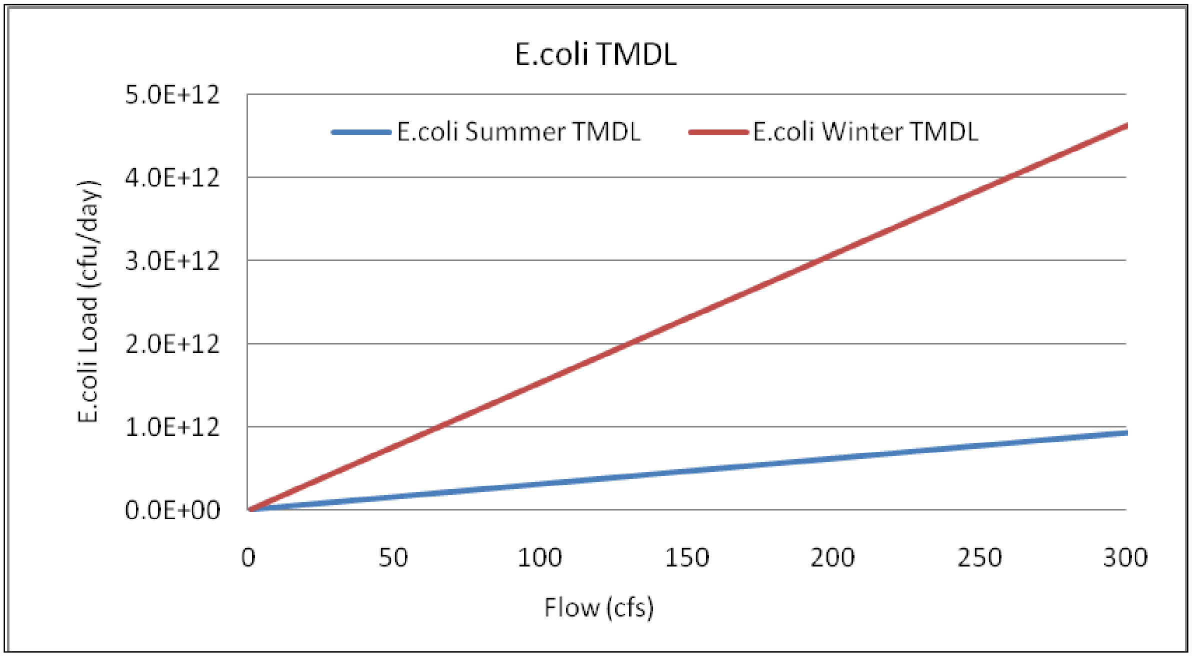

Figure 7-5. Seasonal E. coli TMDLs as a function of flow

TMDLs are allocated to point (wasteload) and nonpoint (load) *E. coli* sources. The TMDL is comprised of the sum of all point sources and nonpoint sources (natural and anthropogenic), plus a margin of safety that accounts for uncertainties in loading and receiving water analyses. In addition to pollutant load allocations, the TMDL must also take into account the seasonal variability of pollutant loads and employ an adaptive management strategy in order to address uncertainties inherent in environmental analyses.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

Where:
WLA = Wasteload Allocation or the portion of the TMDL allocated to point sources.

LA = Load Allocation or the portion of the TMDL allocated to nonpoint recreational/residential sources and natural background

MOS = Margin of Safety or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. Where the MOS is implicit (see **Section 7.8.2**), an additional numeric MOS is unnecessary; therefore the "explicit" MOS is set equal to 0 here.

TMDL = LA_{NB} + LA_{WW} + LA_{RES}

LA_{NB} = Load Allocation to natural background sources

LA_{WW} = Load Allocation to wastewater sources

LA_{RES} = Load Allocation to residential/recreational land use sources

7.6.1 Natural Background Load Allocation

Load allocations for natural background sources are based on a natural background *E. coli* concentration of 48 cfu/100ml (see **Section 7.5.1**), and are calculated using the equation:

LA_{NB} = (X) (Y) (2.44E+7)

X= *E. coli* natural background concentration in cfu/100ml

Y= streamflow in cubic feet per second

(2.44E+7) = conversion factor

7.6.2 Wastewater Load Allocation

The load allocation for unpermitted wastewater sources is set at zero: municipal and residential wastewater is prohibited from entering state waterbodies without an MPDES permit. Properly maintained sewer and septic systems are designed to prevent *E. coli* loads from entering waterbodies and are assumed to meet this allocation. System failures that contribute *E. coli* loads to surface waters are not meeting this allocation.

LA_{WW} = 0

7.6.3 *E. coli* Source: Agricultural/Residential Land Use and Development

Load allocations for residential/recreational sources are calculated as the difference between the allowable daily load (TMDL) and the natural background load:

LA_{RES} = TMDL - LA_{NB}

7.6.4 Allocation Approach

Widespread improvements are needed to decrease pathogen loading and meet TMDLs. Necessary agricultural BMPs may include but are not limited to improved riparian buffers, rotational grazing and effective manure management. These efforts focus on the distribution, usage, and timing of BMP application on the landscape. Control of livestock access to streams via fencing, installation of hardened stream crossings and off-stream water sources will reduce direct pathogen inputs to streams, increase streambank stability, and improve the riparian buffer health. These are essential for meeting the pathogen TMDLs. Pathogen loading reductions can be achieved through a combination of BMPs that meet site-specific conditions.

Although the needed reductions (based on sample data) only apply to the growing season for nonpoint sources, it is anticipated that TMDL implementation will result in year-round reductions in pathogen loading year-round. This will address sources of pathogens that tend to enter streams during runoff, are stored in channels and become available during the summer growing season.

Wasteload allocations (WLAs) were developed for the City of Bozeman MS4 stormwater system for the Bozeman Creek *E. coli* TMDL. The WLA for the City of Bozeman MS4 is a unique case as during normal low flow conditions the WLA = 0 for this point source. Load reductions for an activated system are performance based load reductions requiring successful implementation of a stormwater management program (SWMP). Therefore, the Bozeman Creek *E. coli* TMDL does not include a WLA to the MS4.

For all other *E. coli* impaired streams, TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources. Therefore, for streams without a WLA, all *E. coli* TMDLs are as follows: TMDL = LA. TMDLs and necessary reductions will be presented first for those assessment units with WLAs.

7.6.4.1 Meeting Allocations

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

Progress towards TMDL and individual allocation achievement can be gauged by BMP implementation and improvement in or attainment of water quality targets defined in **Section 6.4.2**. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology and/or models used here to develop the loads and percent reductions.

7.6.5 *E. Coli* TMDLs

Pathogen TMDLs for *E. coli* were developed for the 5 previously identified impaired stream segments.

7.6.5.1 Bozeman Creek

A 15% reduction in *E. coli* loading is needed to meet the TMDL on Bozeman Creek (**Table 7-11**). However, allowing a 0% reduction in natural load, a 21% reduction in *E. coli* loading from agricultural/residential nonpoint sources to Bozeman Creek is necessary to achieve the TMDL. In order to meet the water quality standard that <10% of samples are >252 cfu/100mL, a 34.1% reduction in the peak *E. coli* load is required. The only sample that was >252 cfu/100mL in 2008 or 2009 was an August 2008 sample collected at the mouth of Bozeman Creek.

Table 7-11. *E. Coli* Allocations and TMDL for Bozeman Creek

Source	Existing Load (cfu/day)**	TMDL (cfu/day)	% Reduction
Natural Background	22050.28	22050.28	0.0%
Agriculture/Residential	45614.06	35831.70	21.4%
Summary	67664.34	57881.98	14.5%

**MS4 is given a WLA of 0 during low flow conditions as the system should not be actively discharging at this time

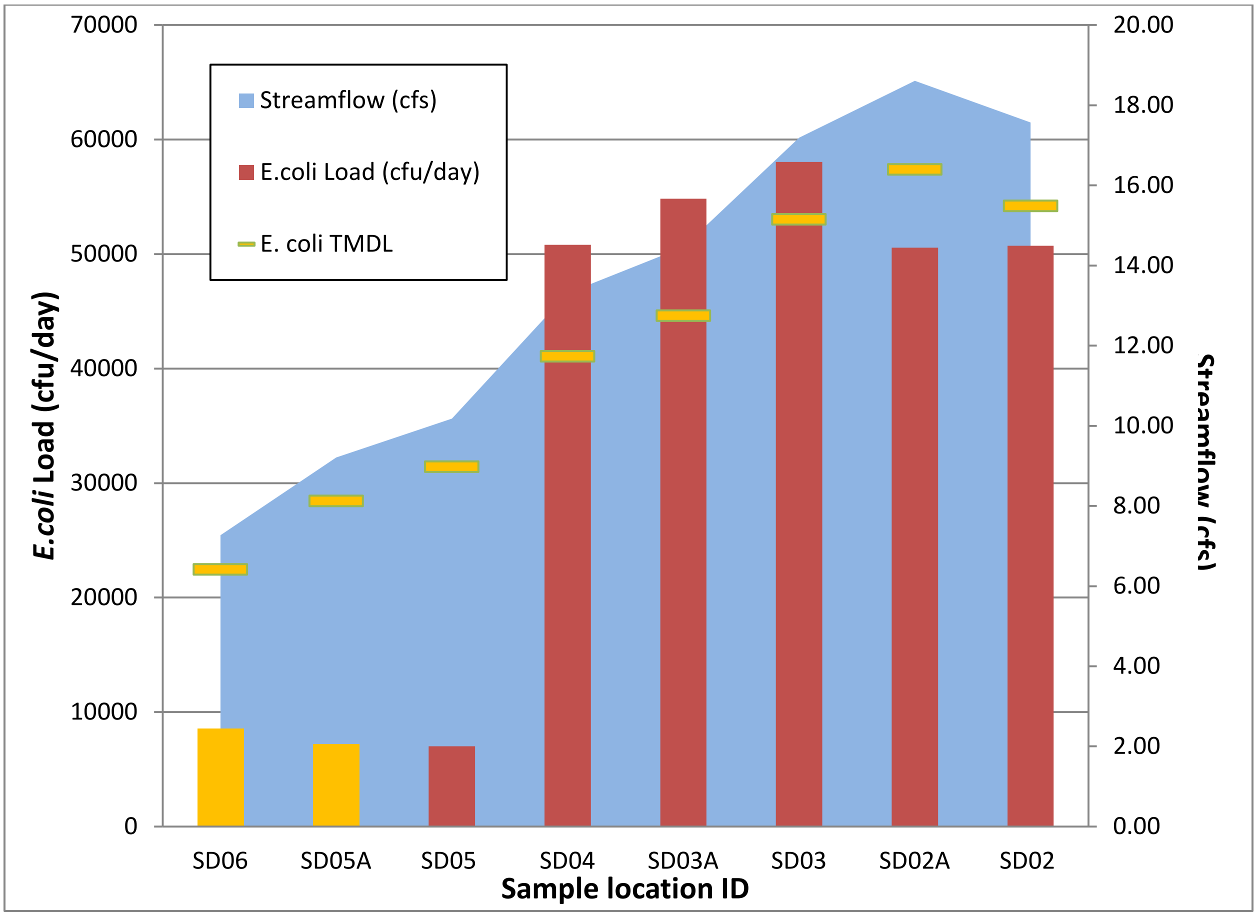

Figure 7-6. Synoptic sampling for *E. coli*, Bozeman Creek, 9/15/2009

Figure 7-6 displays the results of a sampling event on 9/15/2009 compared with the TMDL for *E. coli.* Samples SD06 and SD05A were collected in Bozeman Creek upstream of the assessment unit which starts at the confluence of Limestone Creek and Bozeman Creek. Nash Spring Creek joins Bozeman Creek between SD05 and SD04. On 9/15/2009, Nash Spring Creek comprised 28% of the increase in load between the 2 sample points. Matthew Bird Creek enters Bozeman Creek between SD03 and SD03A. The Mill-Willow irrigation canal diverts flow from Bozeman Creek in the same reach between SD03 and SD03A. On 9/15/2009, the increase in load in this reach was directly attributable to the *E. coli* load from Matthew Bird Creek.

7.6.5.2 Camp Creek

Based on sample data, the *E. coli* load on Camp Creek must be reduced 65% to meet the TMDL (**Table 7-12**). Allowing a 0% reduction in natural background, a 75% reduction from Agricultural/Residential sources is needed to achieve the TMDL. In order to meet the water quality standard that <10% of samples are >252 cfu/100mL, a 72.3% reduction in the peak *E. coli* load is necessary. This assumes a 0% reduction in natural background loading. In the Camp Creek dataset, 9 of 14 samples exceeded 252 cfu/100mL.

Table 7-12. *E. Coli* Allocations and TMDL for Camp Creek

Source	Existing Load (cfu/day)	TMDL (cfu/day)	% Reduction
Natural Background	27998.00	27998.00	0.0%
Agriculture/Residential	179107.42	45496.76	74.6%
Summary	207105.42	73494.76	64.5%

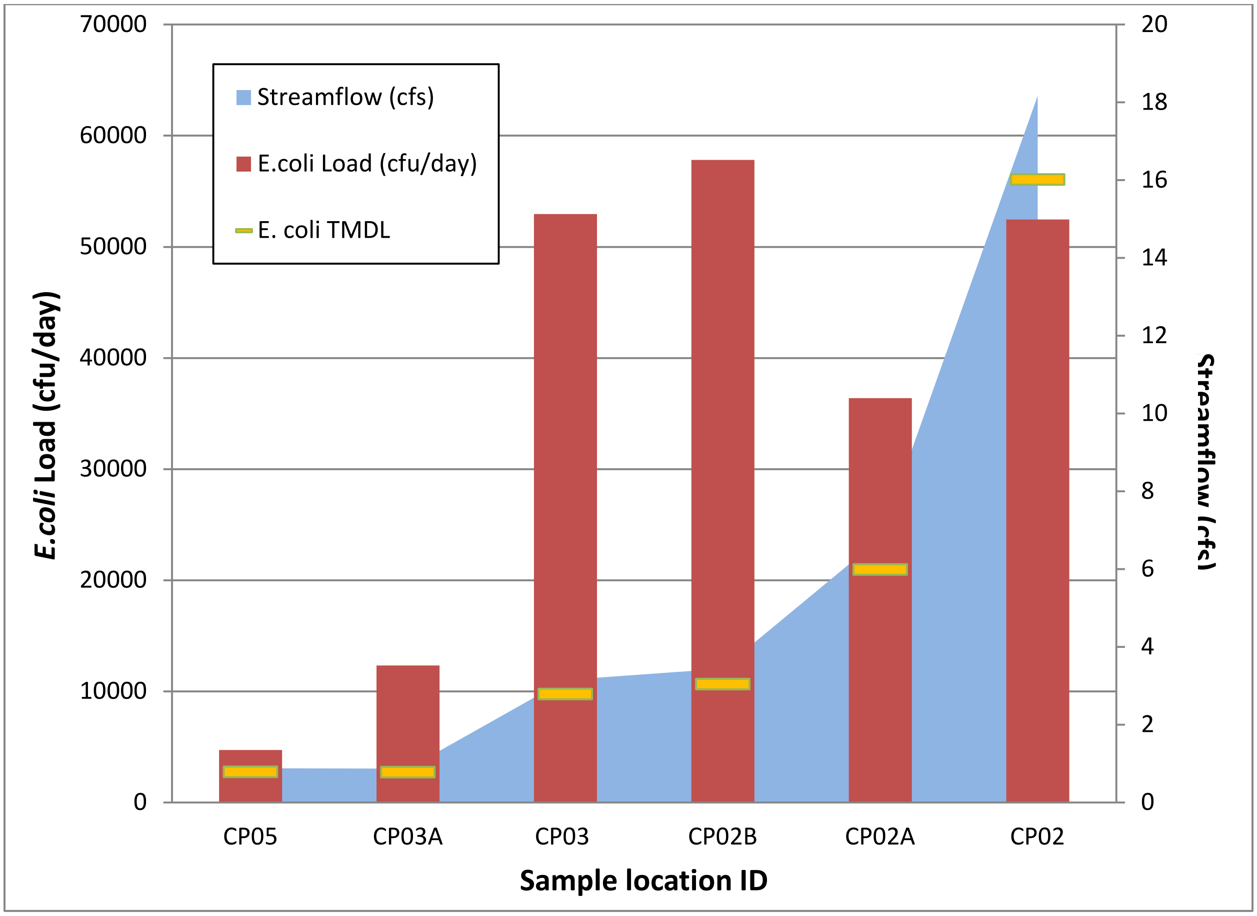

Figure 7-7. Synoptic sampling for *E. coli,* Camp Creek, 9/23/2009

Valley Ditch ends where it joins Camp Creek between CP02A and CP02. Flow was not recorded in Valley Ditch on 9/23/2009. An unnamed irrigation canal terminates in Camp Creek between CP03 and CP03A. The Amsterdam-Churchill WWTP is located between CP02B and CP02A (**Figure 7-7**). The data suggest that the WWTP is not contributing an appreciable pathogen load to Camp Creek.

7.6.5.3 Godfrey Creek

E. coli loads on Godfrey Creek need to be reduced 84% to meet the TMDL (**Table 7-13**). Allowing a 0% reduction in natural background concentrations, all other sources must be reduced 89% to meet the TMDL. In order to meet the water quality standard that <10% of samples are >252 cfu/100mL, an 89% reduction in the peak *E. coli* load is necessary. This assumes a 0% reduction in natural background loading. In the Godfrey Creek dataset, 6 of 11 samples exceeded 252 cfu/100mL.

Table 7-13. *E. Coli* Allocations and TMDL for Godfrey Creek

Source	Existing Load (cfu/day)	TMDL (cfu/day)	% Reduction
Natural Background	4885.97	4885.97	0.0%
Agriculture/Residential	75106.58	7939.70	89.4%
Summary	79992.55	12825.67	84.0%

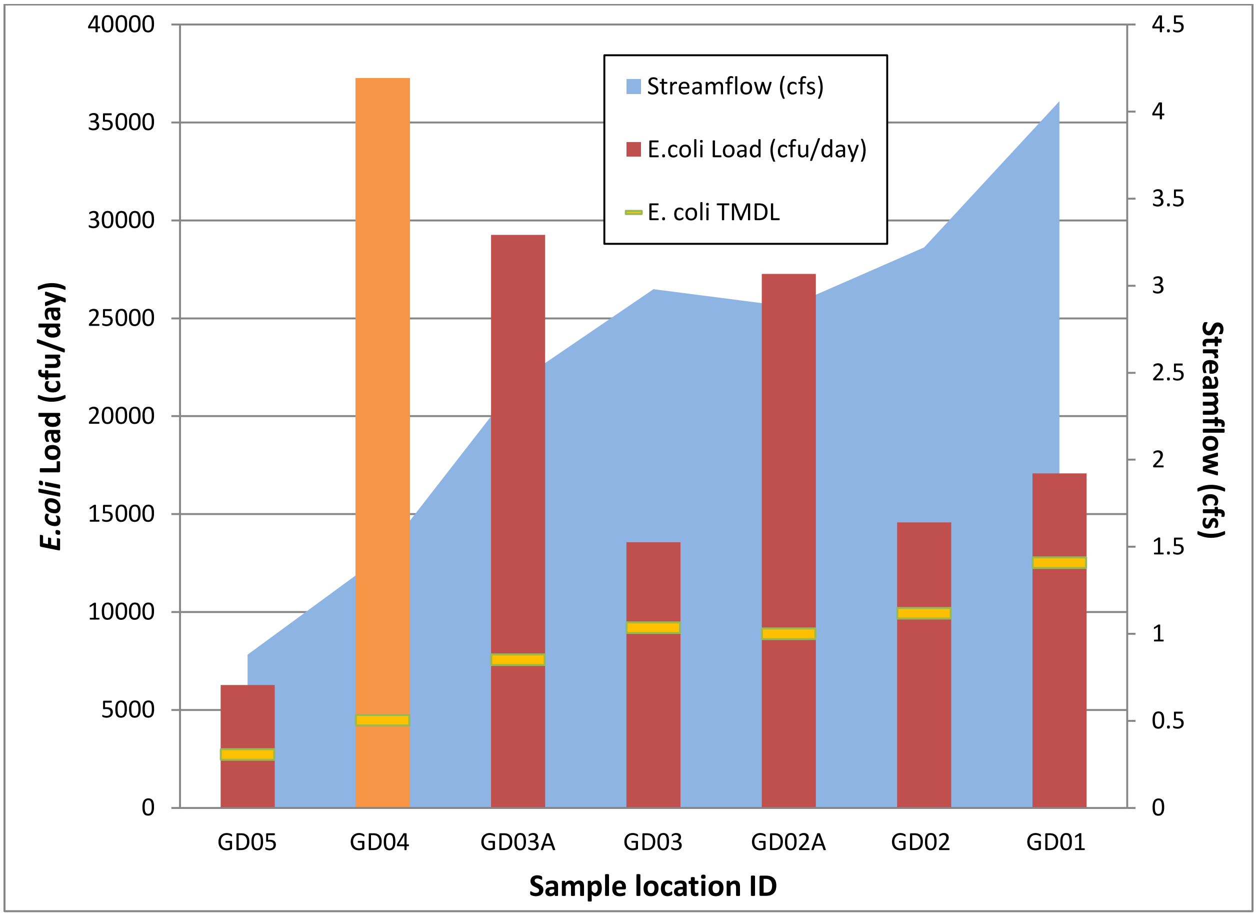

Figure 7-8. Synoptic sampling for *E. coli,* Godfrey Creek, 9/25/2009

On 9/25/2009, all samples collected on Godfrey Creek exceeded the TMDL for *E. coli* (**Figure 7-8**). GD04 is located on a tributary in the upper segment of Godfrey Creek. The samples was collected immediately upstream of where the tributary joins Godfrey Creek. Flow at GD04 on 9/25/2009 was 1.45 cfs and at GD05, on the mainstem of Godfrey Creek, was 0.88 cfs. GD05 was collected on the mainstem immediately upstream of the confluence of Godfrey Creek and the tributary represented by GD04.

Valley Ditch flows into Godfrey Creek and then comparable flow is diverted from the stream between GD02 and GD01.

7.6.5.4 Reese Creek

Sampling data on Reese Creek show that the stream is close to meeting the TMDL and require only a 3% reduction in *E. coli* loading (**Table 7-14**). Allowing a 0% reduction in natural background, loading from all sources must be reduced 4% to meet the TMDL. In order to meet the water quality standard that <10% of samples are >252 cfu/100mL, a 45.6% reduction in the peak *E. coli* load is necessary. This assumes a

0% reduction in natural background loading. In the Reese Creek dataset, 2 of 7 samples exceeded 252 cfu/100mL.

Table 7-14. *E. Coli* Allocations and TMDL for Reese Creek

Source	Existing Load (cfu/day)	TMDL (cfu/day)	% Reduction
Natural Background	9078.97	9078.97	0.0%
Agriculture/Residential	15413.99	14753.33	4.3%
Summary	24492.97	23832.31	2.7%

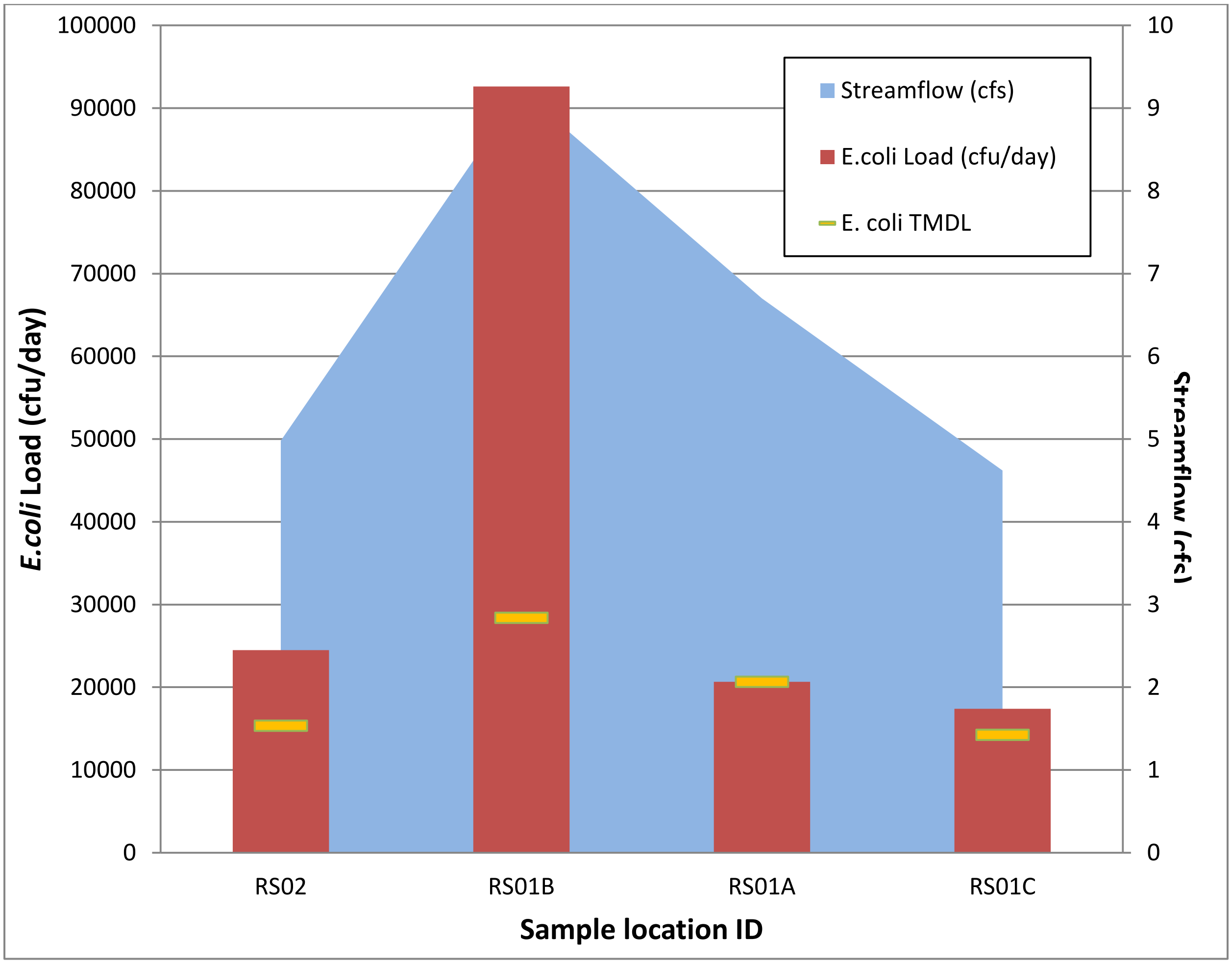

Figure 7-9. Synoptic sampling for *E. coli*, Reese Creek, 9/17/2009

On 9/17/2009, all samples collected on Reese Creek exceeded the TMDL for *E. coli* (**Figure 7-9**). North Cottonwood Creek joins Reese Creek between RS02 and RS01B. The decrease in flow downstream of RS01B is most likely due to several downstream irrigation diversions.

Reese Creek flows westward until it joins Ross Creek which carries flows from the Dry Creek Irrigation Canal. The Dry Creek Irrigation Canal diverts significant flow from the East Gallatin River approximately 4 miles downstream of the Hyalite Creek confluence. The Dry Creek Irrigation Canal flows northward from the East Gallatin River and intersects Ross Creek (**Figure 7-10**). At this point, flows from the canal and Ross Creek continue northward in the same channel. Ross Creek originally continued northeastward to its confluence with Smith Creek but is now channelized along a private road to where it meets Reese

Creek. At this intersection of flow, Ross Creek/Dry Creek Irrigation Canal flow up from the south and join Reese Creek from the east. The Dry Creek Irrigation Canal continues northward. The confluence marks the start of Smith Creek which flows westward to the East Gallatin River. As there is not a headgate or diversion that separates flows at this intersection, water quality analyses assumed that during the summer period Reese Creek flows are forced into the Dry Creek Irrigation Canal which flows northward with a mix of Ross Creek, Reese Creek and East Gallatin River flows. Smith Creek flows westward with a mixture of Ross Creek and East Gallatin River flow. Under this assumption, the Reese Creek watershed is not a source area of nutrient impairment on Smith Creek during the summer period when the irrigation canal is flowing.

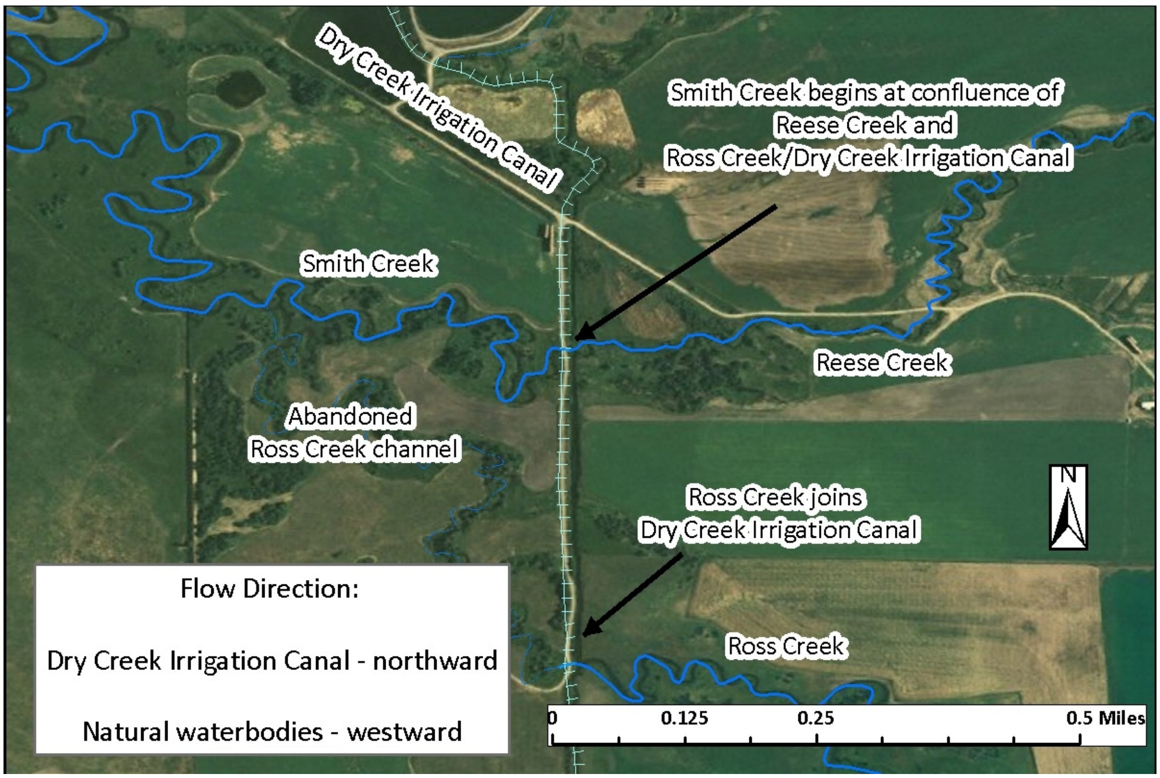

Figure 7-10. Confluence of Ross, Reese, and Smith Creeks and influence of Dry Creek Irrigation Canal

7.6.5.5 Smith Creek

Sampling data on Smith Creek show that the stream is currently meeting the TMDL for *E. coli* (**Table 7-15**). This is based on limited sampling in Smith Creek and is complicated by variable flows caused by local irrigation diversions (**Figure 7-10**). Sampling in the Ross Creek drainage suggests that this is a significant source area of *E. coli* to Smith Creek. The Dry Creek Irrigation Canal does convey flows from the East Gallatin River to Smith Creek. East Gallatin flows are assumed to be at or below the *E. coli* water quality standard.

The limited dataset suggests that flows in Smith Creek can be highly variable due to intra-basin irrigation transfers. Variable flow rates translates to variable *E. coli* loads. While the stream is currently meeting the TMDL for *E. coli* based on the geometric mean of 126 cfu/100mL, 2 of 7 samples exceeded 252 cfu/100mL. In order to meet the water quality standard that <10% of samples are >252 cfu/100mL, a 40% reduction in the peak *E. coli* load is necessary based on the limited dataset. This assumes a 0% reduction in natural background loading.

Table 7-15. *E. Coli* Allocations and TMDL for Smith Creek

Source	Existing Load (cfu/day)	TMDL (cfu/day)	% Reduction
Natural Background	58922.89	58922.89	0.0%
Agriculture/Residential	88272.12	95749.70	0.0%
Summary	147195.01	154672.59	0.0%

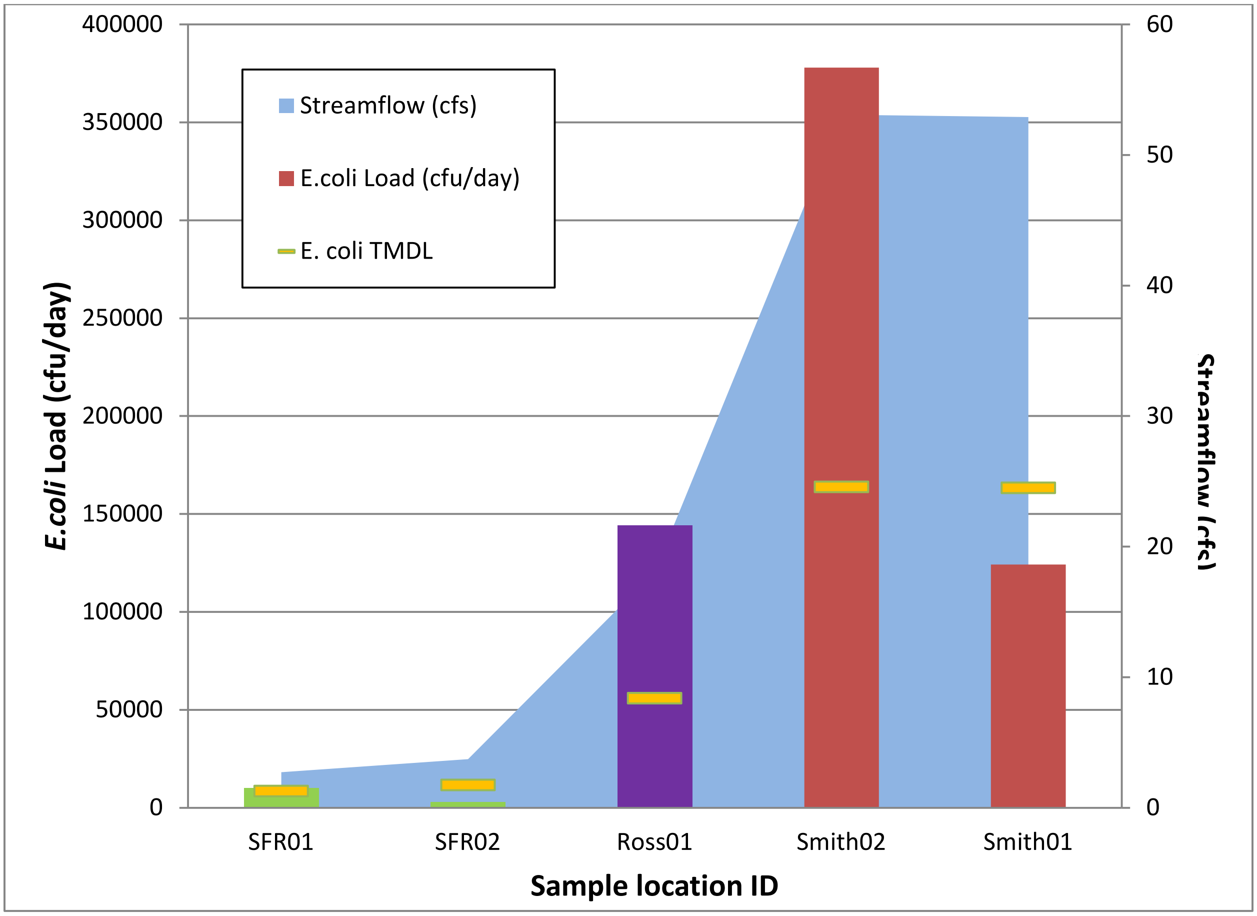

Figure 7-11. Synoptic sampling for *E. coli,* Smith Creek and tributaries, 9/17/2009

In **Figure 7-11**, SFR refers to South Fork Ross Creek which is a tributary to Ross Creek. Ross01 was collected on Ross Creek upstream of where the Dry Creek Irrigation Canal joins Ross Creek. As outlined in the Reese Creek discussion above, Ross Creek and flows from the East Gallatin River via the Dry Creek Irrigation Canal comprise the flows in Smith Creek.

7.7 Seasonality and Margin of Safety

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties in the pollutant loading analyses and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Lower Gallatin River Watershed *E. coli* TMDL development process

7.7.1 Seasonality

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan seasonality is an integral consideration. Water quality and particularly *E. coli* concentrations are recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Water quality standards and consequent *E. coli* water quality targets are developed based on application of seasonal beneficial uses (recreational use) and use a 126 cfu/100 ml value for the summer months and 630 cfu/100ml during the winter months.
- Water quality data was collected during the period of highest probability of target exceedance in the Lower Gallatin during low flow/late summer conditions.
- *E. coli* data and sources were evaluated based on and understanding of local seasonal source prevalence and seasonal pathways.

7.7.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety (MOS) accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading. This plan addresses MOS implicitly in a variety of ways:

- The geometric mean value of 126 cfu/100ml (summer) or 630 cfu/100ml (winter) is used to calculate TMDLs and load allocations. This provides a margin of safety by ensuring that allowable daily load allocations do not result in the exceedance of water quality targets.
- The 90th percentile value of summer natural background concentrations was used to establish a natural background concentration for load allocation purposes. This is a conservative approach, and provides an additional MOS for anthropogenically –derived *E. coli* loads during most conditions.
- Summertime natural background conditions (the highest natural concentrations) were used to establish natural background conditions during all seasons.
- By considering seasonality (discussed above) and variability in *E. coli* loading.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

7.7.3 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are applied throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop better understanding of *E. coli* impairment conditions and the processes that affect impairment. This process of adaptive management is predicated on the premise that TMDLs, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. As further monitoring of water quality and source loading conditions is conducted, uncertainties associated with these assumptions and considerations may be mitigated and loading estimates may be refined to more accurately portray watershed conditions.

As part of this adaptive management approach, land use activities should be tracked. Changes in land use may trigger a need for additional monitoring. The extent of monitoring should be consistent with the extent of potential impacts, and can vary from basic BMP assessments to a complete measure of target parameters above and below the project area before and after project completion. Cumulative impacts from multiple projects must also be a consideration. This approach will help track the recovery of the system and the effects of ongoing management activities in the watershed.

Uncertainties in assessments and assumptions should not paralyze, but should point to the need to be flexible in our understanding of complex systems, and to adjust our thinking and analysis in response to this need. Implementation and monitoring recommendations presented in **Section 9** and **Section 10** provide a basic framework for reducing uncertainty and furthering understanding of these issues.

8.0 Other Identified Issues or Concerns

8.1 Pollution Impairments

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) list. In other cases, streams in the Lower Gallatin TPA may appear on the 303(d) list but may not always require TMDL development for a pollutant, but do have pollution listings such as "alteration in streamside or littoral vegetation covers" that could be linked to a pollutant. These habitat related pollution causes are often associated with sediment issues, may be associated with nutrient or temperature issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Lower Gallatin watershed as a whole. In some cases, pollutant and *pollution* causes are listed for a waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the pollution listings. **Table 8-1** presents the *pollution* listings in the Lower Gallatin TPA, and notes those streams listed that either do not have any associated pollutant listings or a TMDL in this document.

Table 8-1. Waterbody segments with pollution listings on 2012 303(d) List

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT41H003_081	**BEAR CREEK**, headwaters to mouth (Rocky Creek)	Alteration in streamside or littoral vegetative covers
		Excess algal growth
MT41H003_040	**BOZEMAN CREEK**, confluence of Limestone Creek and Bozeman Creek to the mouth (East Gallatin River)	Alteration in streamside or littoral vegetative covers
		Chlorophyll-*a*
MT41H003_110	**BRIDGER CREEK**, headwaters to mouth (East Gallatin River)	Chlorophyll-*a*
MT41H002_010	**CAMP CREEK**, headwaters to mouth (Gallatin River)	Alteration in streamside or littoral vegetative covers
		Other anthropogenic substrate alterations
		Physical substrate habitat alterations
MT41H003_100	**DRY CREEK**, headwaters to mouth (East Gallatin River)	Alteration in streamside or littoral vegetative covers
		Physical substrate habitat alterations
		Cause unknown
MT41H003_020	**EAST GALLATIN RIVER**, Bridger Creek to Smith Creek	Alteration in streamside or littoral vegetative covers
		Low flow alterations
		Excess algal growth
MT41H003_030	**EAST GALLATIN RIVER**, Smith Creek to mouth (Gallatin River)	Alteration in streamside or littoral vegetative covers
MT41H001_010	**GALLATIN RIVER**, Spanish Creek to mouth (Missouri River)*	Low flow alterations
MT41H002_020	**GODFREY CREEK**, headwaters to mouth (Moreland Ditch)	Alteration in streamside or littoral vegetative covers
		Excess algal growth

Table 8-1. Waterbody segments with pollution listings on 2012 303(d) List

Waterbody ID	Stream Segment	2012 Probable Causes of Impairment
MT41H003_134	**HYALITE CREEK,** Bozeman water supply intake to the mouth (East Gallatin River)	Low flow alterations
MT41H003_050	**JACKSON CREEK**, headwaters to mouth (Rocky Creek)	Alteration in streamside or littoral vegetative covers
		Chlorophyll-*a*
MT41H003_080	**ROCKY CREEK**, confluence of Jackson and Timberline Creeks to mouth (East Gallatin River)	Alteration in streamside or littoral vegetative covers
		Other anthropogenic substrate alterations
		Physical substrate habitat alterations
MT41H003_060	**SMITH CREEK**, confluence of Ross and Reese Creeks to mouth (East Gallatin River)	Alteration in streamside or littoral vegetative covers
		Physical substrate habitat alterations
MT41H002_031	**SOUTH COTTONWOOD CREEK**, Middle Creek Association Ditch diversion to mouth (Gallatin River)*	Low flow alterations
MT41H003_120	**STONE CREEK**, headwaters to mouth (Bridger Creek)	Alteration in streamside or littoral vegetative covers
MT41H003_090	**THOMPSON CREEK** (Thompson Spring), headwaters to mouth (East Gallatin River)	Alteration in streamside or littoral vegetative covers
		Chlorophyll-*a*

* Streams listed for pollution only, with no pollutant listings or no TMDL in this document.

8.2 Pollution Causes of Impairment Descriptions

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

Alteration in Streamside or Littoral Vegetation Covers

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

Cause Unknown

This pollutant is a special case that was linked specifically to Dry Creek in the Lower Gallatin project area. Water quality research in the late 1970s in the Gallatin Valley identified water quality issues through extensive sampling in the watershed (Blue Ribbons of the Big Sky Country Areawide Planning Organization, 1977; 1978; 1979). In this case, the impairment was linked to fecal coliform samples that impaired the beneficial use of primary contact recreation. However the source was listed as unknown and the pollution was not further clarified. In this specific case, future monitoring by DEQ Monitoring and Assessment personnel will address this pollutant on Dry Creek in the Lower Gallatin project area.

Chlorophyll-*a*/Excess Algal Growth

These 2 terms are interchangeable as they identify an impairment of a beneficial use to primary contact recreation from algal growth in the stream channel. Excess algal growth refers to the often visual identification of impairment from phytoplankton/algal growth while chlorophyll-*a* is a direct measure of plant productivity. The most abundant form of chlorophyll within photosynthetic organisms, chlorophyll-*a* is used as a surrogate measure of net primary production in a stream. It is used as a measurement of the population and distribution of microscopic living plant matter (phytoplankton or algae) in a stream reach. Chlorophyll monitoring is a way to track algal growth. In surface waters high chlorophyll concentrations are often correlated with high nutrient concentrations such as nitrogen and phosphorus which can cause algal blooms. When an algal bloom dies off at the end of its life cycle or due to a change in environmental conditions, the resulting decomposition depletes dissolved oxygen (DO) levels in the water column. A loss of DO can lead to fish kills. High nutrient concentrations can be indicative of septic system leakages, wastewater treatment plant influences, and fertilizer/manure runoff. Chlorophyll-*a* can therefore be used as an indirect measure of nutrient levels. For both descriptors, chlorophyll-*a* and excess algal growth indicate an oversupply of nutrients to the system.

Physical Substrate Habitat Alterations

Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Low Flow Alterations

Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

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

Other Anthropogenic Substrate Alterations

Streams may be listed for other anthropogenic substrate alterations when data indicates impacts to the stream channel have resulted from apparent anthropogenic activities, but parameters related to substrate (pebble counts) do not appear high, and morphological characteristics such as width/depth or entrenchment are also within expected values. For example, this would take place in a system where the reduction or historic reduction of vegetation capable of producing large woody debris has occurred, in a system where large woody debris is integral to pool development (quality and quantity) and channel function.

8.3 Monitoring and BMPs for Pollution Affected Streams

Streams listed for pollution as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and *E. coli* information where data is minimal and the linkage between probable cause, pollution listing, and effects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 9.0** and **10.0** are presented to address both pollutant and non-pollutant issues for streams in the Lower Gallatin TPA with TMDLs in this document, and they are equally applicable to streams listed for the above pollution categories.

9.0 Restoration Objectives and Implementation Strategy

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

9.1 Water Quality Restoration Objectives

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

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

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

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

9.2 Agency and Stakeholder Coordination

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

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

9.3 Restoration Strategy By Pollutant

This section summarizes the primary restoration strategy for each pollutant with TMDLs in this document as well as some general information on restoration of non-pollutant impairments.

9.3.1 Sediment Restoration Strategy

The goal of the sediment restoration strategy is to prevent the availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Streamside riparian vegetation restoration and long term riparian area management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Vigorous native streamside riparian vegetation filters sediment from upland runoff and improves streambank stability and slows bank erosion. Sediment is also deposited more heavily in healthy riparian zones during flooding because water velocities slow in these areas enough for excess sediment to settle out.

In areas where stormwater is accelerating sediment loading to streams, the sediment restoration strategy will be achieved by BMPs that promote infiltration of runoff and lessen its volume and the timing of delivery to surface water. Smart growth and low impact development are two closely related planning strategies that help reduce stormwater volume, slow its transport to surface waterbodies, and improve groundwater recharge.

Improved grazing management is another major component of the sediment restoration approach. This may include adjusting the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas. Additionally, grazing management, combined with some additional fencing costs in many riparian areas, would promote natural recovery. Active vegetation planting along with bank sloping may increase costs, but still remains within a reasonable and relatively cost effective restoration approach. When stream channel restoration work is needed because of altered stream channels, costs increase and projects should be assessed on a case by case basis. In general, these are sustainable agricultural practices that promote attainment of conservation objectives while meeting agricultural production goals. The appropriate BMPs will differ by landowner and are recommended to be part of a comprehensive farm/ranch plan.

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

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

9.3.2 Nutrient Restoration Strategy

The goal of the nutrient restoration strategy is to reduce nutrient input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of nutrients from rangeland and cropland. Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving nutrient TMDLs in predominantly agricultural watersheds. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

1. The timing and duration of near-stream grazing,
2. The spacing and exposure duration of on-stream watering locations,
3. Provision of off-stream site watering areas to minimize near-stream damage and allow impoundment operations that minimize salt accumulations,
4. Active reseeding and rest rotation of locally damaged vegetation stands,
5. Improved management of irrigation systems and fertilizer applications, and
6. Incorporation of streamside vegetation buffer to irrigated croplands and confined feeding areas

Seasonal livestock confinement areas have a historic precedent for placement near or adjacent to flowing streams. Stream channels were the only available livestock water sources prior to the extension of rural electricity. Although limited in size, their repeated use generates high nutrient concentrations in close proximity to surface waters. Episodic runoff with high nutrient concentrations generates large loads that can settle in pools of intermittent streams and remain bio-available through the growing season. Diversion and routing of confinement runoff to harvestable nutrient uptake areas outside of active water courses are effective controls.

In addition to the agricultural related BMPs, a reduction of sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Additional sediment related BMPs are presented in **Section 9.3.1**.

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible and applied to croplands, pastures and livestock handling facilities. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local USDA Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

9.3.3 *E. coli* Restoration Strategy

In basins dominated by agricultural livestock operations, the goal of the *E. coli* restoration strategy is to reduce source input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of manure from rangeland and cropland to waterbodies. Many of the same nutrient BMPs apply to *E. coli* source management by changing the timing and distribution of manure applications. Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving pathogen TMDLs in predominantly agricultural watersheds. Other BMPs include the control of runoff and leaching from stockpiled manure and eliminating or reducing livestock access to waterbodies. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on upland runoff dynamics. Although limited in size, their repeated use generates high risk of pathogen loading to surface waters. Land application of stored versus fresh manure and allowing a delay prior to incorporation of manure into the soil profile promotes a decrease *E. coli* concentrations through the actions of drying and ultraviolet (UV) light.

For *E. coli* TMDLs that include streams in more urban/residential drainages, efforts to monitor and maintain septic fields are necessary to minimize the loading to surface waters. In Bozeman Creek and other streams that receive discharges from the MS4, efforts to identify and eliminate illicit discharges to the receiving waterbodies are needed. In addition, BMPs that include education and outreach to inform the public to the proper way to handle and dispose of pet waste would further reduce the total loading of pathogens to the MS4 system.

In order to better understand conditions contributing to *E. coli* loading, it is recommended that *E. coli* sampling be continued in areas where elevated *E. coli* concentrations were observed, and to note specific land uses and conditions at the time of sampling that could be contributing to elevated instream concentrations. Additionally, synoptic sampling events should be continued, particularly during late summer low-flow conditions in order to allow analysis of load contributions during times when water quality is most susceptible to impacts from *E. coli* contributions.

9.3.4 Pollution Restoration Strategy

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Lower Gallatin TPA include alteration in streamside or littoral vegetative covers, physical substrate habitat alterations, other anthropogenic substrate alterations, and low flow alterations. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Although flow alterations have the most direct link with temperature, adequate flow is also critical for downstream sediment transport and improving the assimilative capacity of streams for sediment, nutrient, and *E. coli* inputs. Therefore, if restoration goals within the Lower Gallatin TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered. Habitat and flow BMPs are discussed below in **Section 9.4**.

9.4 Restoration Approaches by Source Category

For each major source of human-caused pollutant loads in the Lower Gallatin TPA, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Lower Gallatin TPA should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing significant sources where large load reductions can be obtained within each source category. For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. The source assessment results provided within the appendices and attachments and summarized in **Sections 5.7, 6.5, and 7.5** provide information that should be used to help determine priorities for each major source type in the watershed and for each of the general management recommendations discussed.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 10.0**.

9.4.1 Grazing

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

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Lower Gallatin TPA are providing off-site watering sources, limiting livestock access to streams, providing “water gaps” where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank re-vegetation are a preferred BMPs, in some instances, bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution can be obtained in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2012).

9.4.2 Small Acreages

Small acreages are growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further information may be obtained from the Montana Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012) or the MSU extension website at: http://www.msuextension.org/ruralliving/Index.html.

9.4.3 Animal Feeding Operations

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

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

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

Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:

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

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

9.4.4 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment and nutrient inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendations for the Lower Gallatin TPA are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for filter strips and 50 percent for buffers (Montana Department of Environmental Quality, 2012). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities which will also supply shade to reduce instream temperatures. Filter strips widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2012).

9.4.5 Irrigation

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

Improvements should focus on how to reduce the amount of stream water diverted during July and August, while still growing crops on traditional cropland. It may be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July and August. Understanding irrigation water, groundwater and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons. Although additional investigation of inefficiencies in the irrigation network is needed to obtain the most improvement, potential changes are as follows:

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

9.4.6 Riparian Areas and Floodplains

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Therefore, enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Lower Gallatin TPA. The value of these areas is increasingly being recognized; over the past several years, Gallatin County has incorporated construction setbacks and floodplain development restrictions into county ordinances; the county has a 150 foot setback from the high water mark (Gallatin County, 2012).

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

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

9.4.7 Roads

The road sediment reductions in this document represent an estimation of the sediment load that would remain once appropriate road BMPs were applied at all locations. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012). Examples include:

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

9.4.7.1 Culverts and Fish Passage

Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis found that approximately 32% of the culverts were designed to accommodate a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 19 culverts in the watershed, which is a small percentage of the total culverts, and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish-bearing streams and at least 25 year events on non fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

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

9.4.7.2 Traction Sand

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

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

9.4.8 Beaver Populations and Sediment Yields

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

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

9.4.9 Forestry and Timber Harvest

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

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

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

9.4.10 Storm Water Construction Permitting and BMPs

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

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

9.4.11 Urban Area Storm Water BMPs

Buildings and other impervious surfaces associated with land development prevent water from infiltrating into the ground and can alter watershed hydrology and transport built-up pollutants into nearby waterbodies. An important component to effectively managing stormwater is comprehensive planning that integrates land and infrastructure management. Smart growth and low impact development are two closely related planning strategies that help reduce stormwater volume, slow its transport to surface waterbodies, and improve groundwater recharge. Smart growth emphasizes structuring development to preserve open space, reduce the use of impervious surfaces, and improve water detention so more precipitation can be retained on the landscape before runoff occurs. Low impact development mimics natural processes of water storage and infiltration and can limit the harmful effects that increased percentages of impervious surface have on surface waters. Both concepts focus on applying simple, non-structural, and low cost methods to treat stormwater on the landscape and they can be used to retrofit existing development and also applied to new development.

Starting in 2012, the MS4 general permit requires that to the extent practicable new development or redevelopment projects greater than one acre implement low impact development practices that "infiltrate, evapotranspire, or capture for reuse the runoff generated from the first 0.5 inches of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation." Generally, newer developments in the watershed have better BMP implementation than older developments, and although planning for future development and retrofitting older developments with better levels of treatment are important, consistent maintenance and effectiveness evaluation of new and recently implemented stormwater BMPs is also an important component of effective stormwater management and TMDL implementation. Examples low impact development and smart growth practices include drain chains, rain barrels, vegetated swales, sidewalk storage, permeable pavers, native landscaping, reducing parking areas, and mixed-use development. Parking lot drainage into a swale and a mixed use development are shown in **Figure 8-1**. Additional information about smart growth and low impact development can be found in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012) and at the EPA's website (www.epa.gov/nps/lid; www.epa.gov/dced).

Figure 8-1. Stormwater BMPs: Parking lot designed to drain into a swale and a mixed use development.

9.4.12 Nonpoint Source Pollution Education

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

9.5 Potential Funding Sources

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

9.5.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 25 percent or more match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

9.5.2 Future Fisheries Improvement Program

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

9.5.3 Watershed Planning and Assistance Grants

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

9.5.4 Environmental Quality Incentives Program

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

9.5.5 Other Funding Sources

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

10.0 MONITORING STRATEGY

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

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

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

10.1 ADAPTIVE MANAGEMENT AND UNCERTAINTY

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

The adaptive management approach is outlined below:

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

10.2 Tracking and Monitoring Restoration Activities and Effectiveness

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

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

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

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

10.3 Baseline and Impairment Status Monitoring

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

10.3.1 Sediment

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

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

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

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

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

10.3.2 Nutrients

Water quality sampling for nutrients were distributed spatially along an assessment unit in order to best delineate nutrient sources. Over multiple sample seasons, sampling locations were refined to better quantify loading sources to the impaired waterbodies. Source refinement and nutrient loading dynamics will continue to be necessary on streams with TMDLs and those that have not yet been assessed in the Lower Gallatin project area.

For those watershed groups and/or government agencies that monitor water quality, it is recommended that the same analytical procedures and reporting limits are used in order that water quality data may be compared to TMDL targets (**Table 10-1**). In addition, stream discharge should be measured at time of sampling.

Table 10-1 DEQ Monitoring Parameter Requirements

Analyte	Preferred method	Alternate method	Required reporting limit (ppb)	Holding time (days)	Bottle	Preservative
Total Persulfate Nitrogen (TPN)	A4500-NC	A4500-N B	40	28	250mL HDPE	≤6°C (7d HT); Freeze (28d HT)
Total Phosphorus as P	EPA-365.1	A4500-P F	3			H2S04, ≤6°C of Freeze
Nitrate-Nitrite as N	EPA-353.2	A4500-N03 F	10			

It will be important to continually assess nutrient sources in a watershed with changing land uses and/or new MPDES permitted discharges to surface waters.

10.3.3 *E. coli*

Water quality sampling for *E. coli* were distributed spatially along an assessment unit in order to best delineate pathogen sources. Over multiple sample seasons, sampling locations were refined to better quantify loading sources to the impaired waterbodies. Source refinement and pathogen loading dynamics will continue to be necessary on streams with TMDLs and those that have not yet been assessed in the Lower Gallatin project area. As *E. coli* loading from agricultural sources is often greatest during high flow events with overland runoff to surface waters, sampling during these events may better identify source areas. In addition, targeted sampling of surface waters in proximity to large septic drain fields may better quantify the loading from these sources.

For those watershed groups and/or government agencies that monitor water quality, it is recommended that the same analytical procedures and reporting limits are used in order that *E. coli* data be compared to TMDL targets (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). In addition, stream discharge should be measured at time of sampling. It is important to note that *E. coli* sampling can be complicated by the 6-hour holding time restriction (Section 2.1.4 in Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006).

10.4 Source Assessment Refinement

In many cases, the level of detail provided by the source assessments only provides broad source categories or areas that need to reduce pollutant loads and additional source inventory and load estimate work may be desirable. Strategies for strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described by pollutant in this section. Recommendations for source assessment refinement are described below by pollutant.

10.4.1 Sediment

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

- a refined bank erosion retreat rate for Lower Gallatin watershed streams,
- a better understanding of bank erosion impacts from historical land management activities,
- improved modeling for upland erosion delivery in forested watersheds where riparian zones have recovered from SMZ law implementation,
- improved classification of riparian health,
- evaluation of seasonal loading aspects for the major sources and potential implications regarding TMDL target parameters,
- evaluation of the influence of the irrigation network, particularly where open mixing occurs between streams and an irrigation canal (e.g., Dry Creek Irrigation Canal and Ross/Reese/Smith creeks),
- improved monitoring of stormwater loading,
- a review of land management practices specific to sub-watersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories, and
- additional field surveys of culverts, roads, and road crossings to help prioritize the road segments/crossings of most concern.

10.4.2 Nutrients

Nutrient-related information that could help strengthen the source assessment is as follows:

- a better understanding of septic contributions to nutrient loads
- a better understanding of nutrient concentrations in groundwater and spatial variability
- a better understanding of the irrigation network and its effect on hydrology and nutrient concentrations
  - for Buster Gulch which transports flows from the East Gallatin River to Hyalite Creek
  - for the Dry Creek Irrigation Canal and its interaction with Ross, Reese, and Smith Creeks which requires clarification to better quantify loads and source areas
  - for Farmer's Canal and its influence on Mandeville Creek water quality
- a more detailed understanding of fertilization practices within the watershed
- a review of land management practices specific to sub-watersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories,
- additional sampling in streams with less data such as Bear, Dry, Jackson, Reese, Smith and Ross Creeks in order to complete a full assessment per DEQ assessment methodology

10.4.3 *E. coli*

E. coli information that could help strengthen the source assessment is as follows:

- a better understanding of septic contributions,
- a better understanding of natural background *E. coli* concentrations in surface water and spatial variability
- a better understanding of the irrigation network and its effect on hydrology and nutrient concentrations for the Dry Creek Irrigation Canal and its interaction with Ross, Reese, and Smith Creeks which requires clarification to better quantify loads and source areas
- a more detailed understanding of manure management practices within the watershed
- a review of land management practices specific to sub-watersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories
- additional sampling in streams that lack recent *E. coli* data including Rees, Ross, Smith, and Dry Creeks and the East Gallatin River; the latter to determine the potential contributing load to Smith Creek via the Dry Creek Irrigation Canal

11.0 STAKEHOLDER AND PUBLIC PARTICIPATION

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

This public review period was initiated on September 7, 2012 and ended on October 6, 2012. There were 2 public meetings held during the public comment period. The first meeting was held on September 12th in Bozeman and the second was held in Amsterdam on September 27th. At these public meetings, DEQ provided an overview of the TMDLs for sediment, nutrients and pathogens in the Lower Gallatin project area, made copies of the document available to the public, and solicited public input and comment on the plan. The announcement for that meeting was distributed among the Watershed Advisory Group, and advertised in the following newspapers: The Bozeman Chronicle in Bozeman, Big Sky News in Big Sky, and the Belgrade News in Belgrade, MT. This section includes DEQ's response to all public comments received during the public comment period.

Three respondents provided public comment to DEQ during the public comment period. Excerpts from the comment letters and DEQ responses are provided in **Appendix H**. The original comment letters are held on file at the DEQ and may be viewed upon request.

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