Musselshell *E.coli* TMDLs and Water Quality Improvement Plan

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Cover Photo:
Musselshell River, half mile south of Shawmut
Photo by: Montana Dept. of Environmental Quality

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ERRATUM FOR THE MUSSELSHELL *E. COLI* TMDLS AND WATER QUALITY IMPROVEMENT PLAN

This TMDL document was approved by Environmental Protection Agency (EPA) on August 13, 2021. A copy of the EPA approved TMDL document is posted on DEQ's website. The original version had minor errors that warranted clarification and are explained and corrected in this erratum sheet. If you have a copy of the TMDL document, please note the corrections listed below or simply print out the erratum sheet and insert it in your copy of the TMDL document or download the updated version of the TMDL document from the Montana DEQ website.

Appropriate corrections have already been made in the downloadable version of the TMDL document located on our website at: https://deq.mt.gov/files/Water/WQPB/TMDL/PDF/LMO-TMDL-01a.pdf

The following tables contain the corrections made to the TMDL document. The first row cites the page and paragraph where there is a text error. The second row contains the original text that was in error. The third row contains the new, corrected text.

Location in the Document
Section 5.6.4, Page 5-25, first paragraph
Original Text
In general, the highest concentration occurred higher upstream in the watershed. Monitoring site M24MUSSR10 consistently showed the highest concentrations and M24MUSSR09 consistently had the lowest *E. coli* concentrations. In all instances, flows were above average when samples exceeded the water quality standard.
Corrected Text
In general, higher concentrations occurred upstream in the watershed and concentrations decreased in a downstream direction. Monitoring site M24MUSSR03 consistently showed higher concentrations and M24MUSSR09 consistently had lower *E. coli* concentrations. Samples collected on 7/14 and 7/15 of 2015 showed a rise in *E. coli* concentrations between monitoring location M24MUSSR03 and M24MUSSR10 then a decrease between M24MUSSR10 and M24MUSSR09. Samples collected on 7/26 and 7/28 of 2016 show decreasing concentrations between M24MUSSR03 and M24MUSSR10. No samples were collected at M24MUSSR09 on these dates. In all instances, flows were above average when samples exceeded the water quality standard.

Location in the Document
Section 5.6.7, Page 5-32, second paragraph
Original Text
The Middle Musselshell River was sampled 19 times at three different locations between 7/13/2015 and 7/28/2016. *E. coli* water quality exceedances occurred at each of the monitoring locations. The general trend for data from both 2015 and 2016 indicate decreasing *E. coli* concentrations in the downstream direction, with the highest concentrations being recorded at sampling site M24MUSSR10 and lowest being recorded at M24MUSSR09. In all instances, flows were above average when samples exceeded the water quality standard.
Corrected Text

The Middle Musselshell River was sampled 25 times at four different locations between 8/11/2015 and 9/29/2016. *E. coli* water quality exceedances occurred at monitoring locations MS24MUSSR04 and MS24MUSSR06 during the 8/18/205 sampling event. The general trend for data from both 2015 and 2016 indicate decreasing *E. coli* concentrations in the downstream direction. Typically, higher concentrations were recorded at sampling site M24MUSSR04 and lower concentrations were recorded at the next downstream site (M24MUSSR05). *E. coli* concentrations then either continued to decrease or increased slightly from MS24MUSSR05 to MS24MUSSR06. The lowest concentrations were recorded at MS24MUSSR08 the furthest downstream monitoring location. In both instances (8/11/2015 and 9/29/2016) samples exceeded the water quality standard when flows were above average.

Location in the Document
Section 5.6.12, Page 5-41, first paragraph
Original Text
This impaired section of the Lower Musselshell River (assessment unit MT40A003_010) is from the Highway 87 Bridge to the mouth (Fort Peck Reservoir).
Corrected Text
This impaired section of the Lower Musselshell River (assessment unit MT40C003_010) is from the confluence with Flatwillow Creek to the mouth (Fort Peck Reservoir).

Acknowledgements

DEQ would like to acknowledge the Musselshell Watershed Coalition (MWC) for their contributions in the development of the TMDLs contained in this document. The MWC provided support throughout the TMDL planning and development process by providing assistance with the identification of stakeholders and coordinating stakeholder meetings and public outreach and education. The MWC will also be involved in implementing many of the water quality improvement recommendations contained in this document.

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ACRONYM LIST

Acronym	**Definition**
ARM	Administrative Rules of Montana
AUID	Assessment Unit ID
BLM	Bureau of Land Management (U.S.)
BMP	Best Management Practice
CFR	Code of Federal Regulations (U.S.)
cfs	Cubic Feet Per Second
CFU	Colony Forming Unit
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation (Montana)
EPA	Environmental Protection Agency (U.S.)
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
ID	Identification
IR	Integrated Report (Montana's Water Quality Integrated Report)
LA	Load Allocation
MCA	Montana Code Annotated
mL	Milliliter
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MPN	Most Probable Number
NED	National Elevation Dataset
NRCS	Natural Resources Conservation Service (U.S.)
TMDL	Total Maximum Daily Load
USFS	United States Forest Service
USGS	United States Geological Survey
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan

HOW THIS DOCUMENT IS ORGANIZED

This document is organized into three parts, in addition to a preceding document summary, and one document appendix. Use the tables below to determine which part(s) to read to find the information most useful to you.

Document Part	Read for:
Part 1	Introductory information that provides the context for this document and defines the total maximum daily load (TMDL) process
Part 2	The TMDL components and how they are derived
Part 3	Information on ways to improve water quality in the Musselshell River watershed and information on developing a local water quality restoration plan

PART 1 – INTRODUCTORY INFORMATION

Part 1 Document Section	Section Contents
Section 1.0 Project Overview	Explains why DEQ writes TMDLs and provides a summary of what water quality impairments are addressed and a table of what TMDLs are included in this document
Section 2.0 Musselshell River Watershed Description	Describes the physical and social characteristics of the watershed
Section 3.0 Montana Water Quality Standards	Discusses the water quality standards that apply to the Musselshell River watershed and the TMDLs in this document
Section 4.0 Defining TMDLs and Their Components	Defines the components of TMDLs and how each is developed

PART 2 – TMDL COMPONENTS

Part 2 Document Section	Section Contents
Section 5.0 *Escherichia coli* (*E. coli*) TMDL Components	This section includes (a) a discussion of the affected waterbodies and the pollutant's effect on beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources

Section 6.0 Public Participation and Public Comment	Describes other agencies and stakeholder groups who were involved with the development of this document and the public participation process used to review the draft document. Addresses comments received during the public review period.

PART 3 – WATER QUALITY RESTORATION RECOMMENDATIONS

Part 3 Document Section	**Section Contents**
Section 7.0 Water Quality Improvement Plan and Monitoring Strategy	Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs; also describes a water quality monitoring plan for evaluating the long-term effectiveness of the Musselshell TMDL document.

DOCUMENT SUMMARY

This document presents *E coli* total maximum daily loads (TMDLs) and a water quality improvement plan for eight tributaries of the Musselshell River and three segments of the Musselshell River (**Figure 1-1**).

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 project area includes the mainstem of the Musselshell River and its tributaries from its headwaters in the Little Belt Mountains to the river's mouth, at the confluence of the Missouri River (Fort Peck reservoir) and encompasses approximately 9,482 square miles (6,068,495 acres) (**Figure 2-1)**. The area includes the watersheds of many tributary streams draining to the Musselshell River. The project area includes portions of Meagher, Wheatland, Sweet Grass, Fergus, Petroleum, Garfield, Rosebud, Musselshell, Golden Valley, and Stillwater counties.

DEQ determined that eight tributaries of the Musselshell River, and three segments of the mainstem of the Musselshell River do not meet the applicable water quality standards for *E. coli* and 11 TMDLs are included that address 11 pollutant impairments (**Table DS-1**). Although DEQ recognizes that there are other pollutant listings for this project area, this document addresses only *E. coli* pollutant impairments.

Elevated concentrations of *E. coli* can put humans at risk for contracting water-borne illnesses. Therefore, *E. coli* and other pathogenic pollutants can lead to impairment of a waterbody's beneficial uses. DEQ's water quality assessment methods for *E. coli* impairment are designed to evaluate the most sensitive use, thus ensuring protection of all beneficial uses. For streams in Montana, the most sensitive use assessed for *E. coli* is primary contact recreation. Water quality restoration goals for *E. coli* are established based on Montana's numeric water quality standards. DEQ believes that once these water quality goals are met, all uses currently identified as being affected by *E. coli* will be restored.

This document summarizes *E. coli* loads for all human caused nonpoint sources such as agricultural sources, malfunctioning septic systems, and natural background conditions. It also summarizes state and federal programs that guide TMDL development, as well as potential funding resources for private landowners, to address sources of *E. coli* pollution.

Implementation of most water quality improvement measures 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 document, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

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

Table DS-1. E. coli Impaired Waterbodies in the Musselshell TMDL Project Area with TMDLs Contained in this Document

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)*
American Fork, Confluence of Middle and North Forks American Fork to mouth (Musselshell River)	MT40A002_120	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Musselshell River, North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Musselshell River, Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
Musselshell River, Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	Escherichia coli (*E. Coli*)	Pathogens	Primary Contact Recreation

PART 1
INTRODUCTORY INFORMATION

1.0 Project Overview

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for *Escherichia coli* (*E. coli*) in the Musselshell TMDL Project Area. This document also presents a general framework for resolving water quality problems associated with *E. coli*. **Figure 1-1** below shows a map of the Musselshell TMDL Project Area and the E. coli impaired waterbodies. This project area is a combination of the Careless Creek, Upper-Middle Musselshell, Flatwillow-Box Elder, and Lower Musselshell TMDL Planning Areas.

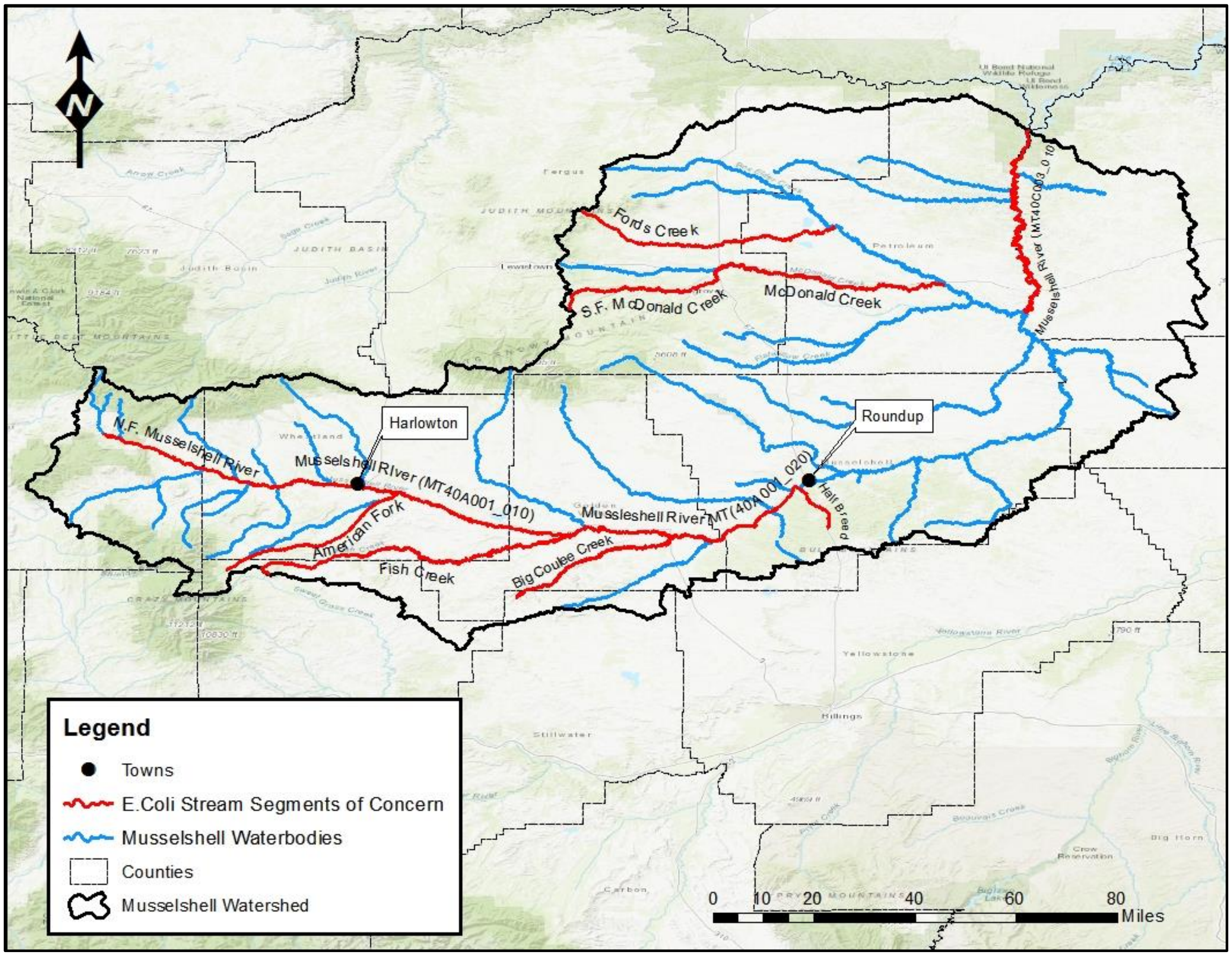

Figure 1-1. The Musselshell TMDL Project Area and *E. coli* Impaired Waters

1.1 Why We Write TMDLs

The Montana Department of Environmental Quality (DEQ) is charged with protection a clean and healthy environment. This includes actions that protect, maintain, and improve water quality, consistent with the Montana Water Quality Act and the federal Clean Water Act.

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

- fish and aquatic life
- wildlife

- recreation
- agriculture
- industry
- drinking water

Each waterbody in Montana has a set of beneficial uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their beneficial uses, and every two years DEQ prepares 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. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant. Both Montana state law (Section 75-5-701, Montana Code Annotated (MCA) of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of TMDLs for impaired waterbodies when water quality is impaired by a pollutant. TMDLs are not required for non-pollutant causes of impairment.

The resulting TMDLs provide information to help ensure that surface water discharge permits are protective of water quality. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. **Section 4.0** provides more detail on TMDL development and the required TMDL components. In Montana, the TMDLs also provide important information that stakeholders can use to help address pollutant sources not covered by surface water permits.

Tables 1-1, **1-2**, and **1-3** identify the impaired waters for the Musselshell TMDL Project Area. **Table 1-3** includes non-pollutant causes included in Montana's 2020 Water Quality Integrated Report. Each table identifies whether the impairment cause has been addressed by TMDL development.

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

Basically, developing a TMDL for an impaired waterbody is a problem-solving exercise: The problem is excess pollutant loading that impairs a beneficial 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.

Additionally, waterbodies that have been monitored by the state are also referred to as "assessment units." Assessment units can be the full length of a stream or the full extent of a lake or reservoir, or a portion of a stream (a stream segment) or lake. Streams may be broken into individual segments, determined by a variety of factors such as stream length for very long streams, or lakes may be broken by ownership boundaries (tribal versus state, for example). Due to its length the mainstem of the Musselshell River for example, has four assessment units / four stream segments (**Table 1-3**).

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists the *E. coli* impairment causes from the "2020 Water Quality Integrated Report" (DEQ 2020a) that are addressed in this document. TMDLs are completed for each waterbody – pollutant combination, and this document contains 11 TMDLs that address 11 *E. coli* impairments (**Table 1-1**).

Table 1-1. Water Quality Impairment Causes for the Musselshell TMDL Project Area Addressed in This Document

Waterbody (Assessment Unit)[1]	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Impairment Cause Status
American Fork, Confluence of Middle and North Forks American Fork to mouth (Musselshell River)	MT40A002_120	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	Flatwillow – Box Elder	E. coli	E. coli TMDL completed
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	Flatwillow – Box Elder	E. coli	E. coli TMDL completed
Musselshell River, North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
Musselshell River, Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	Upper-Middle Musselshell	E. coli	E. coli TMDL completed
Musselshell River, Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	Lower Musselshell	E. coli	E. coli TMDL completed
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	Upper-Middle Musselshell	E. coli	E. coli TMDL completed

Table 1-1. Water Quality Impairment Causes for the Musselshell TMDL Project Area Addressed in This Document

Waterbody (Assessment Unit)[1]	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Impairment Cause Status
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	Upper-Middle Musselshell	E. coli	E. coli TMDL completed

[1] All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)

1.3 Other Completed TMDLs and Future TMDL Development

The Carless Creek Water Quality Restoration Plan was completed in February 2001 (DEQ, 2001a) to address siltation and habitat impairments on segment MT40A002_050 of Careless Creek, Swimming Woman Creek to the confluence with the Musselshell River (previously described as the junction with Deadmans Basin Canal to mouth of the Musselshell River). This segment of Careless Creek was subsequently re-assessed for sediment and habitat impairments in 2018 and found to be meeting water quality standards for sediment, but impaired for habitat alterations and alteration in stream-side or littoral vegetative covers due to riparian degradation. Thus, the sedimentation/siltation impairment cause was removed for Careless Creek.

The Lower Musselshell TMDL Planning Area Decision Document completed in December 2001 (DEQ, 2001b) provides beneficial use assessment determinations for the lower Musselshell River (MT40C003_010) and Blood (MT40C004_030), Lodgepole (MT40C004_020), and Calf (MT40C004_010) creeks. Of those streams, only the lower Musselshell River was determined to be impaired in 2001, for non-pollutants (habitat and flow alterations), which do not require TMDLs. The document also provides basic water quality restoration information for the lower Musselshell River and Blood Creek.

The Judith Mountains Project Area TMDLs and Framework Water Quality Improvement Plan, completed in June 2013 (Montana DEQ and EPA Region 8, 2013), included TMDLs and restoration strategies for Fords, Collar Gulch, and Chippewa creeks (**Table 1-2**). These three waterbodies are in the Flatwillow-Box Elder TMDL Planning Area, which is part of the Musselshell River watershed.

Table 1-2. Other Completed TMDLs in the Musselshell River TMDL Project Area

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Completed TMDLs*	Pollutant Category
Chippewa Creek, Headwaters to confluence with Manitoba Gulch	MT40B002_040	Flatwillow – Box Elder	Antimony, Arsenic, Cyanide, Iron, Mercury	Metals
			Sediment	Sediment

Table 1-2. Other Completed TMDLs in the Musselshell River TMDL Project Area

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Completed TMDLs*	Pollutant Category
Collar Gulch Creek, Headwaters to mouth (Fords Creek)	MT40B002_030	Flatwillow – Box Elder	Aluminum, Arsenic, Cadmium, Copper, Lead, Zinc	Metals
Fords Creek, Headwaters in Chicago Gulch to East Fork Fords Creek	MT40B002_020	Flatwillow – Box Elder	Arsenic, Cadmium, Lead, Zinc	Metals

* All TMDLs found in the December 2013 Judith Mountains Project Area TMDLs and Framework Water Quality Improvement Plan

Although DEQ recognizes that there are other pollutant listings for the Musselshell TMDL Project Area without completed TMDLs (**Table 1-3**), this document only addresses those identified in **Table 1-1**. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types.

Table 1-3. Water Quality Impairment Causes in the Musselshell TMDL Project Area to be Addressed in a Future Project

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Pollutant Category
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	Upper – Middle Musselshell	Iron	Metals
			Nitrate-Nitrite (Nitrite plus Nitrate as N)	Nutrients
			Nitrogen, Total	Nutrients
			Selenium	Metals
Box Elder Creek, Headwaters to mouth	MT40B002_001	Flatwillow – Box Elder	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Iron	Metals
Careless Creek, Headwaters to confluence with Swimming Woman Creek	MT40A002_051	Careless Creek	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
Careless Creek, Confluence with Swimming Woman Creek to mouth (Musselshell River)	MT40A002_050	Careless Creek	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals

Table 1-3. Water Quality Impairment Causes in the Musselshell TMDL Project Area to be Addressed in a Future Project

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Pollutant Category
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals
			Nitrate-Nitrite (Nitrite plus Nitrate as N)	Nutrients
Flatwillow Creek, Headwaters to Highway 87 bridge	MT40B001_021	Flatwillow – Box Elder	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Iron	Metals
			Sediment	Sediment
Flatwillow Creek, Highway 87 bridge to mouth (Musselshell River)	MT40B001_022	Flatwillow – Box Elder	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Iron	Metals
			Selenium	Metals
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	Flatwillow – Box Elder	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Iron	Metals
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Nitrate-Nitrite (Nitrite plus Nitrate as N)	Nutrients
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	Flatwillow – Box Elder	Iron	Metals
			Salinity	Salinity

Table 1-3. Water Quality Impairment Causes in the Musselshell TMDL Project Area to be Addressed in a Future Project

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Pollutant Category
Mill Creek, Headwaters to mouth (North Fork Musselshell River)	MT40A002_040	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Chlorophyll-a	Not Applicable; Non-Pollutant
			Sediment	Sediment
Miller Creek, Confluence of East and West Forks Miller Creek to mouth (Little Elk Creek)	MT40A002_110	Upper – Middle Musselshell	Sediment	Sediment
Musselshell River, North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals
Musselshell River, Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals
			Lead	Metals
			Sediment	Sediment
Musselshell River, HUC boundary near Roundup to Flatwillow Creek	MT40C001_010	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals

Table 1-3. Water Quality Impairment Causes in the Musselshell TMDL Project Area to be Addressed in a Future Project

Waterbody (Assessment Unit)	Waterbody ID (Assessment Unit ID)	TMDL Planning Area	Impairment Cause	Pollutant Category
Musselshell River, Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	Lower Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Flow Regime Modification	Not Applicable; Non-Pollutant
			Habitat Alterations	Not Applicable; Non-Pollutant
			Iron	Metals
North Fork Flatwillow Creek, Headwaters to confluence with South Fork	MT40B001_040	Flatwillow – Box Elder	Sediment	Sediment
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	Upper – Middle Musselshell	Chlorophyll-a	Not Applicable; Non-Pollutant
			Iron	Metals
			Phosphorus, Total	Nutrients
North Willow Creek, Headwaters to mouth Musselshell River)	MT40C002_010	Upper – Middle Musselshell	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Iron	Metals
			Nitrogen, Total	Nutrients
			Phosphorus, Total	Nutrients
			Salinity	Salinity
			Sedimentation – Siltation	Sediment
			Sulfate	Salinity
Painted Robe Creek, Headwaters to mouth (Musselshell River)	MT40A002_080	Upper – Middle Musselshell	Nitrogen, Total	Nutrients
			Salinity	Salinity
			Sulfate	Salinity
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	Flatwillow – Box Elder	Alteration in stream-side of littoral vegetative covers	Not Applicable; Non-Pollutant
			Iron	Metals
Trail Creek, Headwaters to mouth (North Fork Musselshell River)	MT40A002_030	Upper - Middle Musselshell	Chlorophyll-a	Not Applicable; Non-Pollutant
			Phosphorus, Total	Nutrients
			Sediment	Sediment

2.0 MUSSELSHELL WATERSHED DESCRIPTION

This section describes the physical, ecological, and social characteristics of the Musselshell TMDL project Area. These descriptions provide a context for the more detailed pollutant source assessments presented in following sections.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical geography of the project area. This includes location, topography, climate, hydrology, as well geology and soils.

2.1.1 Location

The project area follows the mainstem of the Musselshell River from the headwaters in the Little Belt, Castle and Crazy Mountains to the river's mouth, at the confluence with Fort Peck Reservoir and includes the watersheds of many tributary streams draining to the Musselshell River. The project area encompasses approximately 9,470 square miles (6,060,800 acres) in central Montana. The project area includes portions of Meagher, Wheatland, Sweet Grass, Fergus, Petroleum, Garfield, Rosebud, Musselshell, Golden Valley, and Stillwater counties (**Figure 2-1)**.

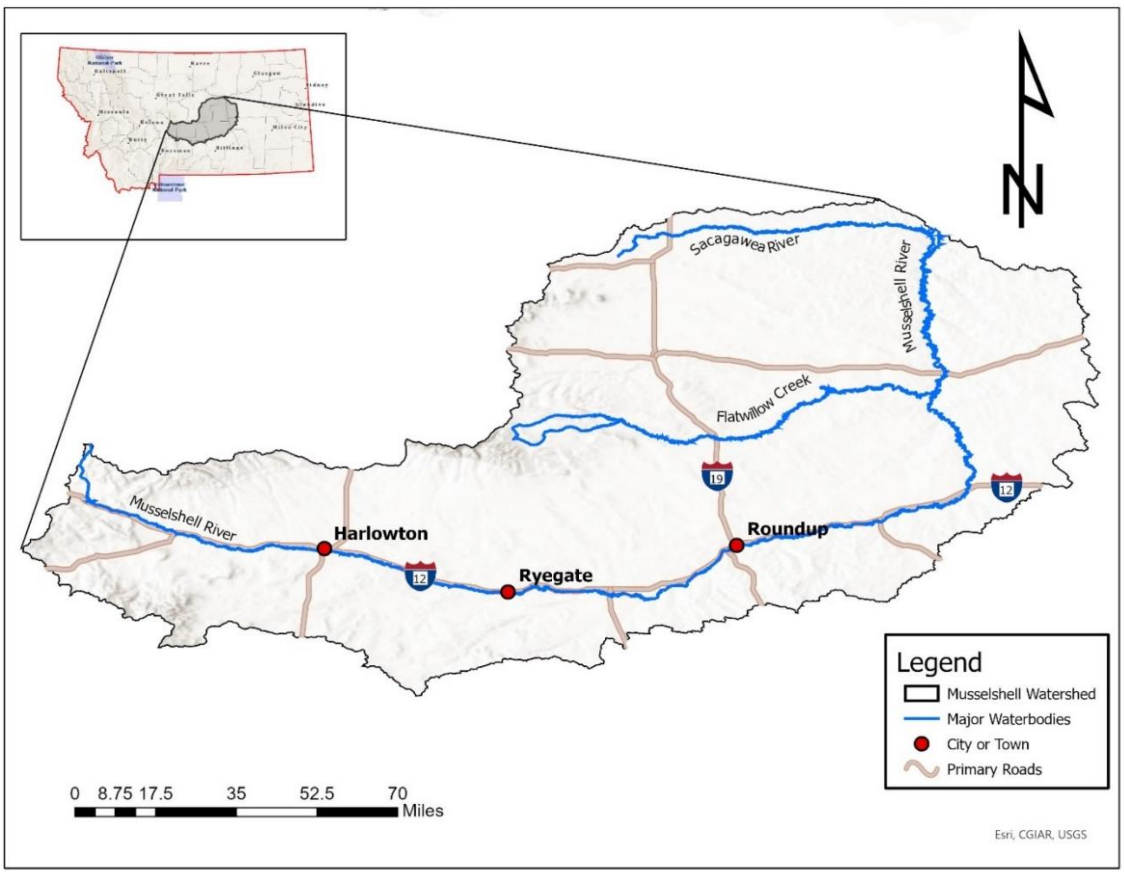

Figure 2-1. Location of Musselshell TMDL Project Area

2.1.2 Topography

The topography is mapped below in **Figure 2-2**. Topographical elevations in the Musselshell River basin range from approximately 11,230 feet in the Crazy Mountains (Crazy Peak) to approximately 2,200 feet at the river's mouth at Fork Peck Reservoir. Terrain in the watershed varies from a high alpine environment in the headwaters to a prairie and shrub land in the eastern portions. The majority of the watershed is expansive grass and shrub lands, broken and rolling foothills, and low-density drainage networks.

Topography data in **Figure 2-2** comes from the National Elevation Dataset (NED). The NED is a seamless raster product primarily derived from USGS 10- and 30-meter Digital Elevation Models. NED data are available from the National Map Viewer: https://www.usgs.gov/core-science-systems/national-geospatial-program/national-map

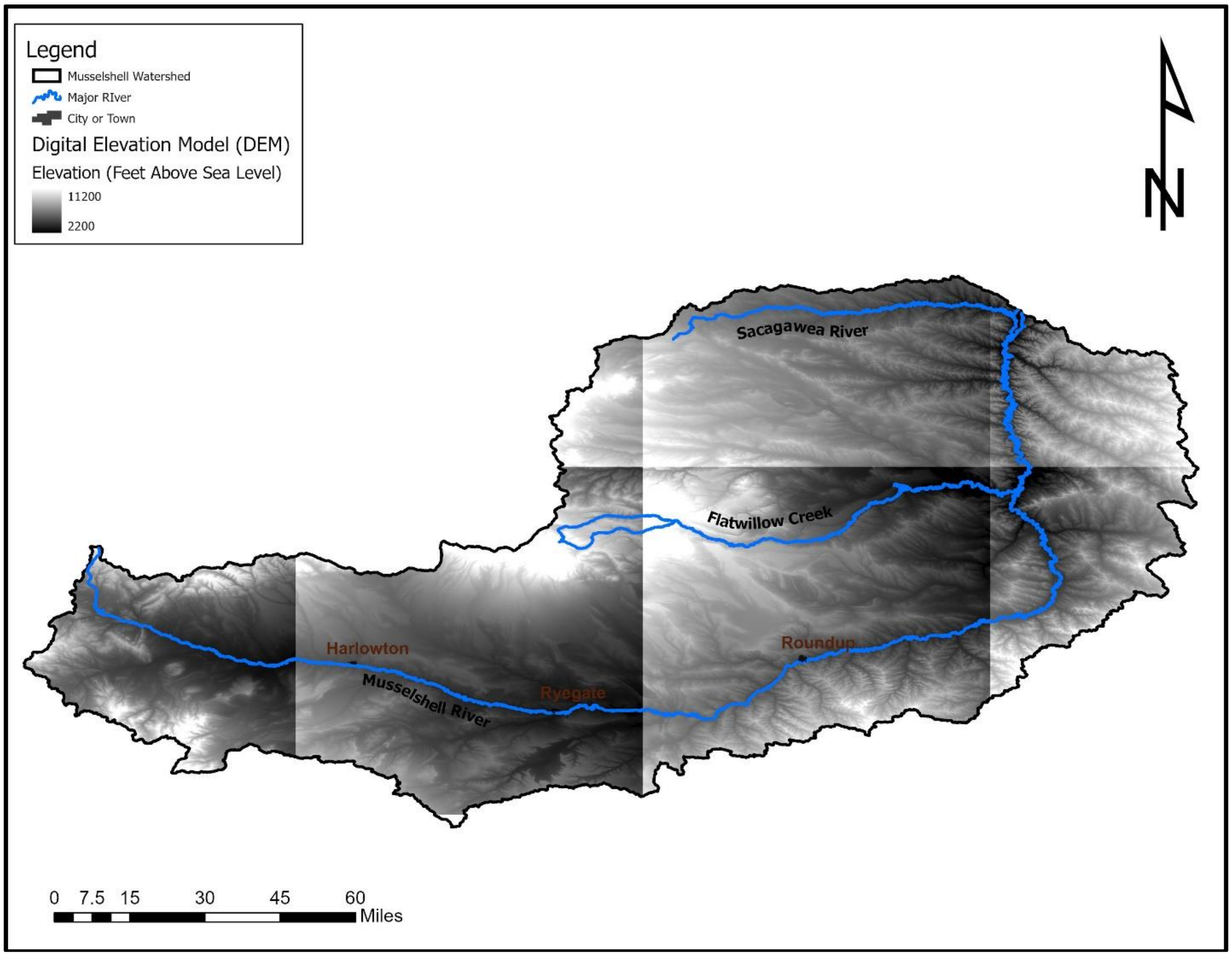

Figure 2-2. Topography of the Musselshell TMDL Project Area

2.1.3 Climate

The project area is large, and there is a measurable gradient in climate along its length. This is well illustrated by considering average precipitation and temperature. Average precipitation along the Musselshell River corridor ranges from just over 35-45 inches per year in the headwaters to 10-15 inches per year closer to the mouth, according to 30-year average precipitation data (http://prism.oregonstate.edu/explorer/). April, May and June are consistently the wettest months of the year, and winter precipitation is dominated by snowfall according to climate summaries monitoring stations throughout the watershed provided by the Western Regional Climate Center (http://www.wrcc.dri.edu/summary/Climsmnidwmt.htmL). Average annual precipitation is mapped below in **Figure 2-3**.

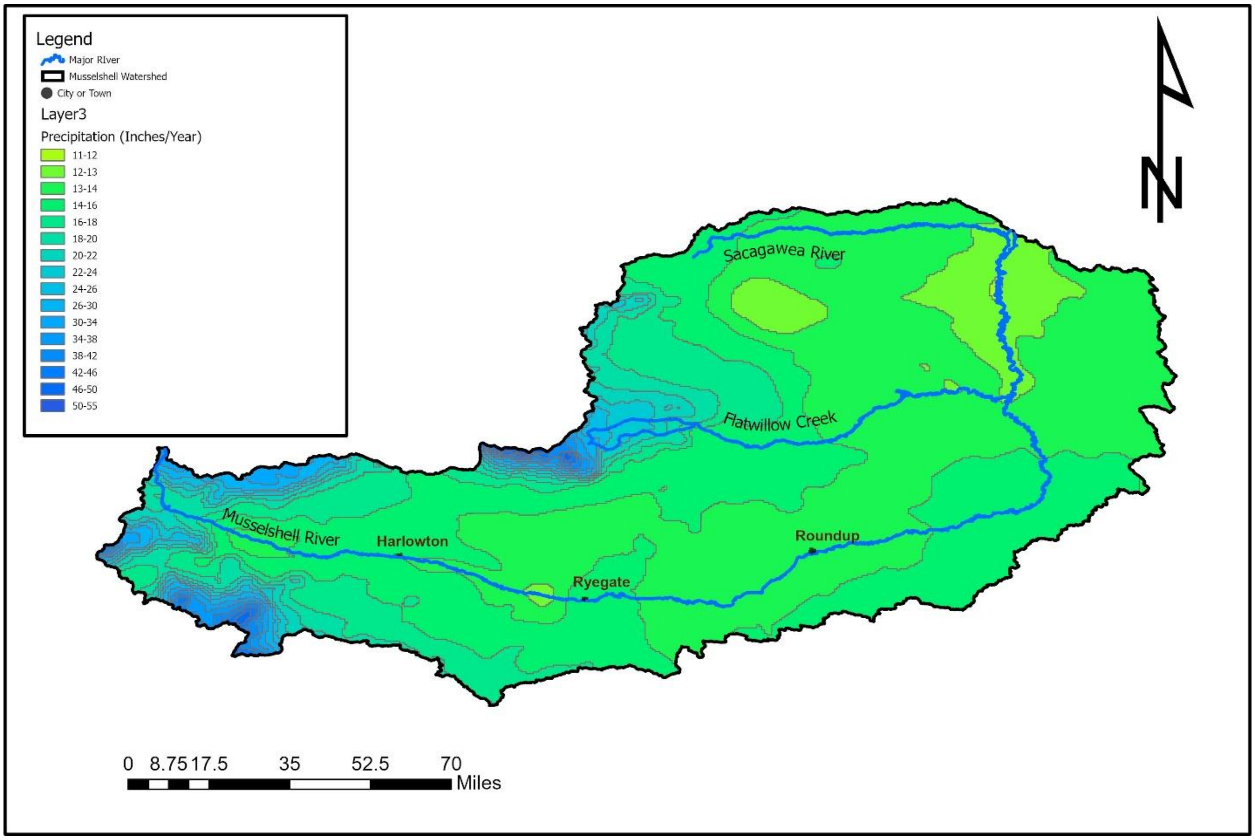

Figure 2-3. Average annual precipitation of the Musselshell TMDL Project Area

The Musselshell Valley is a lower elevation basin typified by cold winters and mild summers. Precipitation is average for watersheds of central Montana and temperatures tend to be lower in the higher elevations (Castle, Little Belt and Crazy Mountains). Average annual temperatures are mapped below in **Figure 2-4**. Climate data was gathered from the Montana Climate Office, which distributes high-quality, timely, scientifically based climate information under the direction of the State Climatologist. Data are comprised of daily meteorological measurements, and satellite-based terrestrial products (rasters). Raster data are available here: https://geoinfo.msl.mt.gov/home/msdi/climate.aspx

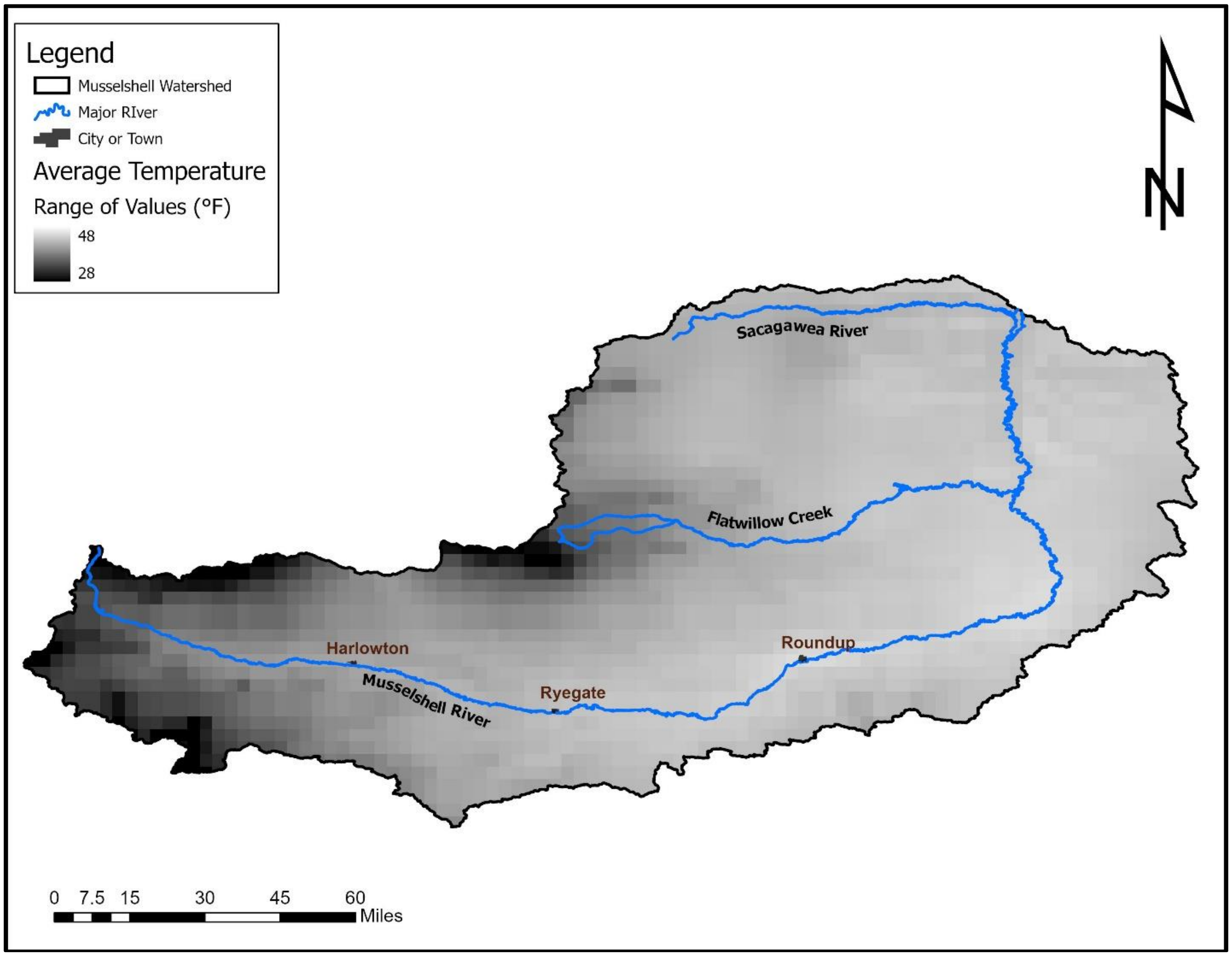

Figure 2-4. Average annual temperatures in the Musselshell TMDL Project Area

2.1.4 Hydrology

The mainstem Musselshell River begins at the confluence of the North Fork and South Fork of the Musselshell Rivers near the town of Martinsdale and flows to the east and then north for approximately 335 miles to its confluence with the Fort Peck Reservoir. The hydrology of the basin is primarily snowmelt driven although significant flows can result from summer precipitation events. The drainage in the project area is characterized by the mainstem of the Musselshell River and its tributary watersheds, mapped below in **Figure 2-5**. The Musselshell River is a 5th order stream at the point where it reaches Fort Peck Reservoir. The major tributaries tend to be 3rd and 4th order streams.

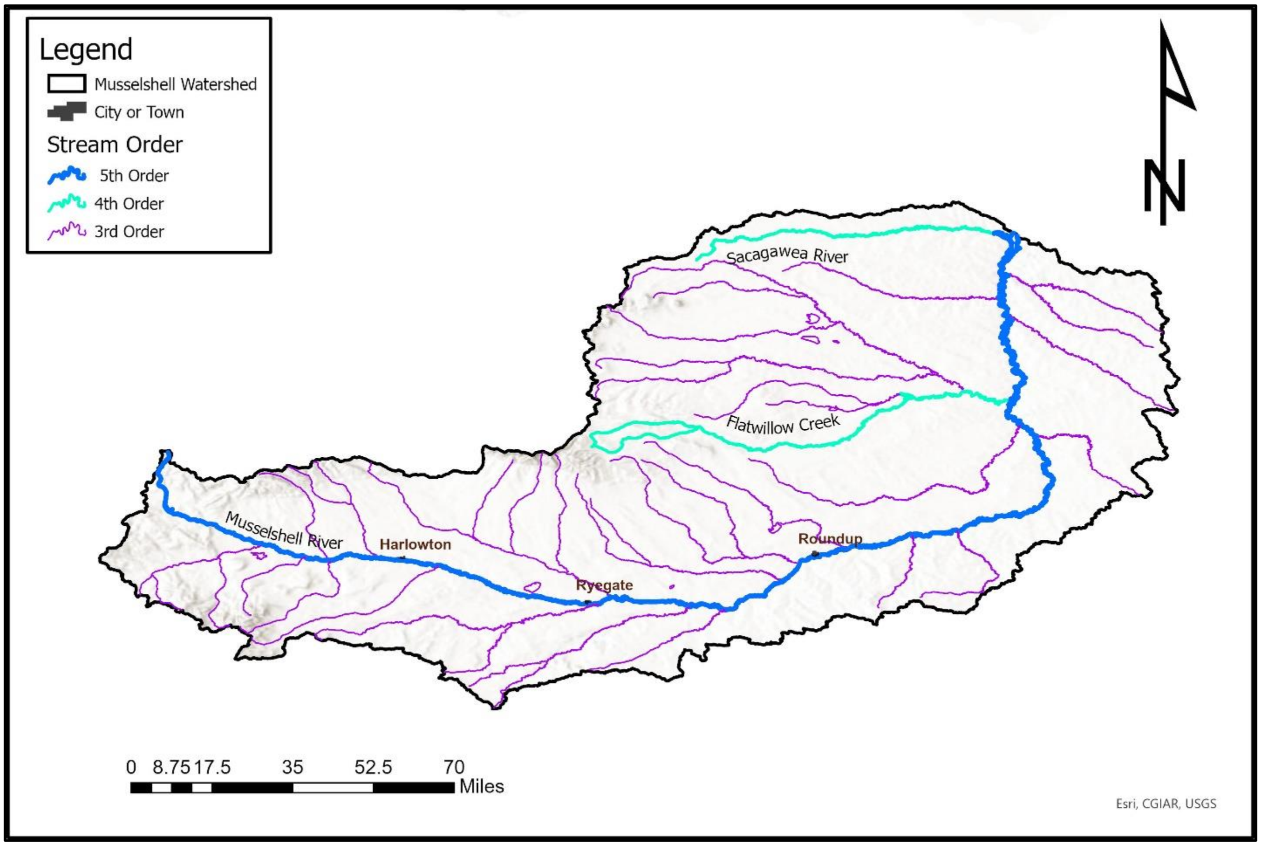

Figure 2-5. Hydrography of the Musselshell TMDL Project Area

The tributary streams generally are not monitored by USGS gaging stations. Their streamflow generally follows a hydrograph typical for the region, highest in May and June. These are the months with the greatest amount of precipitation and snowmelt runoff. Streamflow begins to decline in late June or early July, reaching minimum flow levels in September when many streams go dry. Streamflow begins to rebound in October and November when fall storms supplement the base-flow levels.

2.1.5 Geology and Soils

The Musselshell watershed is large, the geology is varied, and it holds a number of complex geologic structures. The project area bedrock is dominated by Precambrian metamorphic rocks, with significant areas of Paleozoic and Mesozoic sedimentary rocks that are commonly intruded by alkalic dikes and sills. Another prominent geologic feature of the Musselshell watershed is the Bull Mountain Basin. This is an east-west trending asymmetrical syncline within the Paleocene Fort Union Formation. This basin is relatively small (750 square miles) relative to the other coal-producing basins in the region (e.g., Powder River). The project area geology is mapped below in **Figure 2-6**.

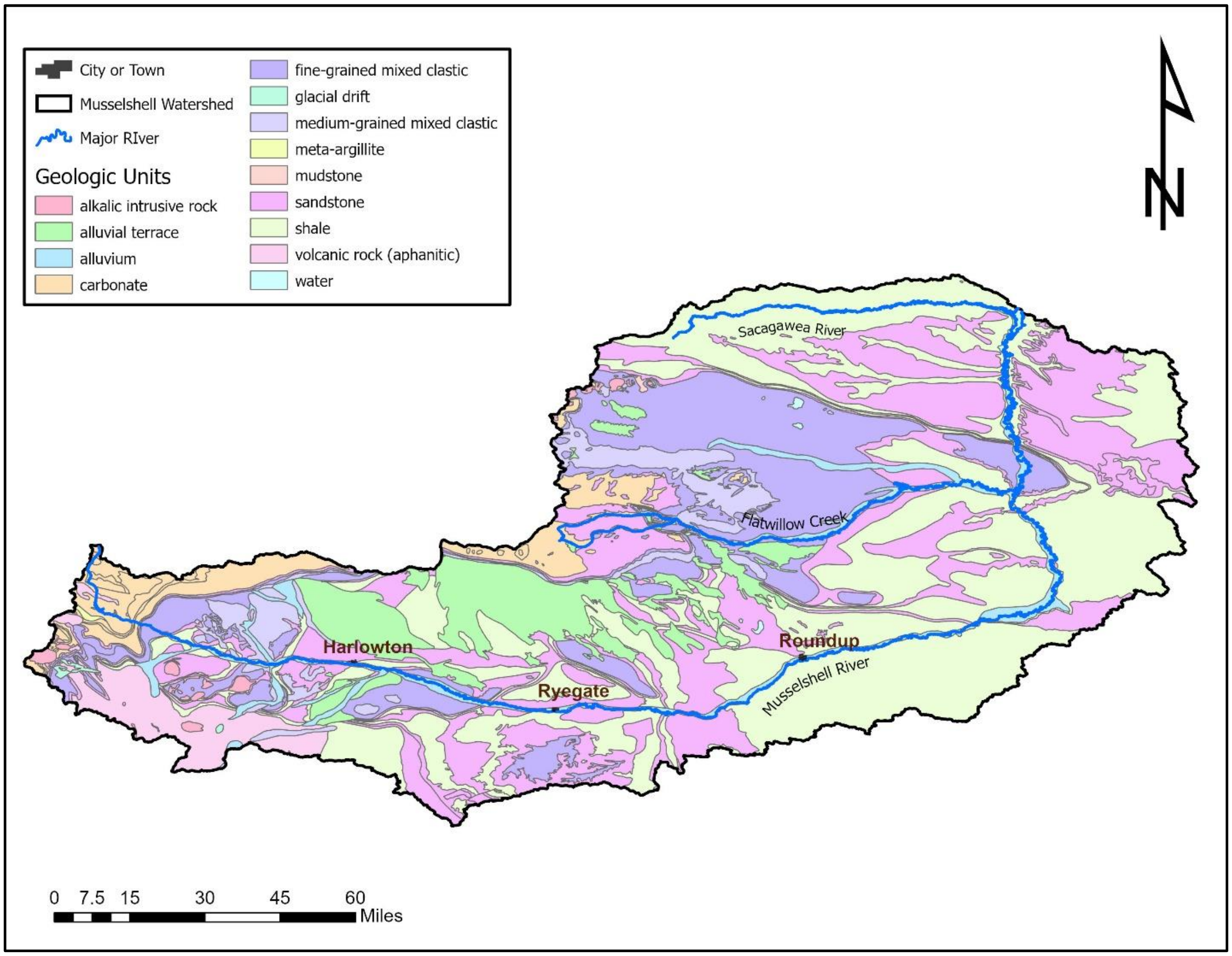

Figure 2-6. Generalized geology of the Musselshell TMDL Project Area

The Musselshell River is an alluvial river, with erodible streambanks, that actively migrates across its floodplain. In the upper part of the watershed the valley edges are fairly erosion resistant due to the sandstone outcrops. Where Bearpaw shale exists in the lower reaches, the riverbanks and valley margins are prone to erosion and mass failure.

The USGS Water Resources Division created a dataset of hydrology-relevant soils, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. Soils data for **Figure 2.7** are derived from the STATSGO database. The USGS interpreted this database for the purposes of water resource planning in 1995 and made subsequent data available here: (https://water.usgs.gov/GIS/metadata/usgswrd/XML/ussoils.xmL). The STATSGO data are intended for small-scale (watershed or larger) mapping and is too general to be used at scales larger than 1:250,000. It is important to realize, that each soil unit in the STATSGO data may include up to 21 soil components.

Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor. K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped below in **Figure 2-7**. In general soils fall within three ranges. These include low (K value 0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. The majority of the project area is mapped with soils rated as having moderate erodibility. No values greater than 0.36 are mapped in the project area.

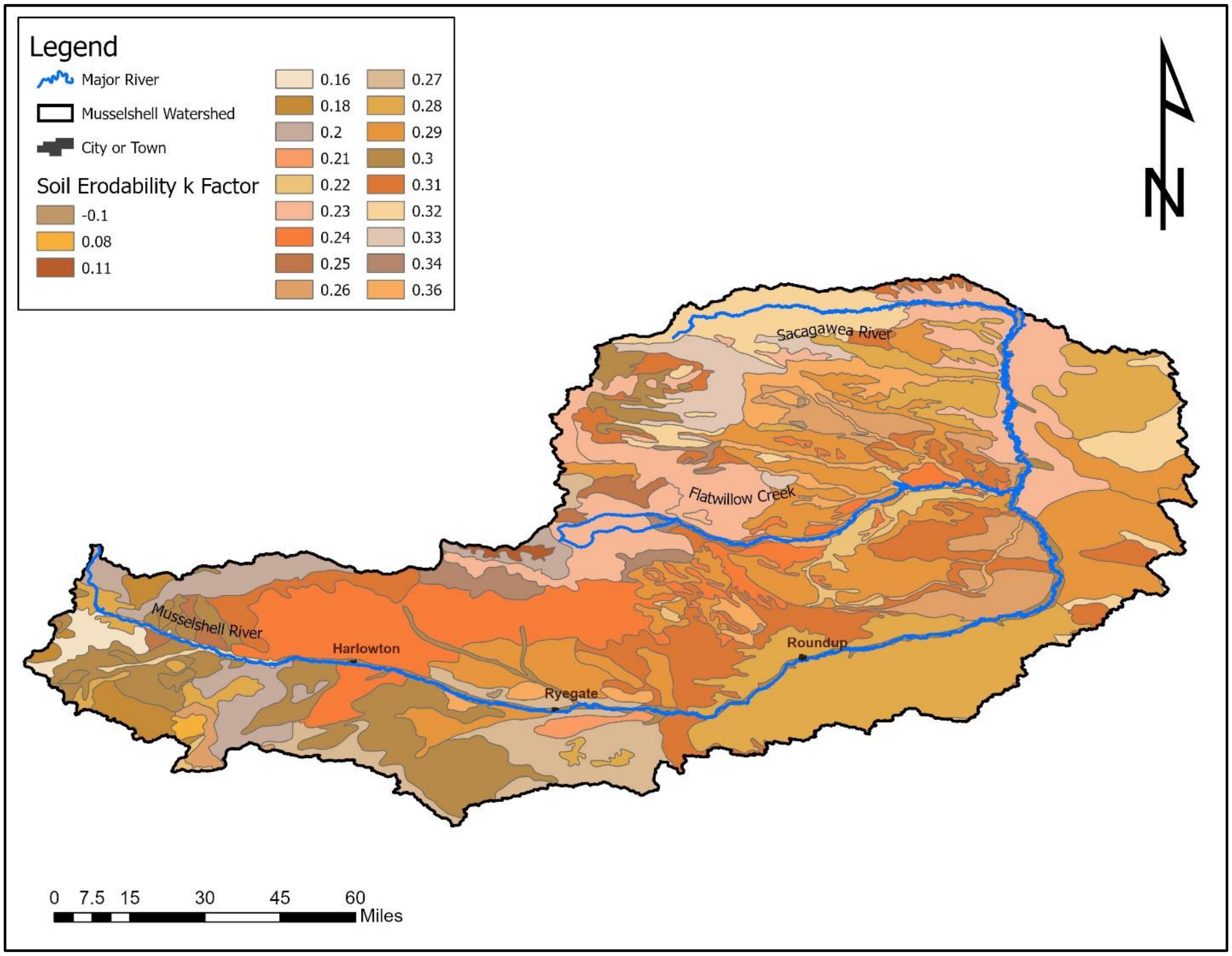

Figure 2-7. Soil erodibility of the Musselshell TMDL Project Area

2.2 Ecological Profile

This section describes the ecology of the project area, including the ecoregions mapped within it, land cover, fire history, and fish species of concern.

2.2.1 Ecoregions

The project is located within the Middle Rockies and Northwest Great Plains Level III Ecoregions. There are fourteen Level IV (subsets) ecoregions within the project area. The Level IV Ecoregions are mapped below in **Figure 2-8**. More detailed information about the ecoregions is available on the Internet at http://www.epa.gov/wed/pages/ecoregions/mt_eco.htm.

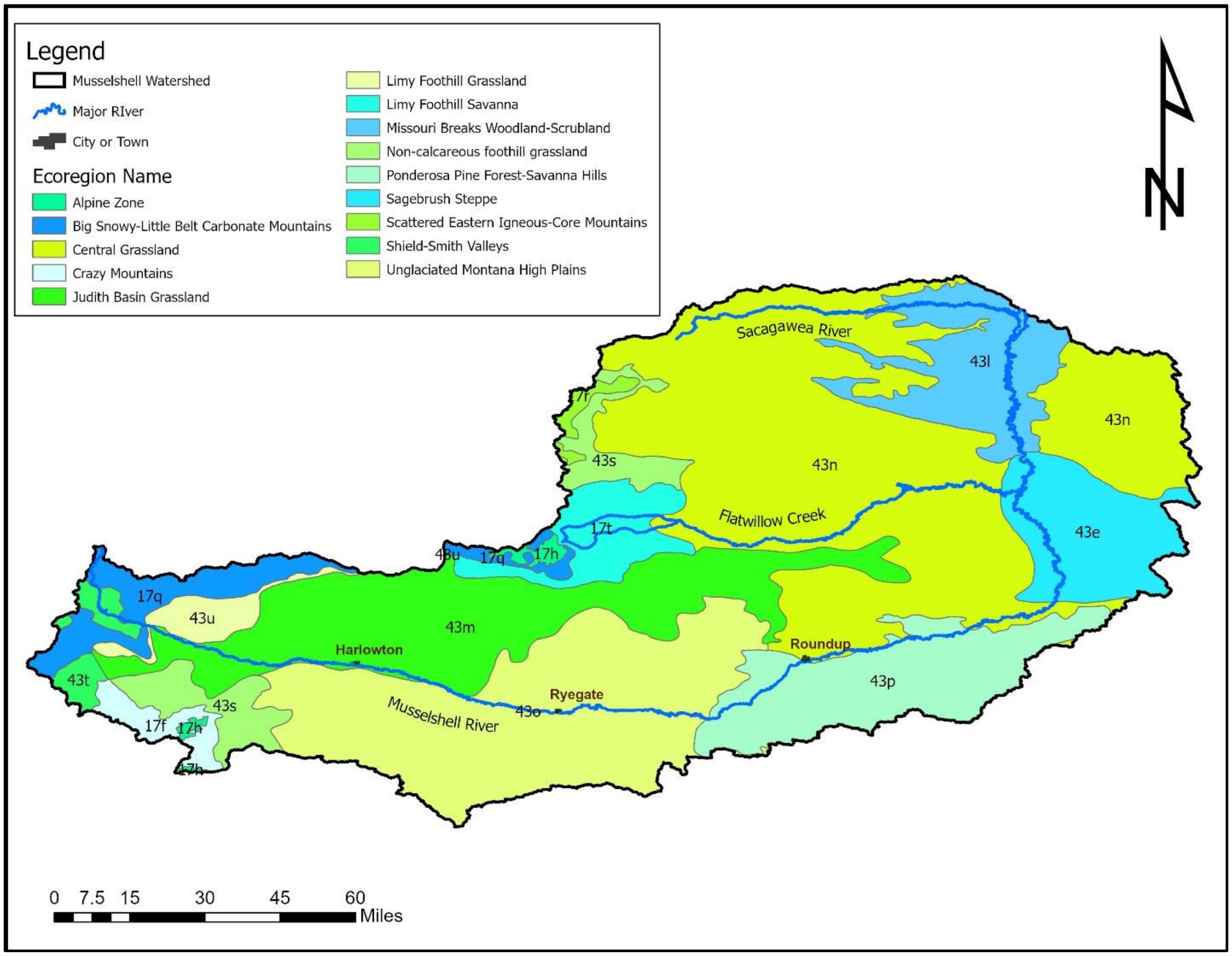

Figure 2-8. Level IV ecoregions in the Musselshell TMDL Project Area

2.2.2 Land Cover

Land cover is mapped below in **Figure 2-9**, based on the USGS National Land Cover Dataset or NLCD (https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects). As apparent in this figure, the project area is dominated by evergreen forest in the uplands, and herbaceous and shrub/scrub cover in the lowlands. Development is largely limited to the larger population centers of Harlowton and Roundup.

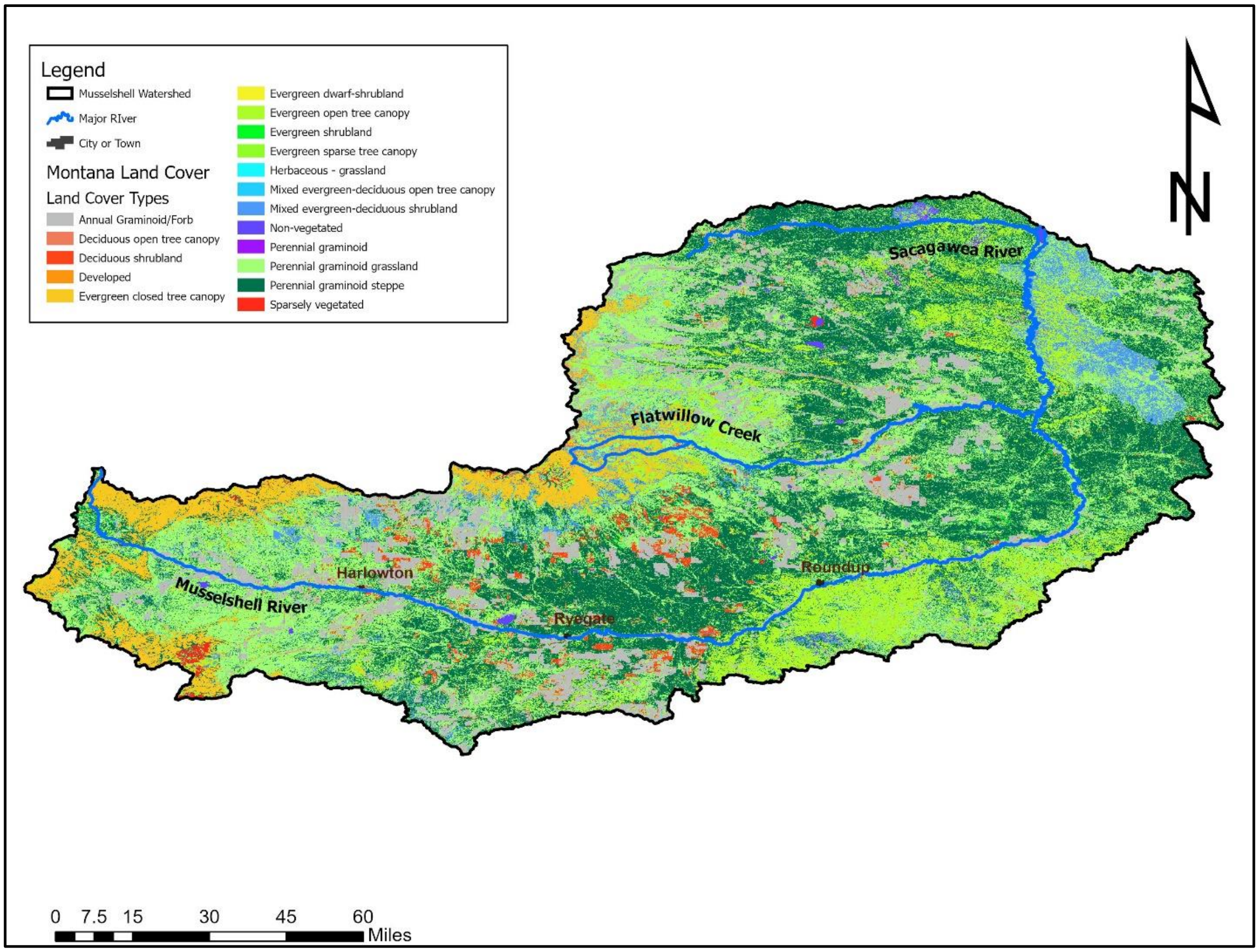

Figure 2-9. Land cover in the Musselshell TMDL Project Area

2.2.3 Fire History

Fire history (1910-2015) is mapped below in **Figure 2-10**. In the last decade, three years stand out as above normal fire years. In 2017, 2008 and 2012 approximately 295,500, 103,500 and 93,800 respective acres burned. The largest single fire reported was the Lodgepole Complex in 2017 that consumed over 270,000 acres. The last several years have been relatively mild with respect to wildland fires in the watershed. The data for the map in **Figure 2-10** are available at the National Interagency Fire Center wildland fire data repository (https://data-nifc.opendata.arcgis.com/).

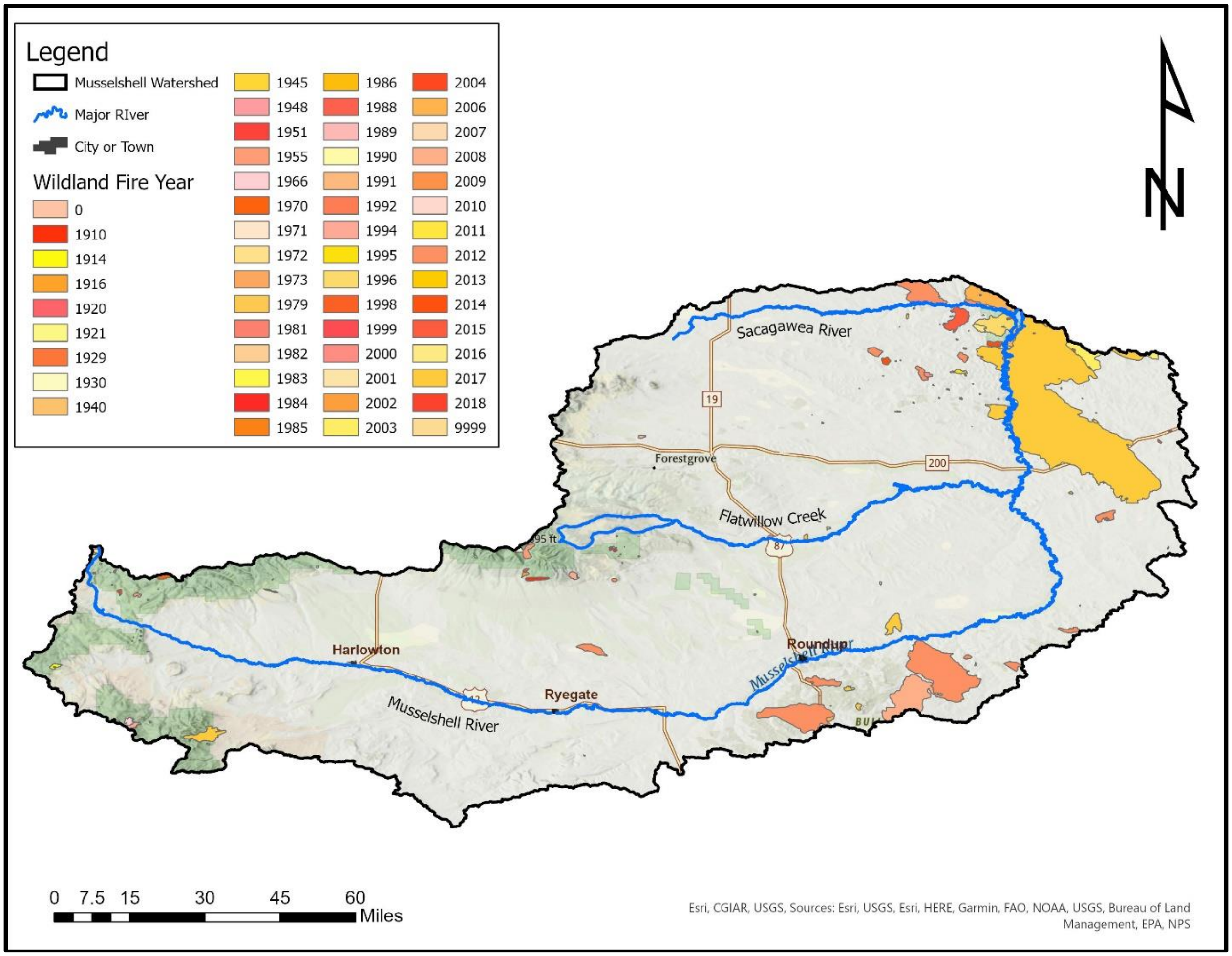

Figure 2-10. Fire history (1910-2018) of the Musselshell TMDL Project Area

2.2.4 Fish Distribution

The project area provides habitat for the Blue Sucker, Northern Red Belly Dance, Northern Red Belly/Fine Dance, Sauger, Westslope Cutthroat Trout, Yellowstone Cutthroat Trout. The Blue sucker, Red Belly Dance and Sauger are mapped in the larger tributaries as well as in the mainstem Musselshell River further down in the watershed. Yellowstone and Westslope cutthroat trout are found in tributary streams, particularly in the higher reaches. The mapped distribution of these species is shown below in **Figure 2-11**, and are based on data provided by Montana Fish, Wildlife, and Parks (https://gis-mtfwp.opendata.arcgis.com/search?tags=mtfwp%20open%20data).

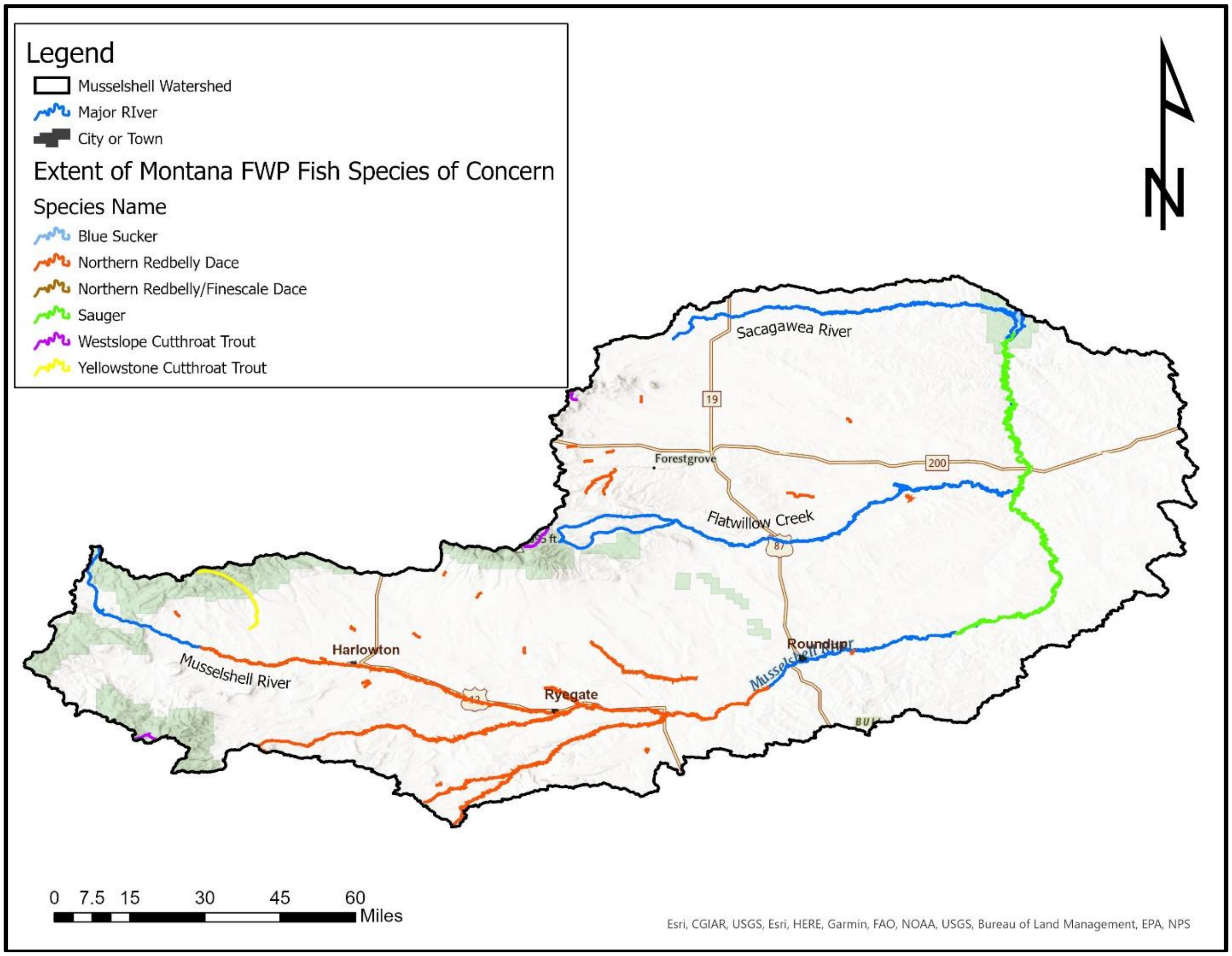

Figure 2-11. Species of Concern distribution in the Musselshell TMDL Project Area

2.3 Social Profile

The following section describes the human geography of the project area. This includes population distribution, land ownership, and land management.

2.3.1 Population

There are no census geometries that exactly correspond to the project area, but DEQ estimates the population based on 2010 census GIS files. The population centers are Roundup (1,788 residents) and Harlowton (997residents). Large areas of land watershed are uninhabited, although there are isolated inholdings. Population is mapped below in **Figure 2-12**.

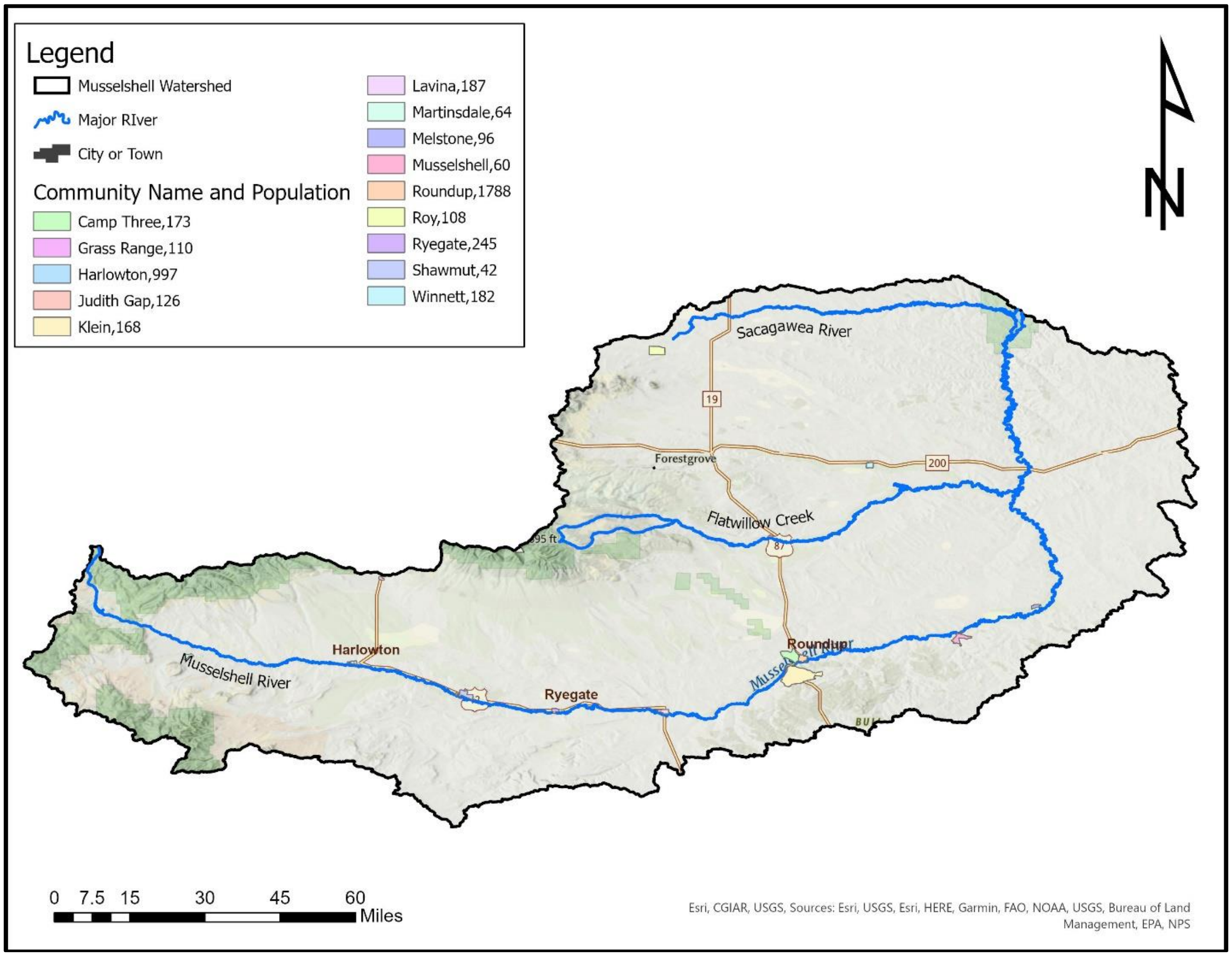

Figure 2-12. Population in the Musselshell TMDL Project Area

2.3.2 Land Management

Private land ownership is the primary means to land management in the Musselshell Project Area. Federal lands managed by the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) are the secondary entities that are responsible for land management. USFS lands are found mostly in the upland areas and the headwaters of the Musselshell River. The Bureau of Land Management (BLM) oversees significant land in the valleys and foothills lower in the watershed. Land management is mapped below in **Figure 2-13**.

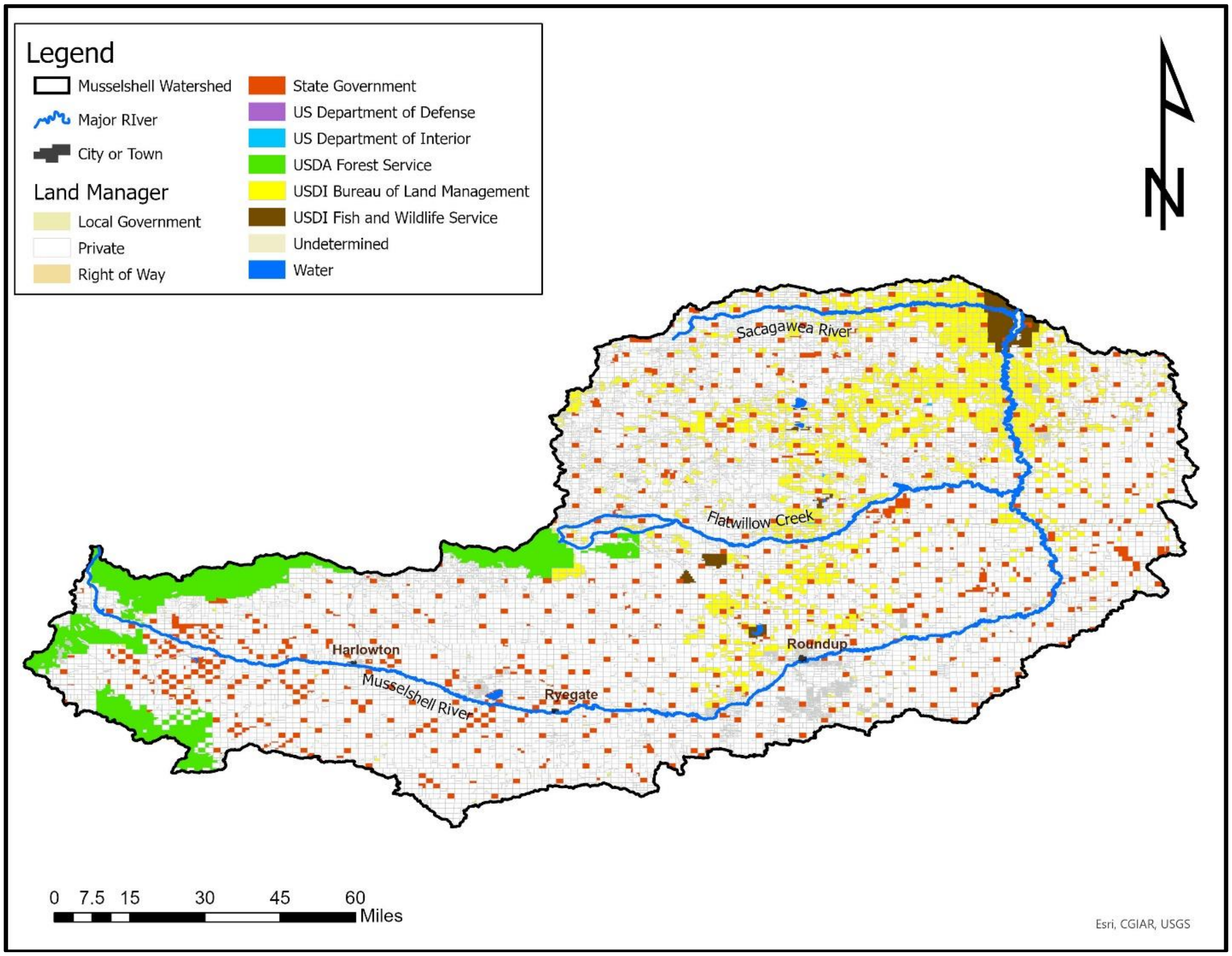

Figure 2-13. Land management in the Musselshell TMDL Project Area

2.3.3 Agricultural Land Use

Montana Department of Revenue assesses agricultural land for taxation. The resulting dataset is known as the Final Land Unit classification. The Final Land Unit is a classification of private agricultural land into one of six uses, fallow, hay, grazing, irrigated, continuously cropped and forest, with forest additionally classified as commercial or non-commercial and irrigated land classified as being flood, pivot, or sprinkler. The agricultural uses were determined by Department of Revenue GIS specialists, and confirmed by maps sent to private landholders for verification. The Final Land Unit data are available at: https://mslservices.mt.gov/Geographic_Information/Data/DataList/datalist_Details.aspx?did={18a47176-0d37-406e-981e-570e1b003832. Agricultural land uses as determined in the Final Land Unit are mapped below in **Figure 2-14**. While it is not reflected in the Department of Revenue classifications, grazing is common on public lands. Included in **Figure 2-14** are BLM and USFS grazing allotments. There are approximately 242,000 acres of USFS grazing allotments and 2 million acres of BLM allotments in the watershed.

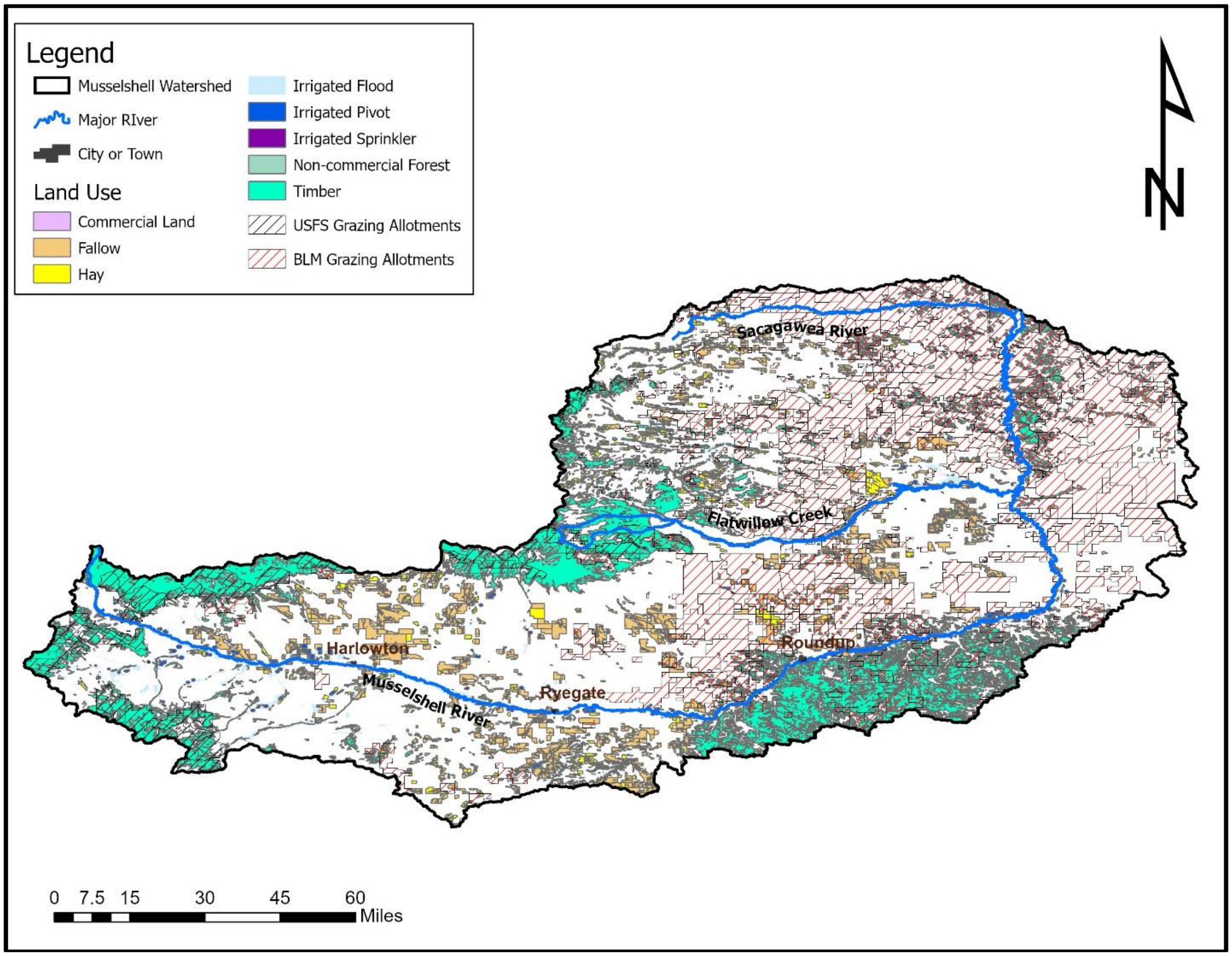

Figure 2-14. Agricultural use and grazing allotments in the Musselshell TMDL Project Area

2.3.4 Road Networks

The Musselshell project area includes an extensive rural road network. The majority of the road networks exist in the valley bottoms and were established to support agricultural land use. In the headwaters the road networks were likely established to support mineral extraction and timber harvest. The project area is too large to analyze the road network at this scale, However, **Figure 2-15** below provides a general idea of where the upland road networks are most extensive.

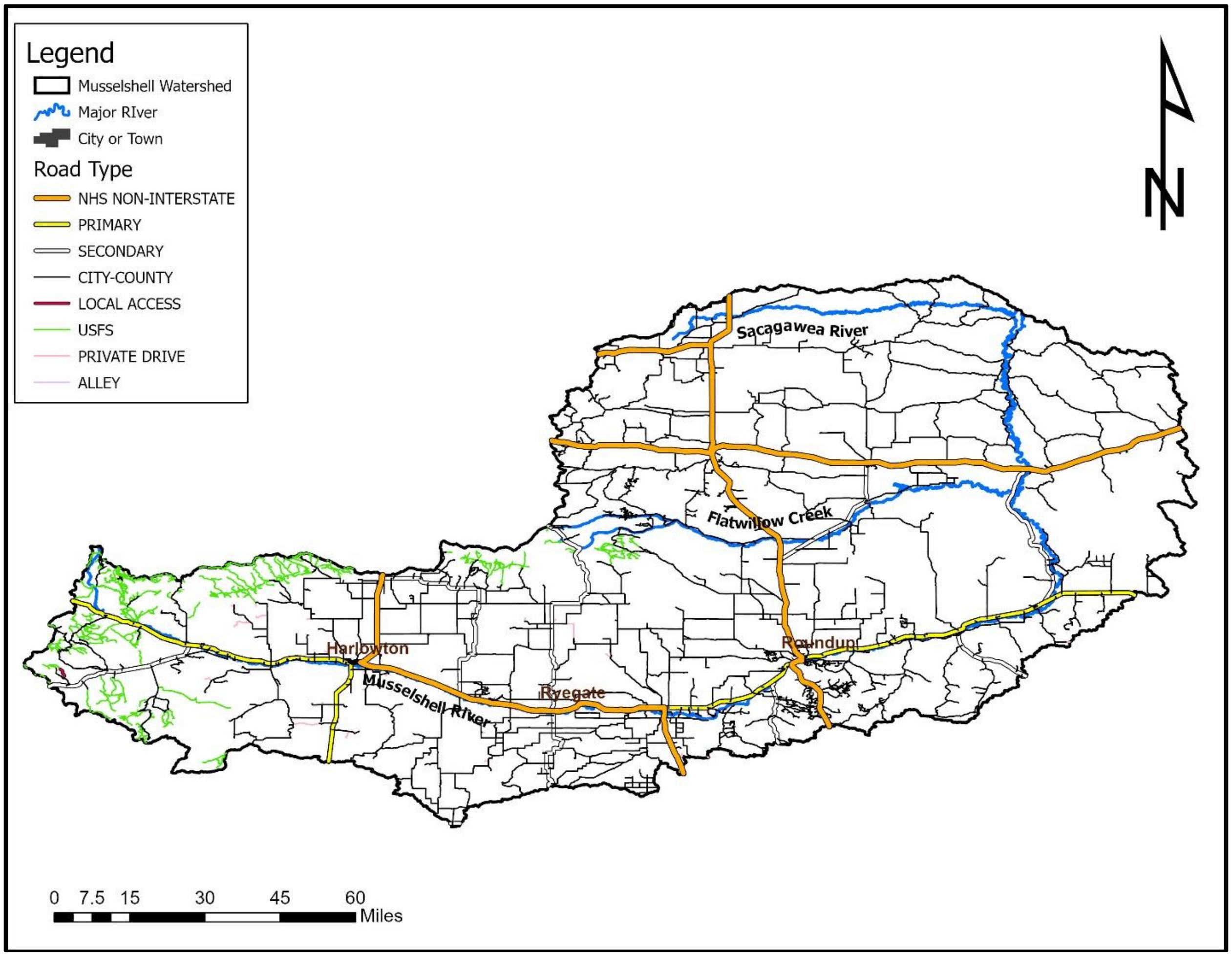

Figure 2-15. Road network in the Musselshell TMDL Project Area

2.3.5 Wastewater Discharges

Sources of pollution originating from a point source discharge are permitted and regulated through the Montana Pollutant Discharge Elimination System (MPDES) administered by the Montana DEQ. The goal of the MPDES program is to control point source discharges such that water quality in state surface water is protected. Levels of water quality that are required to maintain beneficial uses of state surface waters are set forth in the Water Quality Standards (WQS). There are two types of discharge permits issued to point source dischargers: general and individual.

A MPDES General Permit is a permit for wastewater discharges associated with common activities, such as concentrated animal feeding operations and storm water discharges from construction or industrial activity. Individual MPDES Permits regulate wastewater discharges from point sources that do not fall under the guidelines for a General Permit. Individual permitting is more rigorous, as individual permits address the specific conditions of the facility or activity needing authorization.

All point sources of wastewater discharge are required to obtain and comply with the appropriate MPDES permits. The effluent limitations and other conditions for certain categories of wastewaters are required to be treated to federally-specified minimum levels based on available and achievable water treatment technologies. Additionally, effluent limits and permit conditions are established to protect beneficial uses and applicable WQS. If a TMDL has been developed for a waterbody, any appropriate wasteload allocations (WLAs) will be incorporated into the MPDES permits discharging to that waterbody.

There are approximately 26 MPDES general and individual permitted sites that discharge in the Musselshell TMDL Project Area. Not all 26 MPDEs permitted sites have the capability to discharge *E. coli*. Ten permits are from a combination of effective or administratively continued general and individual MPDES permits that can be considered point sources and have waste streams capable of discharging *E*. coli. **Table 2-1** shows those permitted sites that have the potential to contribute *E*. coli loads and the impaired waters that they discharge to. The discharges from these MPDES permitted facilities, the potential loading impacts and how WLAs are applied to each of these facilities is discussed in detail in **Section 5.7**.

Table 2-1. MPDES Permitted Facilities with *E*. coli Loading Potential

Permit Number	Permitee	Permitted Activity	Receiving Water
MT0020354	City of Harlowton	Sewerage Systems	Musselshell River (Upper)
MT0020451	Town of Ryegate	Sewerage Systems	Musselshell River (Middle) via Unnamed Slough
MTG010150	Duncan Ranch Colony	Concentrated Animal Feeding Operations	Musselshell River (Upper)
MTG010156	Golden Valley Colony	Concentrated Animal Feeding Operation	Fish Creek via unnamed tributary
MT0030309	Town of Grass Range	Sewage Systems	South Fork McDonald Creek
MTG010242	Springwater Colony	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary
MTG010244	Martinsdale Colony Inc.	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary
MTG010231	Swanz Ranch	Concentrated Animal Feeding Operation	Little Careless Creek
MTG580013	Town of Lavina	Lagoon (Batch)	Musselshell River (Middle)
MTG580041	Town of Winnett	Lagoon (Batch)	McDonald Creek

3.0 MONTANA WATER QUALITY STANDARDS

The Montana Water Quality Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the state's surface waters so that they support all beneficial uses for which they are classified. Water quality standards are used to determine impairment, establish water quality targets, and to formulate the TMDLs and allocations.

Montana's water quality standards, and water quality standards in general, include three main parts:

1. Stream classifications and beneficial uses
2. Numeric and narrative water quality criteria designed to protect beneficial uses
3. Nondegradation provisions

Montana's water quality standards also incorporate prohibitions against water quality degradation as well as point source permitting and other water quality protection requirements.

Nondegradation provisions are not applicable to TMDLs developed within this document because of the impaired nature of the streams addressed. Those water quality standards that apply to this document are reviewed briefly below.

3.1 STREAM CLASSIFICATIONS AND BENEFICIAL USES

Stream classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Beneficial uses are simple narrative descriptions of water quality expectations or water quality goals. All Montana waters are classified for multiple uses. Waterbodies in the Musselshell TMDL Project Area addressed in this document are classified as B-1, B-2, and C-3 (**Table 3-2**), and must be maintained suitable for the uses presented in **Table 3-1** below (Administrative Rules of Montana (ARM), 17.30.623, 624, and 629).

Table 3-1. Use Classifications in the Musselshell TMDL Project Area

Stream / Waterbody Classification	Beneficial Uses
B-1	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.

While a particular waterbody might not actually be used for a beneficial use (e.g., drinking water supply), its water quality still must be maintained suitable for that beneficial use. DEQ's water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant, thus ensuring protection of all beneficial uses (DEQ 2020b). In the Musselshell, the most sensitive use assessed for Escherichia coli (*E. coli*) is primary contact recreation. DEQ has determined that 11 waterbody segments in the Musselshell TMDL Project Area do not meet the water quality standard for Escherichia coli (*E. coli*) (**Table 3-2**).

Table 3-2. Impaired Waterbodies and their Impaired Beneficial Uses in the Musselshell TMDL Project Area

Waterbody (Assessment Unit)	Assessment Unit ID	Use Classification	Impairment Cause[1]	Impaired Beneficial Use
American Fork, Confluence of Middle and North Forks American Fork to mouth (Musselshell River)	MT40A002_120	B-1	*E. coli*	Primary Contact Recreation
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	C-3	*E. coli*	Primary Contact Recreation
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	C-3	*E. coli*	Primary Contact Recreation
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	C-3	*E. coli*	Primary Contact Recreation
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	C-3	*E. coli*	Primary Contact Recreation
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	C-3	*E. coli*	Primary Contact Recreation
Musselshell River (Upper), North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	B-2	*E. coli*	Primary Contact Recreation
Musselshell River (Middle), Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	C-3	*E. coli*	Primary Contact Recreation
Musselshell River (Lower), Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	C-3	*E. coli*	Primary Contact Recreation
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	B-1	*E. coli*	Primary Contact Recreation

Table 3-2. Impaired Waterbodies and their Impaired Beneficial Uses in the Musselshell TMDL Project Area

Waterbody (Assessment Unit)	Assessment Unit ID	Use Classification	Impairment Cause[1]	Impaired Beneficial Use
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	C-3	*E. coli*	Primary Contact Recreation

[1] Only includes those pollutant impairments addressed by TMDLs in this document

3.2 Numeric and Narrative Water Quality Standards

Montana's water quality standards include numeric and narrative criteria that protect the beneficial uses described above. Numeric criteria define the allowable concentrations, frequency, and duration of specific pollutants so as not to impair beneficial uses.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., *E. coli*, metals, nutrients, other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure via drinking water and other pathways such as fish consumption, 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. Numeric standards also apply to other beneficial uses such as protecting irrigation and stock water quality for agriculture.

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition.

E. coli has numeric standards to protect human health relative to primary and secondary contact recreation. In the Musselshell TMDL Project Area, these numeric standards (within ARM 17.30.620(2)) are applied as the primary targets for *E. coli* impairment determinations and subsequent TMDL development. These targets address the allowable *E. coli* concentrations found in impaired waters. **Section 5.4** defines the water quality criteria for the Musselshell TMDL Project Area.

3.3 Nondegradation Provisions

Nondegradation is addressed via the Nondegradation Policy within Montana state statute (75-5-303, MCA) and via Montana's nondegradation rules (ARM 17.30.7). The Nondegradation Policy states that existing uses of state waters and the level of water quality necessary to protect those uses must be maintained and protected. Montana nondegradation rules apply to any new or increased point or nonpoint source resulting in a change of existing water quality occurring on or after April 29, 1993 (ARM 17.30.702).

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. The ultimate goal of the TMDL is to identify an approach to achieve and maintain water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are often confined or discrete conveyances, such as pipes or ditches from which pollutants are being, or may be, discharged to a waterbody. Point sources are linked to Montana Pollution Discharge Elimination System (MPDES) permits for discharges such as community wastewater treatment systems or industrial facilities. Pollutant loading sources that do not meet the definition of a point source are considered nonpoint sources. Nonpoint sources are associated with diffuse pollutant loading to a waterbody and are often linked to runoff from agricultural, urban, or forestry activities, as well as streambank erosion and groundwater seepage that can occur from these activities. Natural background loading and atmospheric deposition are both considered types of nonpoint sources.

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 = ΣWLA + ΣLA + MOS, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)
MOS = margin of safety

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation as shown. Alternatively, the MOS can be implicit in the TMDL, meaning that the explicit MOS in the above equation is equal to zero and can therefore be removed from the above equation. 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., changes in pollutant loading during the year, or seasonal water quality standards).

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.

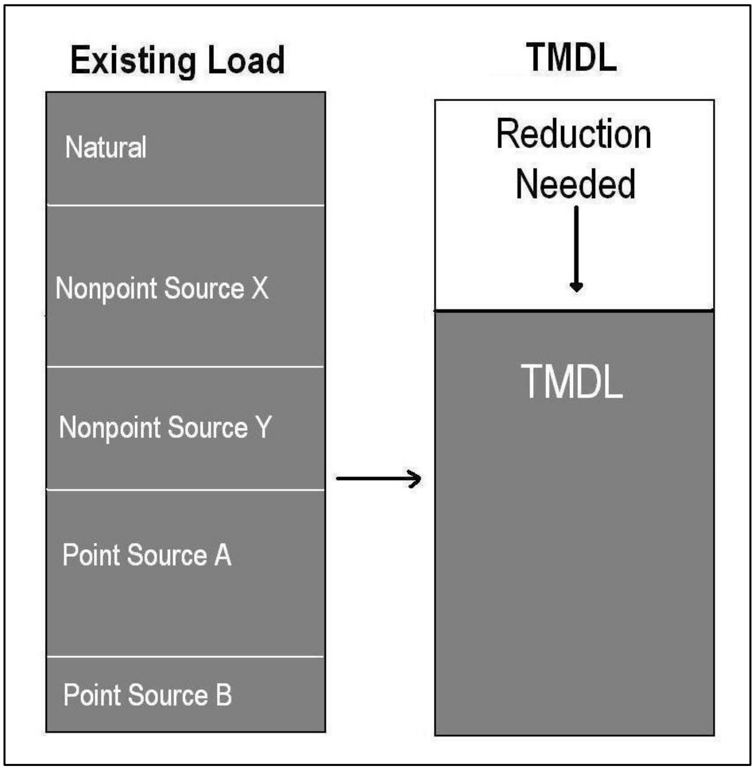

Figure 4-1: Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

For each pollutant, TMDL water quality targets are based on the applicable numeric water quality standard and/or a translation of a narrative water quality standard(s). 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

The goal of TMDL source assessment is to identify all significant pollutant loading sources, including natural background loading, and quantify them 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 includes 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.

Source assessments are conducted on a watershed scale and can vary in level of detail resulting in reasonably accurate estimates or gross allotments, depending on the data availability and the techniques used for predicting the loading (40 CFR 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.

Nonpoint sources are quantified by source categories (e.g., septic systems) and/or by land uses (e.g., agricultural land use or grazing). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, nonpoint pollutant sources in a sub-watershed or source area can be combined for quantification and TMDL load allocation purposes.

Additional detail is required for assessing pollutant loading from surface water point sources permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. This is because the allowable loading within each MPDES surface water permit conditions must be consistent with the assumptions and requirements of the WLA developed within the TMDL (40 CFR 122.44).

4.3 Establishing the Total Allowable Load

Identifying the TMDL requires quantification of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Per EPA requirements (40 CFR 130.2), "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." Where a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. This results in a mass per unit time TMDL expression such as pounds per day. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources so that the sum of the allocations is equal to the TMDL, consistent with the above TMDL equation. Where a TMDL is variable based on streamflow, nonpoint source load allocations are often variable based on this same receiving streamflow. On the other hand, point source wasteload allocations are often based on conservative streamflow and discharge conditions and/or can be variable based on the point source discharge flow and a discharge concentration limit. Where the TMDL is a function of streamflow, the TMDL and allocations are calculated for example high and low flow stream conditions.

Figure 4-2 illustrates how, for a given stream flow, the TMDL is allocated to different sources using WLAs for point sources and load allocations (LA) for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the TMDL for all segments of the waterbody. **Figure 4-2** shows multiple point and nonpoint source allocations. In Montana, nonpoint source allocations are sometimes grouped into one composite allocation. This composite load allocation approach is applied in cases where data is limited, there is significant source assessment uncertainty, and/or DEQ has determined that the best approach is to provide stakeholders with flexibility in addressing sources, allowing them to choose where to focus on improved land management practices and other remediation or restoration efforts.

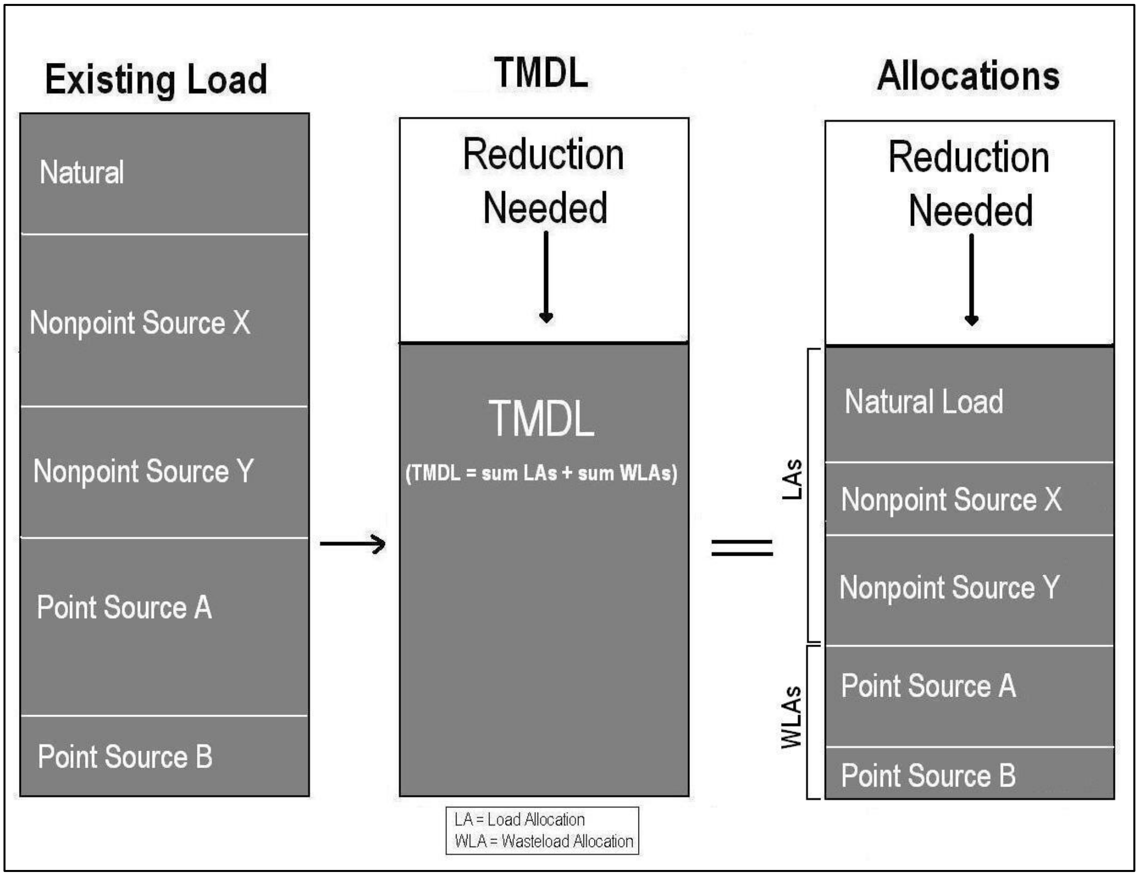

Figure 4.2: Schematic Diagram of a TMDL and its Allocations

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 permitted point source WLAs are not dependent on implementation of the composite LA. 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 permitted point source 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, unless the loading from an individual point source is negligible based on no measurable impacts to water quality.

4.5 Implementing TMDL Allocations

Montana law (Section 75-5-703, MCA of the Montana Water Quality Act) requires that wasteload allocations be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Per federal regulation (40 CFR 122.44), the discharge permit effluent limits must be consistent with the assumptions and requirements of the available WLA developed within the TMDL.

Because of limited state and federal regulatory requirements, nonpoint source reductions linked to LAs are implemented primarily through voluntary measures, although there are some important nonpoint source regulatory requirements, such as Montana streamside management zone law and applicable septic system requirements.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (**Section 6**). This includes a monitoring strategy and an implementation review that is required by Montana statute (Section 75-5-703, MCA of the Montana Water Quality Act). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

PART 2
TMDL COMPONENTS

5.0 ESCHERICHIA COLI (E. COLI) TMDL COMPONENTS

This portion of the document focuses on *Escherichia coli* (*E. coli*) as an indicator of pathogen water quality impairment in the Musselshell TMDL Project Area. It describes: (1) how excess *E. coli* is an indicator of impaired beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to *E. coli* impairment in the watershed, (4) the identification of *E. coli* targets and the comparison of those targets to the affected stream segment, (5) the sources of *E. coli*, (6) the *E. coli* TMDLs and allocations.

5.1 EFFECTS OF EXCESS *E. COLI* ON BENEFICIAL USES

E. coli is a nonpathogenic indicator bacterium that is usually associated with pathogens transmitted by fecal contamination. While its 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 and is an indicator that other pathogenic bacteria are likely present (U.S. Environmental Protection Agency 2001). The Environmental Protection Agency (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. Elevated instream concentrations of pathogenic pollutants put humans at risk for contracting water-borne illnesses and can lead to impairments of a waterbody's recreation beneficial use. In 2006, Montana DEQ adopted *E. coli* water quality criteria for the protection of recreational beneficial uses, replacing the previous Fecal Coliform water quality criteria.

5.2 STREAM SEGMENTS OF CONCERN

Stream segments of concern for *E. coli* in the Musselshell TMDL Project Area include several portions of the mainstem of the Musselshell River and multiple tributaries (**Table 5-1**). Impaired tributaries include Big Coulee Creek, Fish Creek, Fords Creek, Half Breed Creek, McDonald Creek, South Fork McDonald Creek, American Fork and the North Fork of the Musselshell River. Portions of the mainstem of the Musselshell River that are considered impaired for *E. Coli* include the Musselshell River from the confluence of the North Fork and South Fork to the confluence with the Deadman's Basin Canal (AUID MT40A001_010), the portion from the Deadman's Basin Canal to the Hydrologic Unit Code (HUC) boundary near Roundup (AUID MT40A001_020) and the portion from Flatwillow Creek to the Fort Peck Reservoir (AUID MT40C003_010. These segments of the Musselshell River are for the purposes of this document identified as the Upper Musselshell, Middle Musselshell, and Lower Musselshell River, respectively. The above-mentioned waterbodies are listed as impaired for *E. coli* in the 2020 Water Quality Integrated Report (Montana DEQ, 2020a), where they are all listed as having a high priority for TMDL development. **Figure 5-1** contains a map that shows the location of these waterbodies in the Musselshell TMDL Project Area.

Table 5-1. Stream Segments of Concern for *E. coli* Impairment Based on the 2020 Integrated Report

Stream Segment (Assessment Unit)	Assessment Unit ID	Use Classification	Pathogen Related Pollutant Impairments and TMDL Development Prioritization
American Fork, Confluence of Middle and North Forks American Fork to mouth (Musselshell River)	MT40A002_120	B-1	Escherichia coli High
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	C-3	Escherichia coli High
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	C-3	Escherichia coli High
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	C-3	Escherichia coli High
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	C-3	Escherichia coli High
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	C-3	Escherichia coli High
Musselshell River (Upper), North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	B-2	Escherichia coli High
Musselshell River (Middle), Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	C-3	Escherichia coli High
Musselshell River (Lower), Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	C-3	Escherichia coli High
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	B-1	Escherichia coli High
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	C-3	Escherichia coli High

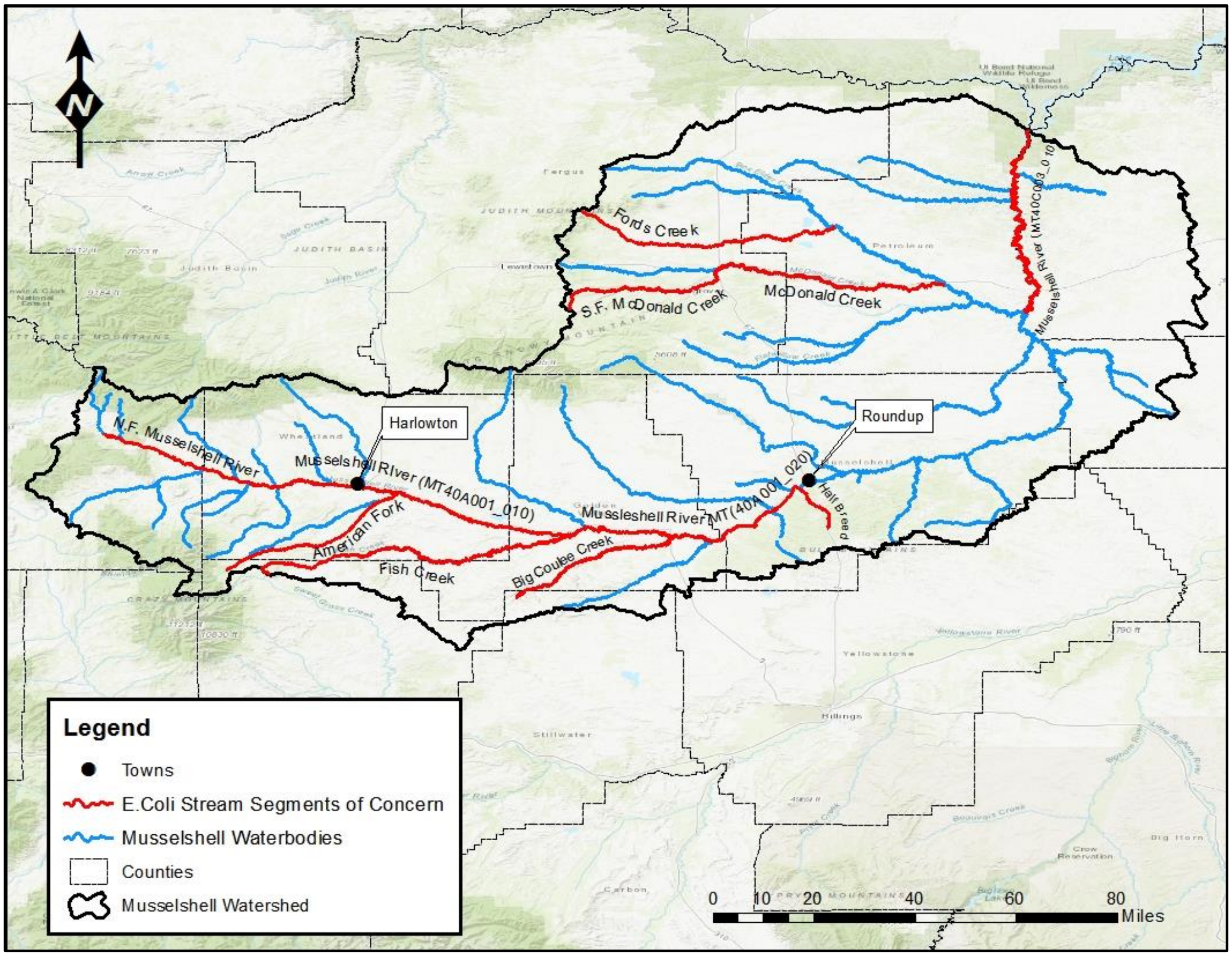

Figure 5-1. Map of the Stream Segments of Concern for E. coli in the Musselshell Watershed

5.3 Information Sources

The information sources used to develop the TMDL components include data used to determine impairments (**Section 5.4.2**), in addition to data obtained during the TMDL development process. The data collected by DEQ was catalogued within DEQ's centralized water quality database and can be found in the National Water Quality Monitoring Council's Water Quality Portal at https://www.waterqualitydata.us/. Flow data and information used for impairment determination, source assessment, and TMDL development consisted of:

- Water biological and streamflow data collected by DEQ
- Streamflow data collected by the USGS
- Grazing management plans developed by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS)
- Aerial imagery and Geographic Information System (GIS) data and analysis
- Literature reviews

5.4 WATER QUALITY TARGETS

Water quality targets are numeric indicators used to evaluate attainment of water quality standards, and are discussed in **Section 4.1**. This section presents *E. coli* water quality targets, and compares those target values to recently collected *E. coli* data.

5.4.1 *E. coli* Target Values and Assessment Methodology

5.4.1.1 E. coli Target Values

The Montana instream numeric water quality standards for *E. coli* are adopted as the *E. coli* target for streams in the Musselshell TMDL Project Area. Each use classification has a specific *E. coli* standard. Use classification of the impaired waterbodies in the Musselshell TMDL Project Area include B-1, B-2, and C-3 classifications (**Table 5-1**). The water quality standards for *E. coli* that are applicable to these classifications are defined by Administrative Rules of Montana (ARM) 17.30.623, 624, and 629 and identified in **Table 5-2** below. The *E. coli* targets are seasonal and based on bacterial colony growth rates (e.g., colonies multiply and grow faster in warmer temperatures), thus creating a more stringent target for the summer period (April 1 through October 31) than the winter period (November 1 through March 31). Because the numeric values within the water quality standard and the TMDL target values are equal, the term "standard" and "target" are used interchangeably throughout the remainder of this document.

Table 5-2. *E. coli* Targets for B-1, B-2, and C-3 Classified Waterbodies in the Musselshell TMDL Project Area

Applicable Period	**Target Concentration** (cfu[1]/100mL)	**Analysis Type**	**Allowable Exceedance Frequency**	**Dataset Requirement**
Summer *(April 1 – October 31)*	126	Geometric mean	Not to be exceeded	Minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period
	252	Individual samples	<10% exceedance rate allowed	
Winter *(November 1 – March 31)*	630	Geometric mean	Not to be exceeded	
	1,260	Individual samples	<10% exceedance rate allowed	

[1]Colony forming units

5.4.1.2 E. coli Assessment Methodology

Each waterbody assessed is compared to target values based on the above stated *E. coli* targets (**Table 5-2**) using the impairment assessment criteria as stated in the Administrative Rules of Montana: ARM 17.30.620(2) and ARM 17.30.602(11). The *E. coli* 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. 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 from April 1 through October 31. 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 (DEQ 2020b). A geometric mean is the value obtained by taking the nth root of the product of the measured values, where n equals the number of samples collected. Values below the detection limit were set to a value equal to the detection limit. If a waterbody does not meet the above-mentioned targets, then it is deemed to be impaired by *E. coli* and identified as such in Montana's Water Quality Integrated Report.

Water quality data in the Musselshell watershed was collected in 2015 and 2016, assessed in 2017 and included in the 2018 Integrated Report (IR). In 2017 DEQ had no official *E. coli* assessment method. Since then DEQ has developed and published the Escherichia coli (E. coli) Assessment Method for State Waters (DEQ 2020b). This document discusses impairment determinations that were made prior to publication of this methodology. That being said, there are inconsistencies in how data was assessed when compared to the 2020 assessment method. For example, in some instances minimum sample numbers needed in the 2020 assessment method were not met, in other instances data was not pooled consistent with the assessment method. Impairment determinations discussed in **Section 5.4.2** make note of some of these inconsistencies.

5.4.2 Existing Conditions and Comparison to Targets

DEQ evaluated attainment of *E. coli* water quality targets for all impaired waterbodies by comparing existing water quality conditions with the water quality targets presented in **Table 5-2** and applied the assessment methodology described above in **Section 5.4.1.2**. The following subsections provide a summary of the existing *E. coli* impairments along with a comparison of existing data with targets, using the assessment methodology. TMDL development determinations depend on results of the data evaluation, and these updated impairment determinations are found in the Montana Department of Environmental Quality 2020 Water Quality Integrated Report (DEQ 2020a). The waterbodies discussed in the following sections are in order from an upstream to downstream order.

5.4.2.1 North Fork of the Musselshell River

A total of two *E. coli* samples were collected by DEQ from one monitoring location along the North Fork of the Musselshell River in the summer of 2016. *E. coli* concentrations ranged from 98.3 cfu/100 mL to 325.5 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. Given that only two samples were collected, there was insufficient data to calculate a geometric mean for this site (**Table 5-3**). That being said, one single sample being greater that 252 cfu/100 mL surpasses the 10% exceedance rate. Do to this exceedance rate, the North Fork of the Musselshell River was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-3. North Fork Musselshell River *E. coli* Data and Target Comparison Summary

Station ID	**Sample Collection Date**	***E. coli* Result Value (cfu[1]/100mL)**	**Geometric Mean (cfu[1]/100mL)**	**Target Exceedances[2]**		**Assessment Determination[4]**
				Geometric Mean > 126 cfu[1]/100mL?	**10% of the samples > 252 cfu[1]/100mL?**	
M24MSNF06	7/26/2016	98.3	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/2 = 50%)	**Impaired**
	7/28/2016	**325.5**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)

[3]Site M24MSNF06 only had two samples, which was not enough to calculate the 5-sample geometric mean for that site
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.2 American Fork

A total of two *E. coli* samples were collected by DEQ from one monitoring location along the American Fork in the summer of 2016. *E. coli* concentrations ranged from 203.5 cfu/100 mL to 613.1 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. As only 2 samples were collected, there was insufficient data to calculate a geometric mean for this waterbody (**Table 5-4**). That being said, one single sample being greater that 252 cfu/100 mL surpasses the 10% exceedance rate. Due to this exceedance rate, the American Fork was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-4. American Fork *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M24AMERF01	7/26/2016	**613.1**	*Insufficient data*[3]	*Insufficient data*[3]	**YES** (1/2 = 50%)	**Impaired**
	7/28/2016	203.5				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M24AMERF01 only had two samples, which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.3 Upper Musselshell River (MT40A001_010)

A total of 19 *E. coli* samples were collected by DEQ from four monitoring locations along the Upper Musselshell River in the summers of 2015 and 2016. *E. coli* concentration values ranged from 7.4 cfu/100 mL to 488.4 cfu/100mL. The *E. coli* standard is based on a minimum of five samples collected during separate 24-hour periods during a consecutive 30-day period. As such, the data collected during the 30-day period in 2015 cannot be compared to the data collected during the 30-day period in 2016.

Four samples from the 2015 time period (26.7%) surpassed the exceedance rate of 10% of the samples being greater than 252 cfu/100mL (**Table 5-5**). The geometric mean of samples collected during this same time period exceeded the target of 126 cfu/100mL. Samples collected during the 2016 time period did not meet the minimum sample size to be compared to the geometric mean target and no samples exceeded the 252 cfu/100 mL target. Due to the exceedances of the geometric mean and 10% of samples being greater than the 252 cfu/100mL targets (when assessed against the 2015 data) the Upper Musselshell River (assessment unit MT40A001_010) was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-5. Upper Musselshell River (MT40A001_010) *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100 mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL ?	10% of the samples > 252 cfu[1]/100mL ?	
M24MUSSR10	7/13/2015	62	148.7	**YES**	**YES** (4/15 =26.7%)	**Impaired**
	7/14/2015	**410.6**				
	7/15/2015	**488.4**				
	7/20/2015	98.5				
	7/21/2015	185				
M24MUSSR03	7/13/2015	76.8				
	7/14/2015	129.6				
	7/15/2015	127.4				
	7/20/2015	238.2				
	7/21/2015	**387.3**				
M24MUSSR09	7/13/2015	46.5				
	7/14/2015	98.3				
	7/15/2015	225.4				
	7/20/2015	46				
	7/21/2015	**307.6**				
M24MUSSR09	7/26/2016	7.4	*Insufficient data*[3]	*Insufficient data*[3]	**NO** (0/4 = 0%)	
	7/28/2016	15.5				
M24MUSSR10	7/26/2016	43.7				
	7/28/2016	95.9				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M24MUSSR09 and M24MUSSR10 only had two samples in the 30-day time period (7/26/2016 - 7/28/2016), which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.4 Middle Musselshell River (MT40A001_020)

A total of 25 *E. coli* samples were collected by DEQ along the Middle Musselshell River in the summers of 2015 and 2016. *E. coli* concentrations ranged from 10.6 cfu/100 mL to 344.8 cfu/100 mL. The *E. coli* standard is based on a minimum of five samples collected during separate 24-hour periods during a consecutive 30-day period. As such, the data collected during the 30-day period in 2015 (8/10/2015-8/18/2015) cannot be compared to the data collected during the 30-day periods in 2016 (7/26/2016 - 7/28/2016, 7/26/2016 – 9/27/2016, and 9/27/2016 – 9/29/2016).

The geometric mean of samples collected during the 2015 time period did not exceed the target of 126 cfu/100mL. Two samples from this same time period (13.3%) surpassed the exceedance of 10% of the samples being greater than 252 cfu/100 mL (**Table 5-6**). Samples collected during the 2016 time period did not meet the minimum sample size to be compared to the geometric mean target and no samples exceeded the 252 cfu/100 mL target. Due to the exceedance rate of 13.3% (based on 2015 data), the Middle Musselshell River (assessment unit MT40A001_020) is determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-6. Middle Musselshell River (MT40A001_020) E. coli Data and Target Comparison Summary

Station ID	**Sample Collection Date**	***E. coli* Result Value (cfu[1]/100 mL)**	**Geometric Mean (cfu[1]/100 mL)**	**Target Exceedances[2]**		**Assessment Determination[4]**
				Geometric Mean > 126 cfu1/100mL ?	**10% of the samples > 252 cfu1/100mL ?**	
M24MUSSR04	8/10/2015	72.8	52.04	**NO**	**YES** (2/15 = 13.3%)	**Impaired**
	8/11/2015	18.5				
	8/12/2015	53.7				
	8/17/2015	69.7				
	8/18/2015	**344.8**				
M24MUSSR05	8/10/2015	38.1				
	8/11/2015	26.6				
	8/12/2015	14.5				
	8/17/2015	33.6				
	8/18/2015	248.1				
M24MUSSR06	8/10/2015	21.1				
	8/11/2015	10.8				
	8/12/2015	46.8				
	8/17/2015	88.8				
	8/18/2015	**275.5**				
M24MUSSR06	7/26/2016	10.6	*Insufficient data[3]*	*Insufficient data[3]*	**NO** (0/10 = 0%)	
	7/28/2016	24.2				
M24MUSSR04	7/26/2016	18.7				
	7/28/2016	20.2				
M24MUSSR05	7/26/2016	15.2				
	7/28/2016	25.7				
M24MUSSR08	7/26/2016	11.6				
	9/27/2016	13.4				
M24MUSSR06	9/27/2016	14.4				
	9/29/2016	35				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Sites M24MUSSR06, M24MUSSR04, M24MUSSR05 and M24MUSSR08 only had two samples in each 30-day time period (7/26/2016 -7/28/2016, 7/26/2016 – 9/27/2016, and 9/27/2016 – 9/29/2016), which was not enough to calculate the 5-sample geometric mean

[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.5 Fish Creek

A total of four *E. coli* samples were collected by DEQ from one monitoring station along Fish Creek in the summer of 2016. *E. coli* concentrations ranged from 13.0 cfu/100 mL to 1,413.6 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods, during any consecutive 30-day period. Fish Creek was sampled in two separate 30-day periods (July 2016 and September 2016). Only two samples were collected in each 30-day period (7/26/2016 -7/28/2016 and 9/27/2016 – 9/29/2016). In both 30-day time periods there was insufficient data to calculate a geometric mean for this waterbody (**Table 5-7**). One sample (50%) from the July 2016 timeframe and two samples (100%) from the September time frame surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the exceedance rates of 50% and 100%, Fish Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-7. Fish Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M24FISHC09	7/26/2016	13	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/2 = 50%)	**Impaired**
	7/28/2016	**1,413.6**				
	9/27/2016	**461.1**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (2/2 = 100%)	
	9/29/2016	**1,119.9**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M24FISHC09 only had two samples in each 30-day time period (7/26/2016 -7/28/2016 and 9/27/2016 – 9/29/2016), which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.6 Big Coulee Creek

A total of four *E. coli* samples were collected by DEQ from one monitoring location along Big Coulee Creek in the summer of 2016. *E. coli* concentrations ranged from 248.1 cfu/100 mL to 1,299.7 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. Big Coulee Creek was sampled in two separate 30-day periods (July 2016 and September 2016). As only two samples were collected in each 30-day period (7/26/2016 -7/28/2016 and 9/27/2016 – 9/29/2016), these data sets are assessed separately. In both 30-day time periods there was insufficient data to calculate a geometric mean for this waterbody (**Table 5-8**). One sample (50%) from the July 2016 timeframe and both samples (100%) from the September time frame surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the exceedance rates of 50% and 100%, Big Coulee Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-8. Big Coulee Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M24BIGCC01	7/26/2016	**1,299.7**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/2 = 50%)	**Impaired**
	7/28/2016	248.1				
	9/27/2016	**488.4**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (2/2 = 100%)	
	9/29/2016	**488.4**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M24BIGCC01 only had two samples in each 30-day time period (7/26/2016 -7/28/2016 and 9/27/2016 – 9/29/2016), which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.7 Half Breed Creek

A total of four *E. coli* samples were collected by DEQ from two monitoring stations along Half Breed Creek in the summer of 2016. *E. coli* concentrations ranged from 240 cfu/100 mL to 980.4 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. Half Breed Creek was sampled in two separate 30-day periods (July 2016 and September 2016). Two samples were collected in each 30-day period (7/26/2016 - 7/28/2016 and 9/27/2016 - 9/29/2016). In both 30-day time periods there was insufficient data to calculate a geometric mean for this waterbody (**Table 5-9**). Two samples collected in the same 30-day period (7/26/2016 and 7/28/2016) surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the total sample exceedance rate of 100% Half Breed Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-9. Half Breed Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M24HLFBC02	7/26/2016	**980.4**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (2/2 = 100%)	**Impaired**
M24HLFBC03	7/28/2016	**461.1**				
	9/27/2016	240	*Insufficient data[3]*	*Insufficient data[3]*	**NO** (0/2 = 0%)	
	9/29/2016	218.7				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Sites M24HLFBC02 and M24HLFBC03 reported one sample in each 30-day time period (7/26/2016-7/28/2016 and 9/27/2016-9/29/2016), which was not enough to calculate the 5-sample geometric

[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.8 South Fork McDonald Creek

A total of two *E. coli* samples were collected by DEQ from two separate monitoring stations along the South Fork of McDonald Creek in the summer of 2016. *E. coli* concentrations were 160.7 cfu/100 mL and 307.6 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. The South Fork of McDonald Creek was sampled once at each monitoring stations. As only two samples were collected for the entire waterbody, there was insufficient data to calculate a geometric mean (**Table 5-10**). One sample (50%) surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the total sample exceedance target at 50%, the South Fork of McDonald Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-10. South Fork McDonald Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M26MCSFC01	9/28/2016	160.7	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/2 = 50%)	**Impaired**
M26MCSFC02	9/28/2016	**307.6**				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M26MCSFC01 and M26MCSFC02 only reported two samples, which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.9 McDonald Creek

A total of four *E. coli* samples were collected by DEQ from three separate monitoring stations along McDonald Creek in the summer of 2016. *E. coli* concentrations ranged from 85.7 cfu/100 mL to 770.1 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. McDonald Creek was sampled a total of four times at three separate monitoring stations. As only four samples were collected for the entire waterbody, there was insufficient data to calculate a geometric mean (**Table 5-11**). The single sample collected from monitoring station M26MCSDLC01 (7/27/2016) exceeded the target of 10% of samples being greater than 252 cfu/100 mL. Only one sample collected from the three remaining monitoring stations during a separate 30-day time period (9/28/2016) surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the exceedance rates of 100 % and 33%, McDonald Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-11. McDonald Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M26MCDLC01	7/27/2016	**275.5**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/1 = 100%)	**Impaired**
M26MCDLC09	9/28/2016	**770.1**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/3 = 33.3%)	
M26MCDLC01	9/28/2016	129.6				
M26MCDLC06	9/28/2016	85.7				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Sites M26MCDLC01, M26MCDLC09, and M26MCDLC06 only reported one sample each in each 30-day time period (7/27/2016 and 9/28/2016), which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.10 Fords Creek

One *E. coli* samples was collected by DEQ from one monitoring station along Fords Creek in the summer of 2016. The *E. coli* concentration was 1,732.9 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. As only one sample was collected for the entire waterbody, there was insufficient data to calculate a geometric mean (**Table 5-12**). The one sample collected surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the exceedance rate of 100% Ford Creek was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-12. Fords Creek *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M26FORDC01	9/28/2016	**1,732.9**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/1 = 100%)	**Impaired**

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M26FORDC01 only reported one sample, which was not enough to calculate the 5-sample geometric mean for that site
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.4.2.11 Lower Musselshell River (MT40C003_010)

A total of eight *E. coli* samples were collected by DEQ from one monitoring station in this segment of the Lower Musselshell River in the summers of 2015 and 2016. *E. coli* concentrations ranged from 22.1 cfu/100 mL to 461.1 cfu/100mL. As discussed in **Section 5.4.1.2**, the *E. coli* standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period. The Lower Musselshell River was sampled a total of five times during 2015. During this time, the geometric mean did not exceed 126 cfu/100mL and 10% of samples were not greater than 252 cfu/100 mL. During 2016, three samples were collected; as such, there was insufficient data to calculate a geometric mean (**Table 5-13**). During one of the two 30-day time periods samples were collected in 2016 one sample surpassed the exceedance of 10% of samples being greater than 252 cfu/100 mL. Due to the exceedance rate of 100% for this sample, the Lower Musselshell River was determined to be impaired by *E. coli* and a TMDL will be developed.

Table 5-13. Lower Musselshell River (MT40C003_010) *E. coli* Data and Target Comparison Summary

Station ID	Sample Collection Date	*E. coli* Result Value (cfu[1]/100mL)	Geometric Mean (cfu[1]/100mL)	Target Exceedances[2]		Assessment Determination[4]
				Geometric Mean > 126 cfu[1]/100mL?	10% of the samples > 252 cfu[1]/100mL?	
M28MUSSR01	8/10/2015	41.4	51.11	**NO**	**NO** (0/5 = 0%)	**Impaired**
	8/11/2015	75.9				
	8/12/2015	35.4				
	8/17/2015	79.8				
	8/18/2015	39.3				
	7/27/2016	**461.1**	*Insufficient data[3]*	*Insufficient data[3]*	**YES** (1/1 = 100%)	
	9/27/2016	109.5	*Insufficient data[3]*	*Insufficient data[3]*	**NO** (0/2 = 0%)	
	9/29/2016	22.1				

[1]Colony forming units
[2]Water quality targets presented are for the summer period (April 1 through October 31)
[3]Site M28MUSSR01 only reported three samples in the 30-day time period in 2016, which was not enough to calculate the 5-sample geometric mean
[4]Assessment based on 2018 impairment determination
Bolded results indicate target exceeded

5.5 Total Maximum Daily Loads

This section summarizes the approach used for TMDL development, and presents the TMDL, allocations, and estimated reductions necessary to meet water quality targets for *E. coli* impaired waterbodies in the Musselshell TMDL Project Area. **Table 5-14** shows the waterbody, assessment unit, the impairment cause and the TMDLs developed. Loading estimates and load allocations are based on observed water quality data and representative flow conditions and are discussed later in this section.

Table 5-14. *E. coli* TMDLs Developed in the Musselshell TMDL Project Area

Stream Segment/Waterbody (Assessment Unit)	Assessment Unit ID	Impairment Cause and TMDL Developed
American Fork, Confluence of Middle and North Forks American Fork to mouth (Musselshell River)	MT40A002_120	Escherichia coli (*E. Coli*)
Big Coulee Creek, Confluence of North and South Forks Big Coulee Creek to mouth (Musselshell River)	MT40A002_130	Escherichia coli (*E. Coli*)
Fish Creek, Headwaters to mouth (Musselshell River)	MT40A002_070	Escherichia coli (*E. Coli*)
Fords Creek, East Fork Fords Creek to mouth (Box Elder Creek)	MT40B002_021	Escherichia coli (*E. Coli*)
Half Breed Creek, Headwaters to mouth (Musselshell River)	MT40A002_090	Escherichia coli (*E. Coli*)
McDonald Creek, North and South Forks to mouth (Box Elder Creek)	MT40B002_010	Escherichia coli (*E. Coli*)
North Fork Musselshell River, Bair Reservoir to confluence with South Fork Musselshell River	MT40A002_012	Escherichia coli (*E. Coli*)
Musselshell River (Upper), North & South Fork confluence to Deadmans Basin Diversion Canal	MT40A001_010	Escherichia coli (*E. Coli*)
Musselshell River (Middle), Deadmans Basin Supply Canal to HUC boundary near Roundup	MT40A001_020	Escherichia coli (*E. Coli*)
Musselshell River (Lower), Flatwillow Creek to Fort Peck Reservoir	MT40C003_010	Escherichia coli (*E. Coli*)
South Fork McDonald Creek, Headwaters to confluence with North Fork McDonald Creek	MT40B002_070	Escherichia coli (*E. Coli*)

Because streamflow varies seasonally, *E. coli* TMDLs are not expressed as a static value, but as an equation of the appropriate target multiplied by flow, as shown in **Equation 5-1**:

Equation 5-1: TMDL = (X) (Y) (K)/1,000,000

TMDL= Total Maximum Daily Load in million colony forming units/day (Mcfu/day)
X = E. coli water quality target in cfu/100mL
Y = streamflow in cubic feet per second (cfs)
K = conversion factor of 2.44×10^7

Like the water quality targets, the TMDLs change seasonally between the winter season (November 1 through March 31) and the summer season (April 1 through October 31). The *E. coli* TMDLs displayed in

Figure 5-2 are based on **Equation 5-1** and show TMDLs based on the geometric mean targets (126 cfu/100 mL for the summer season and 630 cfu/100mL for the winter season). The TMDL calculation and the resulting graphical representation of this equation (**Figure 5-2**) assume that if the geometric mean targets of 126 cfu/100 mL or 630 cfu/100mL are being met in a waterbody, the 10% exceedance target of 252 cfu/100 mL or 1,1260 cfu/100mL will also be met.
Figure 5-2 also displays the relationship that the TMDL has in regard to flow; as flow increases, the allowable load (TMDL) increases. The TMDL is not expressed as a load or mass, but instead expressed as the number of colony forming units per day due to the nature of the pollutant. This approach is consistent with EPA's recommended analytical method for measuring *E. coli* in ambient waters and the flexibility offered in 40 CFR §130.3(i) to express TMDLs in other appropriate, non-mass based, measures. For example, at a flow rate of 5 cfs, the application of **Equation 5-1** would result in a. *E. coli* TMDL of 15,372,000 cfu/day for the summer period and 76,860,000 cfu/day for the winter period. To convert the examples above to Mcfu, simply divide by 1 million for values of 15.4 Mcfu for the summer period and 76.8 Mcfu for the winter period. Typically, *E. coli* loads are expressed as million colony forming units (Mcfu).

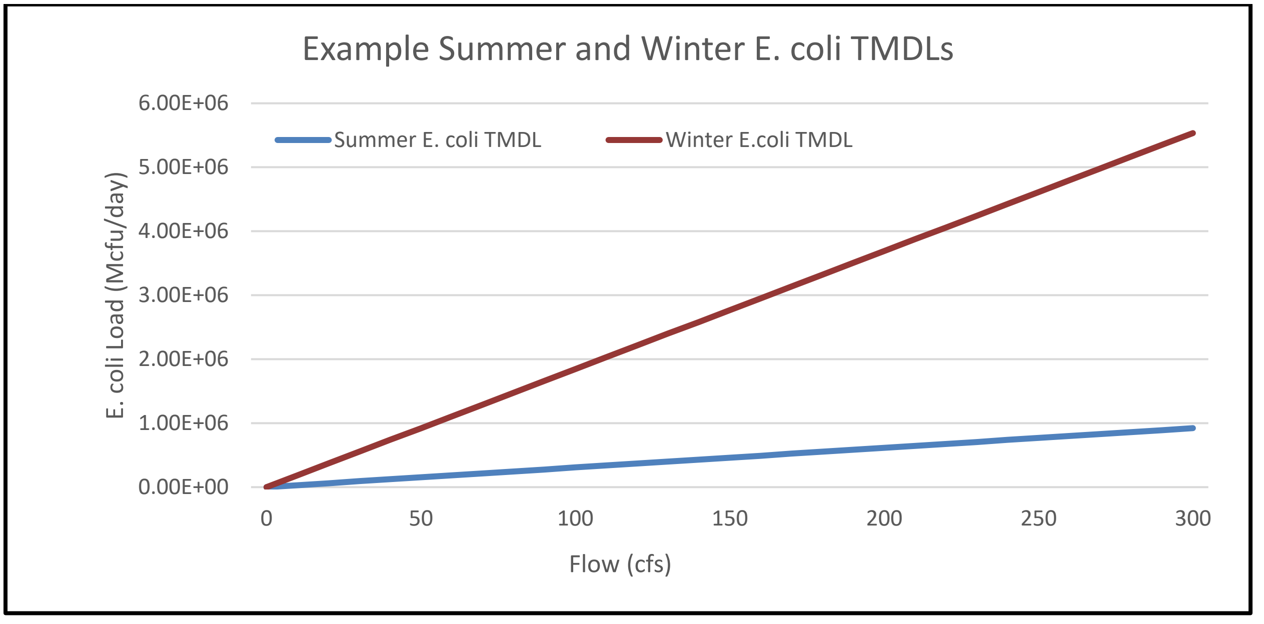

Figure 5-2. TMDLs for *E. coli* at streamflows ranging from 0 to 300 cfs

5.6 Source Assessment

This section provides the *E. coli* source assessment, which characterizes the type and distribution of sources contributing to *E. coli* loading to the tributary and mainstem waterbodies in the Musselshell TMDL Project Area, and establishes the approach used to develop the TMDL and allocations to specific source categories.

Source characterization and assessment to determine the major sources in each of the *E.coli* impaired waterbodies was conducted by using monitoring data collected from the Musselshell TMDL Project Area from 2015 to 2016 (the most recent *E. coli* data available). These data were collected to 1) evaluate attainment of water quality targets, 2) assess contributions from *E. coli* sources, and 3) provide rationale for specific TMDL allocations. *E. coli* water quality data used to conduct these analyses are presented in **Section 5.4.2** and are publicly available at: https://www.waterqualitydata.us/. Additional sources of information include aerial photographs, geographic information system (GIS) analysis, field work, and literature reviews.

E. coli pollution in the Musselshell TMDL Project Area is coming from three source types: 1) natural sources derived from wildlife excrement, 2) human-caused nonpoint sources dispersed across the landscape (e.g., agriculture), and 3) human-caused point sources (permitted discharges). These sources may include a variety of discrete and diffuse pollutant inputs that have differing pathways to a waterbody.

5.6.1 Description of E. coli Sources

5.6.1.1 Natural Background

TMDL development is dependent on a allocation of a portion of the *E. coli* load to natural sources. Natural sources of *E. coli* are primarily from wildlife excrement, from species that utilize riparian and stream corridors. During the development of the Musselshell *E. coli* TMDLs, *E. coli* data were collected at sampling sites throughout the watershed, none of these sampling sites were identified as *E. coli* 'reference' sites for the purposes of quantifying natural background loads for *E. coli*. As these sites are not considered 'reference," data representative of natural conditions needed to be selected from other watersheds. Those waterbodies that were selected to represent background water quality and were sampled and assessed during the same efforts that identified the impaired waters discussed in **Section 5.4.2**. These waterbodies were found to not be impaired for *E. coli*. The waterbodies in **Table 5-15** were selected based the lack of point sources of *E. coli* (MPDES permitted sites), on their relatively central location within the watershed and the relative abundance of data for each of the sampling sites. The *E. coli* results reported in **Table 5-15** are appropriate for use as natural background concentrations when compared with natural background *E. coli* concentrations found in other watersheds in Montana. For example, *E. coli* data collected on the Smith, Gallatin and Beaverhead Rivers reported geometric means of 33.6 cfu, 28 cfu and 35.3 cfu respectively. For purposes of estimating natural background concentrations for TMDL development and associated load allocations, the median value of 37 cfu/100mL is used (**Section 5.7**).

Table 5-15. Water Quality Data used for Natural Background *E. coli* Concentration

Waterbody	Station ID	Sample Collection Date	Results (CFU/100mL)
Careless Creek	BKK034	7/26/2016	17.1
Careless Creek	BKK034	7/28/2016	48.1
Careless Creek	BKK034	9/27/2016	38.8
Careless Creek	BKK034	9/29/2016	151.5
Painted Robe Creek	M24PTRBC02	7/26/2016	19.9
Painted Robe Creek	M24PTRBC02	7/28/2016	11
Painted Robe Creek	M24PTRBC02	9/27/2016	4.1
Painted Robe Creek	M24PTRBC02	9/29/2016	2
Flatwillow Creek	M27FLTWC01	7/27/2016	36.9
Flatwillow Creek	M27FLTWC01	9/27/2016	101.2
Flatwillow Creek	M27FLTWC01	9/29/2016	33.2
Flatwillow Creek	M27FLTWC02	9/28/2016	127.4
Flatwillow Creek	M27FLTWC05	9/28/2016	101.7
Median=36.9			

*All data was collected by DEQ during the 2015-2016 field seasons

5.6.1.2 Human Caused Nonpoint Sources

A significant portion of *E. coli* inputs to the impaired waterbodies of the Musselshell watershed come from nonpoint sources (i.e., diffuse sources that cannot easily be pinpointed). Human caused nonpoint sources of *E. coli* in the Musselshell watershed consist primarily of agriculture (pasture, rangeland, and manure applied on cropland), and those other sources that are human caused (subsurface wastewater disposal, domestic pets, recreation, etc.). **Figure 2-14** show types of land use including areas of cropland, pasture, and other potential sources. Livestock grazing on private rangeland occurs throughout the watershed but is not specifically identified in these figures.

Agriculture

The transport of *E. coli* from agricultural land to surface water can happen where there is grazing of riparian areas by livestock. The proximity of deposited excrement to nearby surface waters provides an efficient transport route. Excrement deposited in and near a waterbody, and through the field application of manure on crops, can cause travel to surface water via overland runoff and irrigation return flows. The following subsections describe the most prominent land use practices that present these conditions.

Livestock Grazing

Livestock grazing in the Musselshell watershed occurs on both large tracts of private and public rangeland and pastureland. Livestock are typically allowed to roam and graze in areas along the valley bottoms during the summer months. Rangeland is typically grazed during the summer months (June-October). Pastures are typically managed for hay production during the summer and for grazing during the fall and spring. Hay pastures are typically thickly vegetated in the summer and less so in the fall through spring. During the winter grazing period (October through May), trampling and winter feeding further reduces biomass when it is already low. Livestock manure deposition occurs in higher quantities on pasture ground from October through May because of higher cattle density than that found on range and forested areas. Rangeland differs from pasture in that rangeland has much less biomass. However, grazing impacts do factor in and manure deposition can result in significant *E. coli* contribution to surface water via riparian grazing.

Private land grazing occurs throughout the watershed, and in areas where livestock have direct access to the stream, they can be significant sources of *E. coli*. If not managed properly, manure from livestock corrals can runoff into surface water. In addition to private land grazing, there are public land grazing allotments throughout the watershed. The Musselshell watershed is approximately 6 million acres in size, and 2.2 million acres of the watershed is in federal grazing allotments. Both the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS) maintain grazing allotments in sub basins throughout the Musselshell watershed. There are approximately 67 USFS grazing allotments in the Musselshell watershed accounting for approximately 242,000 acres. Most of these allotments occur in the headwaters or upper half of the watershed. The BLM has just over 800 grazing allotments in the watershed accounting for approximately 2 million acres of grazed land. The vast majority of these occur in the lower half of the watershed.

Irrigated and Dryland Cropping

Cropland in the Musselshell watershed is primarily irrigated hay and pastureland (grass and alfalfa), with some irrigated small grains production (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). Manure applied to cropland can be a source of *E. coli* to surface water if it is not incorporated into the soil correctly (in a timely manner) and applied at agronomic rates. When properly applied, manure can provide an excellent source of fertilizer for crops, but improper application can leave excess manure on the soil surface, which makes it susceptible to being transported off-site via overland runoff from precipitation or irrigation. Prior to field application, manure must be properly stored in areas where the risk for surface and groundwater contamination is low. Improper manure storage in areas with a high water table or areas adjacent to surface water pose the greatest risk for off-site *E. coli* transport. The extent of manure application on cropland in the Musselshell watershed is unknown, but likely minimal in comparison to the application of commercial fertilizers.

Failing or Malfunctioning Septic Systems

Additional sources with the potential to contribute *E. coli* loads to surface waters include residential septic systems, aging and failing septic systems, improperly designed or maintained systems, and faulty residential service connections. Properly located, designed, installed, and maintained, these systems pose no significant loading threat to surface waters. As such loading from properly functioning systems will not be considered a potential source of *E. coli*. However, improperly installed systems, unmaintained systems, and failing systems have the potential to contribute *E. coli* loads where they are in close proximity (100 feet) to surface waters.

Failing or malfunctioning septic systems include individual wastewater systems that are not providing adequate treatment of bacterial contaminants before they reach surface waters. To consider a failing septic system as a source, it would need to produce an effluent stream capable of reaching a waterbody in order to provide a significant *E. coli* load. For this to occur, a septic system would need to be in close proximity to the waterbody to receive overland flow from the failing system. Typically failing systems exhibit evidence of failure by surface ponding or routing of effluent, and these symptoms are easily identifiable by the owner of the system in most circumstances. Because a failing or malfunctioning septic system is easily identifiable by the owner, repairs are likely done in a timely manner, limiting the risk of *E. coli* contamination to nearby surface or groundwater.

Septic systems in the Musselshell watershed are at very low densities, but high densities adjacent to impaired waterbodies are seen around the towns of Checkerboard, Harlowton, and Winnett (**Figures 5-6**, **5-8**, and **5-14**, respectively). While no information is available regarding failing septic systems in the Musselshell watershed, the number of failing septic systems is likely very low and is not expected to be a significant contributor of *E. coli*.

Domestic Pets and Recreational Use

Domestic pets such as dogs and recreational livestock are common in areas in the Musselshell watershed and have the potential to contribute *E. coli*. It is likely a safe assumption that contributions from pets and recreational livestock within the residential area and areas used for recreation are insignificant because the number of pets and recreational livestock is low when compared to the number of cattle, the largest contributing sources of *E. coli*. Given the lower number of pets and recreational livestock and the resulting lower volume of excrement this source is not expected to be a significant contributor of *E. coli* to the Musselshell or its tributaries. Nonetheless, steps should be taken to minimize contributions of E. coli to surface waters from domestic pets.

Re-suspension of *E. coli* in substrate sediments as a result of recreational usage or general disturbance (fishing, swimming, stream crossing, domestic pets, etc.) may contribute to instream *E. coli* loads during the summer recreation season. A study conducted in Oak Creek, Arizona found that water quality violations occurred when sediments were found to have high levels of fecal coliform (Cabrill et al., 1999). The largest potential contributor of *E. coli* in this category includes recreational stock, which may be maintained by individuals and businesses. Limited information regarding the specific contribution from recreational activities in the Musselshell watershed is available. However, this source is not expected to be a significant contributor of *E. coli* to the Musselshell and its tributaries.

5.6.1.3 Point Source Discharges
All point sources of wastewater discharge are required to obtain and comply with Montana Pollutant Discharge Elimination System (MPDES) permits. If a TMDL has been developed for a waterbody, appropriate wasteload allocations (WLAs) will be incorporated into the MPDES permits discharging to that waterbody.

Montana Pollutant Discharge Elimination System (MDPES) Permitted Facilities
There are approximately 26 MPDES-permitted discharges that release wastewater to *E*. coli impaired waterbodies in the Musselshell TMDL Project Area. 16 of these permits do not have waste streams that are expected to contain *E. coli.* Examples of permitted sites such as these are stormwater construction discharges or discharges associated with oil and gas development, etc. The remaining 10 permits are from a combination of effective or administratively continued general and individual MPDES permits that can be considered point sources and have waste streams capable of discharging *E*. coli. **Table 5-16** shows those permitted sites that have the potential to contribute *E*. coli and the impaired waters to which they have the potential to contribute.

Table 5-16. MPDES Permitted Facilities with E. coli Loading Potential

Permit Number	Permittee	Permitted Activity	Receiving Water
MT0020354	City of Harlowton	Sewerage Systems	Musselshell River (Upper)
MT0020451	Town of Ryegate	Sewerage Systems	Musselshell River (Middle) via Unnamed Slough
MT0030309	Town of Grass Range	Sewage Systems	South Fork McDonald Creek
MTG010150	Duncan Ranch Colony	Concentrated Animal Feeding Operations	Musselshell River (Upper)
MTG010156	Golden Valley Colony	Concentrated Animal Feeding Operation	Fish Creek via unnamed tributary
MTG010242	Springwater Colony	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary
MTG010231	Swanz Ranch	Concentrated Animal Feeding Operation	Little Careless Creek
MTG010244	Martinsdale Colony Inc.	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary
MTG580013	Town of Lavina	Lagoon (Batch)	Musselshell River (Middle)
MTG580041	Town of Winnett	Lagoon (Batch)	McDonald Creek

The discharges from those MPDES permitted facilities that are contributing *E.* coli loads, the potential loading impacts, and how WLAs are applied to each of these facilities is discussed in detail in **Section 5.7**.

5.6.2 North Fork of the Musselshell River Source Assessment
E. coli inputs to the North Fork of the Musselshell River come from a number of nonpoint sources. The primary sources of *E. coli* are limited to those that occur naturally and those that are human-caused

(agricultural, and to a limited degree wastewater from domestic wastewater). There are no permitted point sources in the North Fork of the Musselshell watershed.

The North Fork of the Musselshell River occurs in the headwaters of the Musselshell basin (**Figure 5-1**). Land use in the watershed is approximately 92% forested, 5% irrigated land, 1% non-irrigated hay land and 2% summer fallow. Throughout Montana these land use types are commonly utilized for grazing. Grazing land use in the North Fork of the Musselshell is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-3**). The U.S. Forest Service (USFS) has approximately 81,400 acres of land in federally managed grazing allotments and the Bureau of Land Management (BLM) has approximately 1,070 acres. Cropland in the North Fork of the Musselshell watershed is widespread and consists primarily of dryland small grains production (specifically wheat and barley), irrigated and dryland hay and pastureland (grass and alfalfa) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019).

Another potential source of *E. coli* loading to the North Fork of the Musselshell is the community of Checkerboard adjacent to Story Creek (a tributary to the North Fork of the Musselshell). This community was plated as a subdivision prior to the Montana Sanitation Act. Therefore, there has been no subdivision review of the domestic wastewater treatment systems currently servicing this community. This means that there was no review and approval of the systems that were installed, and very limited reporting requirements for the owners of these systems. As there is no review, approval, and required compliance, there is no way for DEQ to know if these systems are potential sources of *E. coli*.

To consider a septic system as a source, it would need to be failing, and produce an effluent stream capable of reaching a nearby surface water. For this to occur, a septic system would need to be in close enough proximity to a surface water to receive overland flow from the failing system. Approximately 7 of the 40 identified septic systems in Checkerboard are within 100 feet of Story Creek, which is a conservative estimate of distance that a effluent stream could (without infiltrating into surface soils or becoming diluted by other means) be expected to persist and reach Story Creek. A somewhat conservative rate of failure for septic systems is from 10-20% (USEPA, 2002). Therefore, it could be assumed that of the 7 septic systems within 100 feet, only 1 or 2 of these systems might be failing and have the capability of contributing an *E. coli* load. That being said, the likely contributing load from failing septic systems in Checkerboard is low. There were no other septic systems within 100 feet of the North Fork of the Musselshell identified as potential sources of *E. coli*. **Figure 5-3** shows the dominate sources of *E. coli* in the watershed and their proximity to the North Fork of the Musselshell.

The North Fork of the Musselshell was sampled twice at the same location (M24MSNF06) on June 26 and June 28, 2016. As there was only one monitoring location, it is difficult to distinguish those sources in the watershed that might be contributing sources of *E. coli*. The sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human caused. Specific load allocations for the North Fork of the Musselshell are discussed in detail in **Section 5.8.1**.

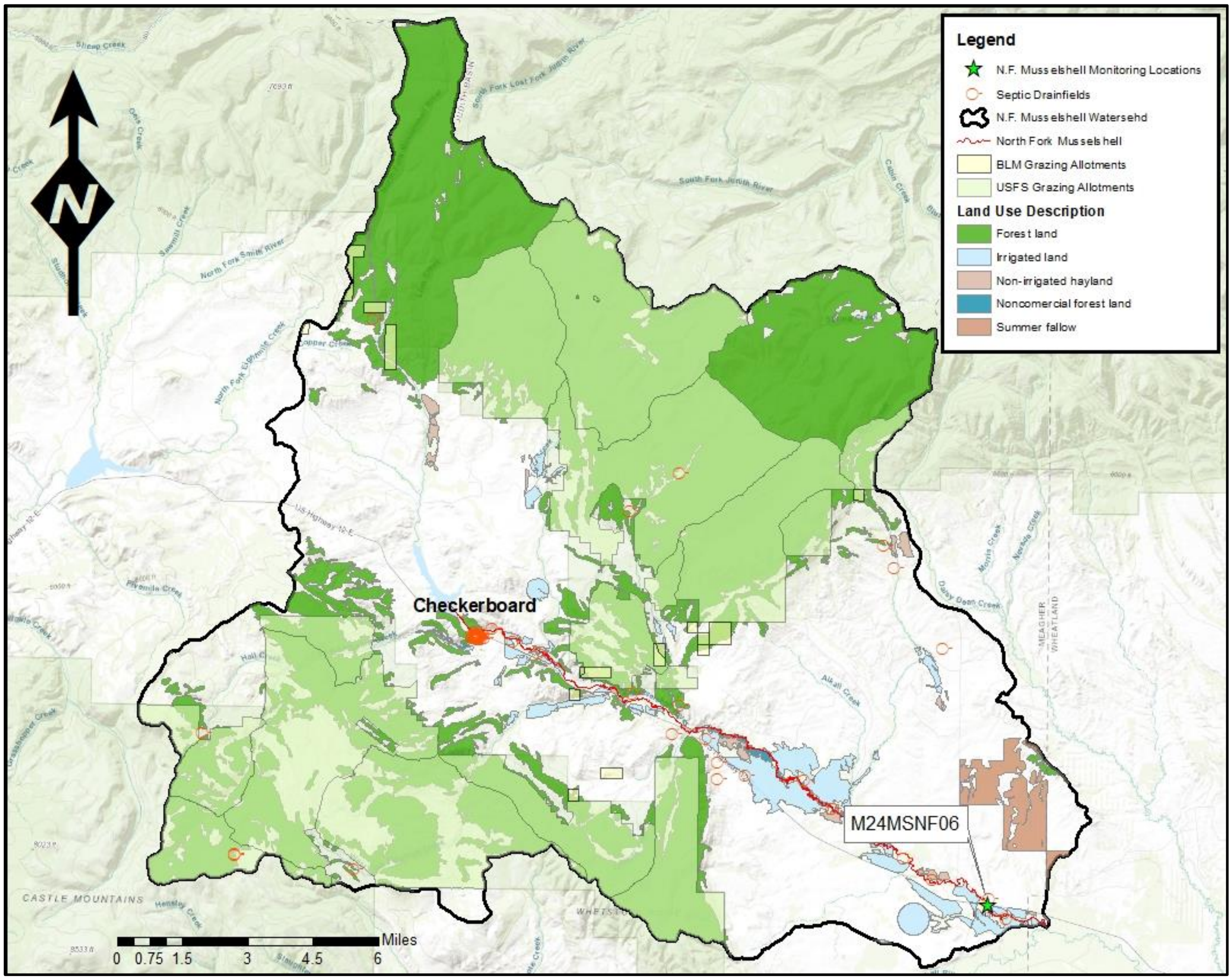

Figure 5-3. Water Quality Monitoring Site and E. coli Sources in the N.F Musselshell River Watershed

5.6.3 American Fork Source Assessment

E. coli inputs to the American Fork are similar to those in the North Fork of the Musselshell River (i.e., nonpoint sources). The primary sources of *E. coli* are limited to those that occur naturally and those associated with agricultural sources. There are no permitted point sources in the American Fork watershed.

The American Fork occurs in the headwaters of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 16.5% irrigated land, 16% non-irrigated hay land, and 12% summer fallow. Approximately 55% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the American Fork watershed. Grazing land use in the American Fork is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-4**). The USFS has approximately 21,000 acres of land in federally managed grazing allotments and the BLM has approximately 75 acres. Cropland in the American Fork watershed widespread and consists primarily of irrigated and dryland hay and pastureland (grass/pasture, alfalfa and other hay), and to a limited degree, dryland small grains production (specifically wheat and barley) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the American Fork watershed, they are few in number and fairly well dispersed. As such, they are not considered a significant source of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure etc.

The American Fork was sampled twice at the same location (M24AMERF01) on June 26 and June 28, 2016. As there was only one monitoring location is difficult to distinguish sources in the watershed that might be contributing sources of *E. coli*. That being said, the sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human caused. Specific load allocations for the North Fork of the Musselshell are discussed in detail in **Section 5.8.2**.

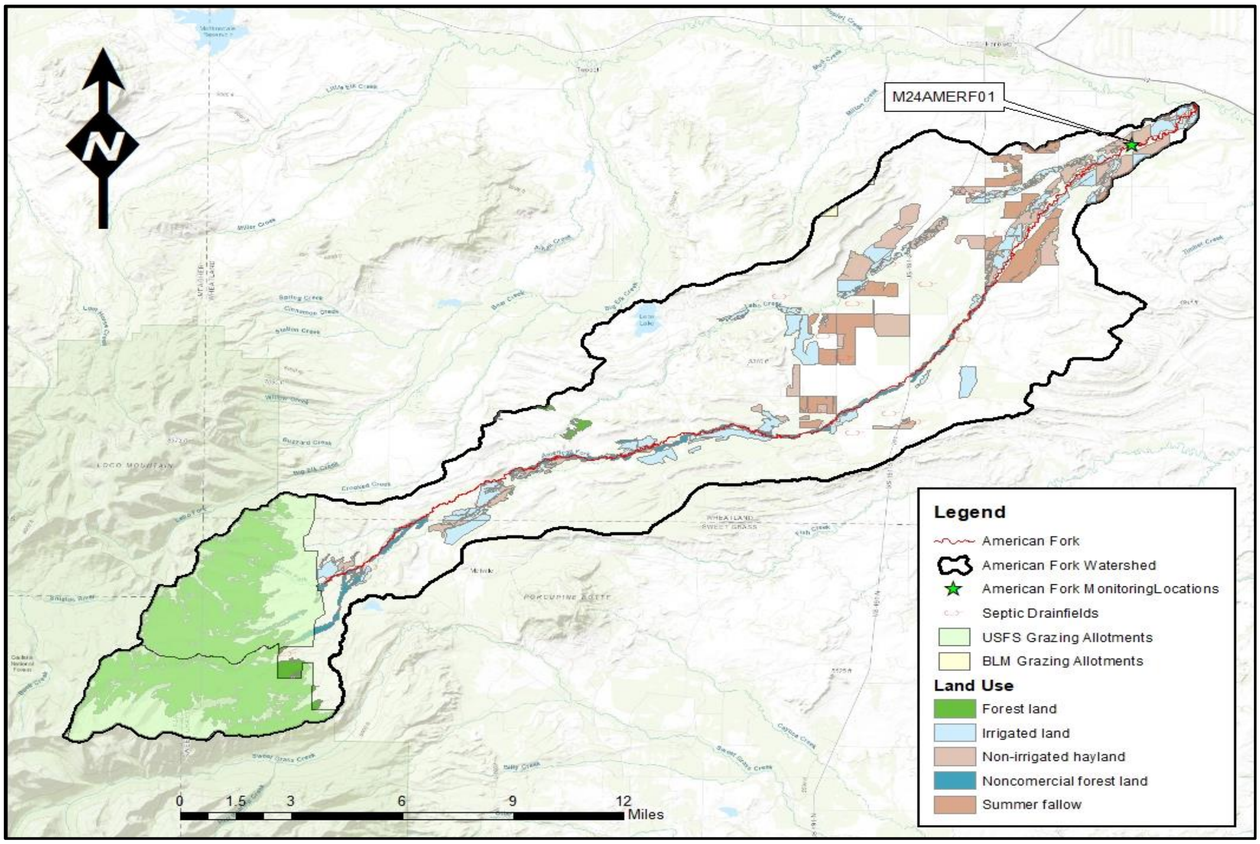

Figure 5-4. Water Quality Monitoring Site and E. coli Sources in the American Fork Watershed

5.6.4 Upper Musselshell River MT40A001_010 Source Assessment

The Upper Musselshell River includes the full headwaters of the Musselshell River watershed. The impaired section of the Upper Musselshell River occurs from the confluence of the North and South Fork to the irrigation diversion for Deadmans Basin. *E. coli* inputs to the Upper Musselshell River (assessment unit MT40A001_010) consist of point and nonpoint sources as well as loads form other impaired waters (North Fork of the Musselshell River and American Fork). The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. The point sources of *E. coli* in the watershed include contributions from municipal wastewater and agricultural point sources.

Land use in the watershed is approximately 10.5% irrigated land, 5% non-irrigated hay land, and 14.5% summer fallow. Approximately 70% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. Grazing land use in the Upper Musselshell is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-5**). The USFS has approximately 191,630 acres of land in federally managed grazing allotments and the BLM has approximately 16,090 acres. Cropland in the Upper Musselshell watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass/pasture, alfalfa and other hay), and to a limited degree, dryland small grains production (specifically wheat and barley) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019).

Septic systems in the Upper Musselshell River watershed are not prolific but are worth discussing. The highest number of septic systems is in and around the town of Harlowton, which is also served by a municipal wastewater treatment plant. As discussed earlier, only failing septic systems in close proximity to a surface water can be considered a potential sources of *E. coli* pollution. Only about 5 of the approximately 850 identified septic systems are within 100 feet of the Musselshell River, with one hundred feet being a conservative estimate of distance an effluent stream could (without infiltrating into surface soils or becoming diluted by other means) be expected to persist and reach the Musselshell River. A somewhat conservative rate of failure for septic systems is from 10-20% (USEPA, 2002). Therefore, it could be assumed that of the 5 septic systems within 100 feet, only 1 or 2 of these systems might be failing and have the capability of contributing an *E. coli* load. That being said, the likely contributing load from failing septic systems is low.

Both the North Fork of the Musselshell and the American Fork are *E. coli* impaired tributaries that have the potential to contribute a *E.coli* load to the Upper Musselshell River. As such, a loading evaluation was performed for both the North Fork of the Musselshell and the American Fork. *E. coli* loads were calculated from recent (2016) water quality data using the measured concentrations for *E. coli* and a representative flow. As flow data were not collect during *E. coli* sampling efforts, flow data from nutrient sampling that took place on both the North Fork of the Musselshell and the American Fork was used (**Appendix A**). While flow data associated with nutrient sampling were not collected on the same day as *E. coli* samples, they were collected within a few days of *E. coli* data, providing a representative flow. Loads for the North Fork of the Musselshell and the American Fork are calculated as the product of *E. coli*, flow, and a conversion factor. **Table 5-17** shows the tributary *E. coli* loading to the Musselshell River.

Table 5-17. Tributary *E. coli* loading to the Upper Musselshell River

<table>
<tr><th>Contributing Waterbody</th><th>E. coli Sample Collection Date</th><th>E. coli Concentration (cfu/100 mL)</th><th>Flow Data Collection Date</th><th>Flow (cfs)</th><th>Conversion Factor</th><th>E. coli Load (Mcfu/day)</th></tr>
<tr><td rowspan="2">N. F. Musselshell River</td><td>7/26/2016</td><td>98.3</td><td>7/23/2016</td><td>3.55</td><td rowspan="2">2.44×10^{7}</td><td>8,514</td></tr>
<tr><td>7/28/2016</td><td>325.5</td><td>8/1/2016</td><td>2.56</td><td>20,300</td></tr>
<tr><td colspan="6">Average Load</td><td>14,407</td></tr>
<tr><td rowspan="2">American Fork</td><td>7/26/2016</td><td>613.1</td><td>7/23/2016</td><td>4.86</td><td rowspan="2">2.44×10^{7}</td><td>72,691</td></tr>
<tr><td>7/28/2016</td><td>203.5</td><td>8/2/2016</td><td>3.1</td><td>15,354</td></tr>
<tr><td colspan="6">Average Load</td><td>44,022</td></tr>
</table>

The Upper Musselshell River watershed is unique in that it has multiple MPDES permitted discharges. These permitted entities discharge various types of wastewater to the Upper Musselshell River or to direct tributaries of the Musselshell. Those permitted facilities that have the potential to contribute *E. coli* loads to the Upper Musselshell River are included in **Table 5-18.** The discharges from these facilities are discussed below and wasteloads allocated to these facilities are detailed in **Section 5.8.3**. As discussed in **Section 5.6.1.3**, there are a number of permitted facilities throughout the Musselshell watershed that do not have the potential to contribute *E. coli* to the Upper Musselshell and therefore will not be discussed.

Table 5-18. MPDES Permitted Facilities Potentially Contributing E. coli to the Upper Musselshell River

Permit Number	Permitee	Permitted Activity	Receiving Water
MT0020354	City of Harlowton	Sewerage Systems	Musselshell River
MTG010150	Duncan Ranch Colony	Concentrated Animal Feeding Operations	Musselshell River
MTG010242	Springwater Colony	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary
MTG010244	Martinsdale Colony Inc.	Concentrated Animal Feeding Operation	Musselshell River via unnamed tributary

The City of Harlowton is authorized to discharge treated domestic wastewater under MPDES permit number MT0020354. The wastewater treatment plant (WWTP) treats wastewater by means of three aerated lagoons and disinfection with chlorine prior to discharge to the Musselshell River. The discharge from the WWTP is continuous and is directly to the Musselshell River via one outfall (outfall 001). The WWTP has a permitted effluent limit not permitted to exceed 126 CFU/100 mL from April 1, through October 1, and 630 CFU/100 mL from November 1 –March 31. The WWTP discharges wastewater at an average of about 0.22 million gallons per day (mgd). DEQ's permit files show multiple violations of effluent exceedances of *E. coli*, biological oxygen demand (BOD), total suspended solids (TSS), total residual chlorine (TRC) and pH. This TMDL will develop a wasteload allocation (WLA) to the Harlowton WWTP, which is discussed in detail in **Section 5.8.3**.

There are three concentrated animal feeding operations (CAFO) permitted sites in the Upper Musselshell watershed (**Table 5-18**). Each of these sites maintains a general MPDES permit. Under the stipulations of these permits, these site are prohibited from continually discharging wastewater and associated pollutants to state waters, are required to contain all wastewater and stormwater, and use general practices to reduce pollutants in stormwater discharges. The general permit does not include specific load limits for *E.coli*. According to the general permit, these facilities are required to maintain best management practices (BMPs) to ensure there is minimal contact between runoff, sediment, and pollutants to minimize any potential stormwater pollution. The permittees are only required to collect water quality data in the event of a discharge, or during a 24-hour, 25-year rain event. None of the CAFOs listed in **Table 5-18** have collected effluent quality data. As such, there is no information available as to the quality or quantity of a potential discharge. Due to the infrequent discharges from facilities of this nature, there is relatively low potential for *E. coli* loading. This TMDL will develop a composite wasteload allocation (COMP WLA) to the CAFOs in this watershed. Given the low potential for *E.coli* loading from these CAFOs, the COMP WLA will be set to zero. The WLA is discussed in detail in **Section 5.8.3**.

The Upper Musselshell River was sampled 19 times at three different locations between 7/13/2015 and 7/28/2016. *E. coli* water quality exceedances occurred at each of the monitoring location between 7/14/2015 and 7/21/2015. In general, the highest concentration occurred higher upstream in the watershed. Monitoring site M24MUSSR10 consistently showed the highest concentrations and M24MUSSR09 consistently had the lowest *E. coli* concentrations. In all instances, flows were above average when samples exceeded the water quality standard. No data was collected in the North Fork of the Musselshell or the American Fork in 2015, which makes it difficult to include these waterbodies (and their associated sources) as potential upstream sources. The general trend for data from both 2015 and 2016 indicate a decreasing concentration in the downstream direction, with the highest concentrations being recorded at M24MUSSR10. Given that highest concentrations of *E. coli* were found higher in the watershed and the lack of identifiable upstream sources, it is likely that *E. coli* loading is originating from diffuse nonpoint sources higher upstream in the watershed. The nonpoint sources identified above are likely the sources causing *E. coli* exceedances. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for the Upper Musselshell River are discussed in detail in **Section 5.8.3**.

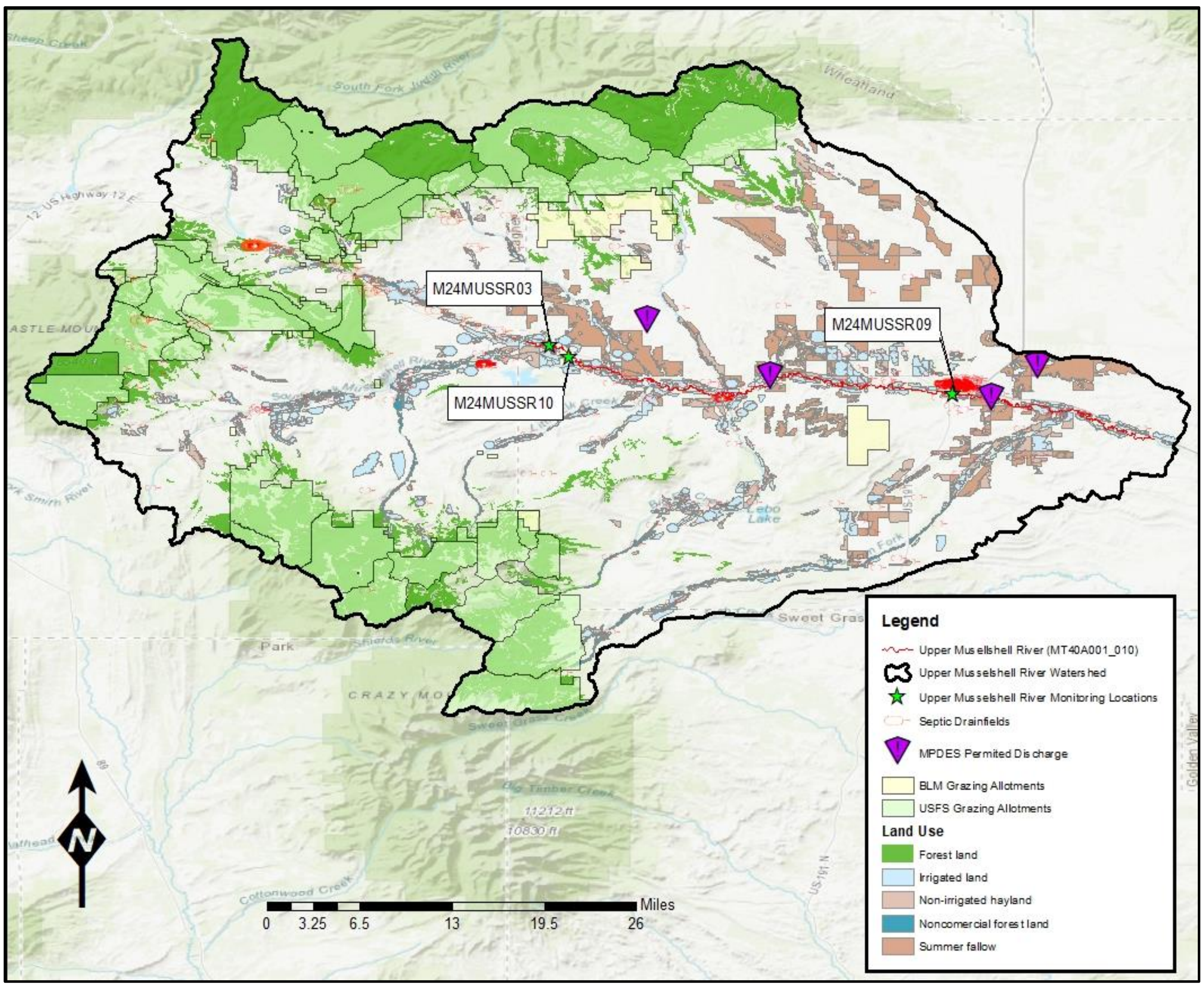

Figure 5-5. Water Quality Monitoring Sites and E. coli Sources in the Upper Musselshell Watershed

5.6.5 Fish Creek Source Assessment

E. coli inputs to Fish Creek consist of point and nonpoint sources. The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. The point sources of *E. coli* in the watershed include contributions from agricultural point sources.

Fish Creek is located in the upper 1/3 of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 3% irrigated, 17% non-irrigated hay land, 61% summer fallow, and 19% forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the Fish Creek watershed. Grazing land use in Fish Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-6**). The BLM has approximately 14,400 acres of land in federally managed grazing allotments, and there are no USFS grazing allotments in this watershed. Cropland in the Fish Creek watershed is widespread and consists primarily of irrigated and dryland hay and pasture land (grass/pasture, alfalfa and other hay), and to a limited degree, dryland small grains production (specifically wheat and barley) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the Fish Creek watershed, they are few in number and fairly well dispersed. As such, they are not considered significant sources of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

There is one CAFO permitted in Fish Creek. Golden Valley Colony maintains a general MPDES permit (MTG010156). As mentioned in the previous section, CAFOs are required to contain all process wastewater and stormwater and use general practices to reduce pollutants in stormwater discharges. CAFOs are also required to maintain BMPs to ensure that there is minimal contact between runoff, sediment, and other pollutants to minimize any potential stormwater pollution. The permittee is only required to collect water quality data in the event of a discharge, or during a 24-hour, 25-year rain event. As such, there is no information available as to the quality or quantity of a potential discharge. Given the infrequent discharges from facilities of this nature, there is relatively low potential for *E. coli* loading. The WLA developed for this CAFO is discussed in detail in **Section 5.8.4**.

Fish Creek was sampled four times at the same location on June 26 and 28, and again on September 27 and 29 of 2016. As there was only one monitoring location it is difficult to distinguish those locations and sources in the watershed that might be contributing sources of *E. coli*. That being said, the sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human caused. Specific load allocations for Fish Creek are discussed in detail in **Section 5.8.4**.

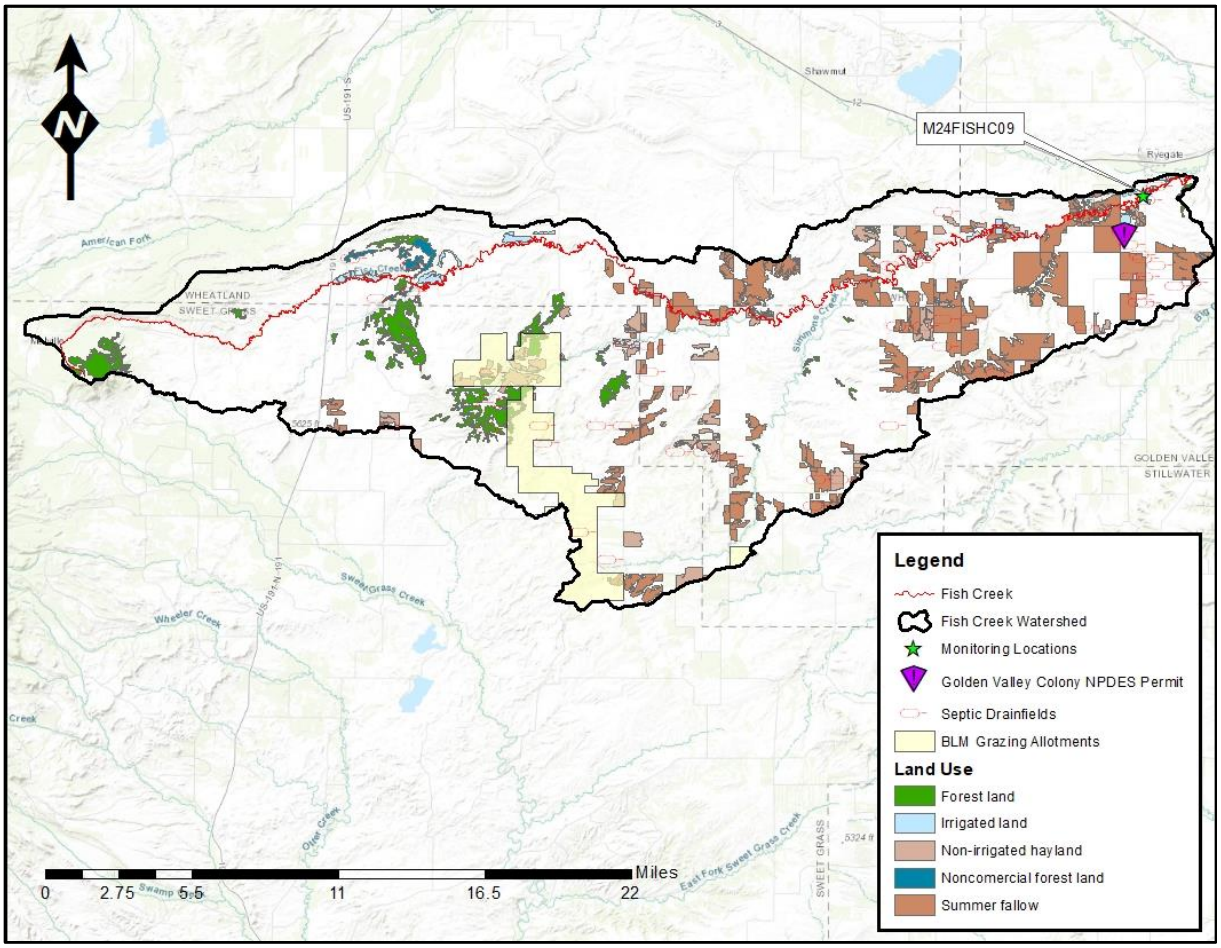

Figure 5-6. Water Quality Monitoring Site and *E. coli* Sources in the Fish Creek Watershed

5.6.6 Big Coulee Creek Source Assessment

Nonpoint sources of *E. coli* inputs to Big Coulee Creek are similar to those in the other portion of the Musselshell River. The primary sources of *E. coli* are limited to those that occur naturally and those associated with agricultural sources (nonpoint). There are no permitted point sources in Big Coulee Creek.

Big Coulee Creek is located in the middle of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 73% summer fallow, 18% non-irrigated hay land, 8% forested, and about 1% irrigated. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the Big Coulee Creek watershed. Grazing land use in Big Coulee Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-7**). The BLM has approximately 15,400 acres of land in federally managed grazing allotments, there are no USFS grazing allotments in this watershed. Cropland in the Big Coulee Creek watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass/pasture, alfalfa and other hay) and to a limited degree dryland small grains production (specifically wheat and barley) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the Big Coulee Creek watershed, they are few in number and fairly well dispersed. As such, they are not considered a significant source of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

Big Coulee Creek was sampled four times at the same location (monitoring site M24BIGCC01) on June 26 and 28, and again on September 27 and 29, of 2016. As there was only one monitoring location, it is difficult to distinguish those locations and sources in the watershed that might be contributing sources of *E. coli*. That being said, the sources identified above are the likely causes of *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for Big Coulee Creek are discussed in detail in **Section 5.8.5**.

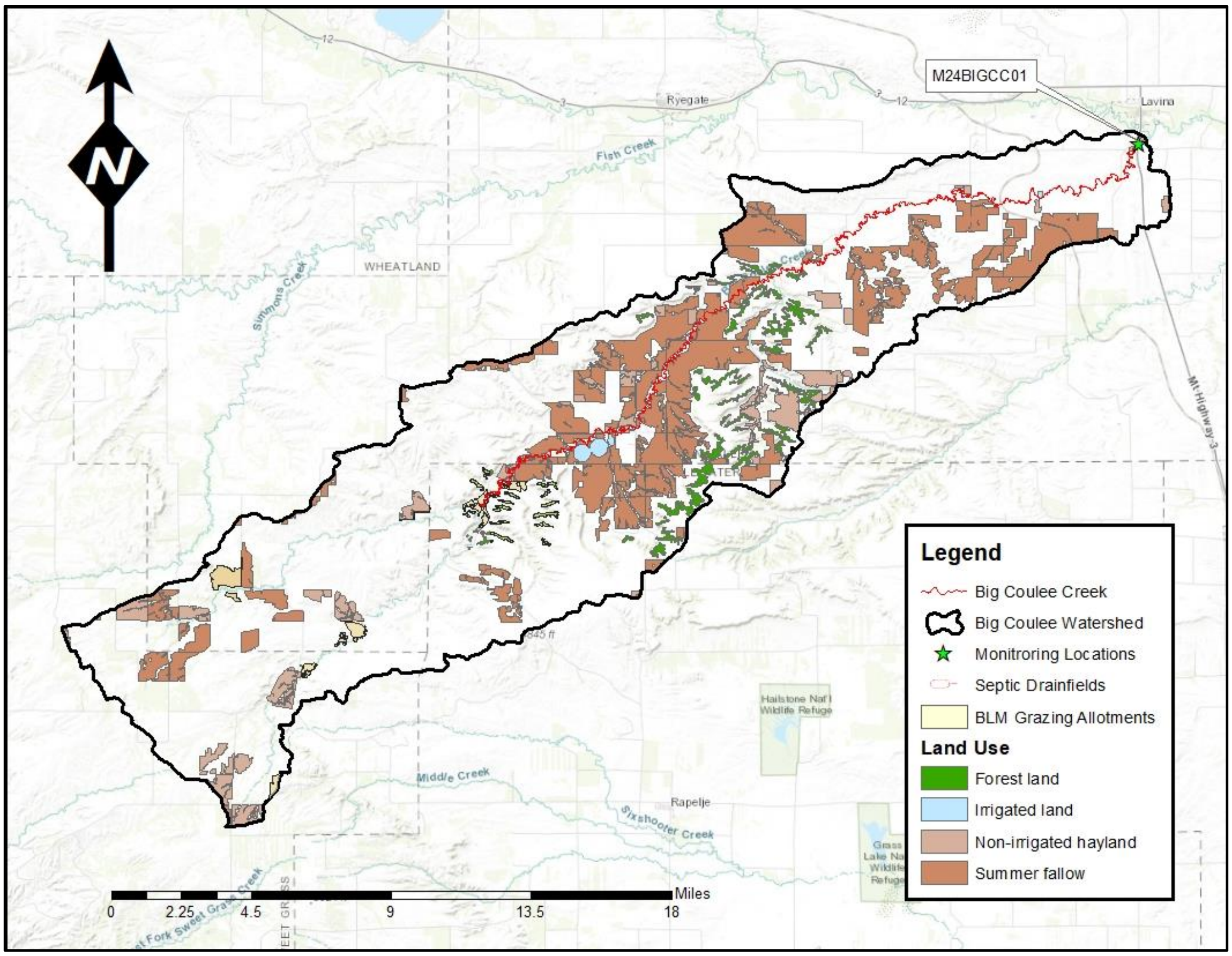

Figure 5-7. Water Quality Monitoring Site and E. coli Sources in the Big Coulee Creek Watershed

5.6.7 Middle Musselshell River MT40A001_020 Source Assessment

The Middle Musselshell River includes tributaries from the middle portion of the Musselshell watershed and the Upper Musselshell River. The impaired section of the Middle Musselshell River (assessment unit MT40A001_020) occurs from the Deadmans Basin supply canal to the hydrologic unit (HUC 10040201) boundary near Roundup. *E. coli* inputs to the Middle Musselshell River consist of point and nonpoint sources as well as loads form other impaired waters including the Upper Musselshell River, Big Coulee

Creek, and Fish Creek (**Figure 5-8**). The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. The point sources of *E. coli* in the watershed include contributions form municipal wastewater sources.

Land use in the watershed is approximately 7% irrigated land, 7% non-irrigated hay land and 31% summer fallow. Approximately 55% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the Middle Musselshell River watershed. Grazing land use in the Middle Musselshell is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-8**). The USFS has approximately 231,500 acres of land in federally managed grazing allotments and the BLM has approximately 280,400 acres. Cropland in the Middle Musselshell watershed is widespread and consists primarily of irrigated and dryland hay and pasture land (grass/pasture, alfalfa and other hay), and to a limited degree, dryland small grains production (U.S. Department of Agriculture, National Agricultural Statistics Service 2019).

Septic systems in the Middle Musselshell River watershed are not prolific. That being said, the Middle Musselshell River has the highest septic systems density in the Musselshell watershed. The highest number of septic systems is in and around the population centers (Ryegate and Lavina). These areas are also served by a municipal wastewater treatment plant. As discussed earlier, only failing septic systems in close proximity to a surface water can be considered a potential sources of *E. coli* pollution. In this segment of the Musselshell River only about 15 of the approximately 2000 identified septic systems are within 100 feet of the river. One hundred feet being a conservative estimate of distance an effluent stream could (without infiltrating into surface soils or becoming diluted by other means) be expected to persist and reach the Musselshell River. A somewhat conservative rate of failure for septic systems is from 10-20% (USEPA, 2002). Therefore, it could be assumed that of the 15 septic systems within 100 feet, only 2 or 3 of these systems might be failing and have the capability of contributing an *E. coli* load. That being said, the likely contributing load from failing septic systems is low.

The Middle Musselshell River, Big Coulee Creek, and Fish Creek are *E. coli* impaired tributaries that have the potential to contribute a *E.coli* load to the Middle Musselshell River. As such, a loading evaluation was performed for these tributaries. *E. coli* loads were calculated from recent (2015 and 2016) DEQ-collected water quality data using the measured concentrations for *E. coli* and a representative flow. As flow data were not collect during *E. coli* sampling efforts, flow data from nutrient sampling was used to calculate loads. Flow data were not collected on the same day as *E. coli* samples; however, they were collected within a few days of *E. coli* data, providing a representative flow (**Appendix A**). Loads for the Upper Musselshell River, Big Coulee Creek, and Fish Creek are calculated as the product of *E. coli*, flow, and a conversion factor. **Table 5-19** shows the tributary *E. coli* loading to the Middle Musselshell River.

Table 5-19. Tributary *E. coli* loading to the Middle Musselshell River

Contributing Waterbody	*E. coli* Sample Collection Date	Sample Station ID	*E. coli* (cfu/100 mL)	Flow Data Collection Date	Flow (cfs)	Conversion Factor	*E. coli* Load (Mcfu/day)
Upper Musselshell	6868	M24MUSSR10	62	7/20/15	45.4	2.44×10^7	6868
	45485		410.6				45485
	54103		488.4				54103
	10911		98.5				10911

Table 5-19. Tributary *E. coli* loading to the Middle Musselshell River

Contributing Waterbody	*E. coli* Sample Collection Date	Sample Station ID	*E. coli* (cfu/100 mL)	Flow Data Collection Date	Flow (cfs)	Conversion Factor	*E. coli* Load (Mcfu/day)
	20494		185				20494
	4872	M24MUSSR03	76.8	7/13/15	26		4872
	8222		129.6				8222
	8082		127.4				8082
	19761		238.2	7/23/15	34		19761
	32130		387.3				32130
	10779	M24MUSSR09	46.5	7/13/15	95		10779
	22786		98.3				22786
	52248		225.4				52248
	10663		46				10663
	71302		307.6				71302
	1444	M24MUSSR09	7.4	7/15/16	80		1444
	3026		15.5				3026
	1333	M24MUSSR10	43.7	7/26/16	12.5		1333
	2925		95.9				2925
Average Load							**20391**
Big Coulee Creek	317	M24FISHC09	1299.7	7/23/16	0.1	2.44×10^7	317
	303		248.1	8/3/16	0.5		303
	1156		488.4	9/19/16	0.97		1156
	1788		488.4	9/27/16	1.5		1788
Average Load							**891**
Fish Creek	8	M24BIGCC01	13	7/23/16	0.25	2.44×10^7	8
	3449		1413.6	8/2/16	1		3449
	6751		461.1	9/27/16	6		6751
	2049		1119.9	10/1/16	0.75		2049
Average Load							**3064**

The City of Ryegate is authorized to discharge treated domestic wastewater under MPDES permit number MT0020451. The WWTP treats wastewater by means of a two-cell facultative lagoon. This facility does not disinfect the wastewater prior to discharge to the Musselshell River. There was no reported discharge from this facility from 2015-2020. The 2009 DEQ MPDES fact sheet that was developed for this permit for this facility indicated that it has never reported any discharge. The permittee is authorized to discharge to an abandoned oxbow of the Musselshell River via one outfall (Outfall 001). The WWTP has a permitted effluent limit not to exceed 126 CFU/100 mL from April 1 through October 1, and 630 CFU/100 mL from November 1 to March 31. The WWTP has a design capacity of 0.05 million gallons per day (mgd). Due to the potential for this facility to contribute a *E.coli* load to the Middle Musselshell River, this TMDL will develop a wasteload allocation (WLA) to the Ryegate WWTP. The WLA is discussed in detail in **Section 5.8.6**.

The Town of Lavina is authorized to discharge treated domestic wastewater under MPDES general permit number MTG580013. The WWTP treats wastewater by means of aerated lagoons and does not use disinfection prior to discharge to the Middle Musselshell River. The discharge from the WWTP is intermittent (batch) and is direct to the Middle Musselshell via one outfall (Outfall 001). The WWTP has an average summer design flow of 0.014 million gallons per day (mgd) or 0.026 cfs. The WWTP has a permitted effluent limit not permitted to exceed 126 CFU/100 mL from April 1 through October 1 and 630 CFU/100 mL from November 1 through March 31. The WWTP discharges wastewater during the winter months, when the winter (November-March) *E. coli* standards apply. DEQ's permit files show this facility incurred multiple effluent quality exceedances. This includes BOD and pH exceedances in 2012 and 2013 as well as BOD and *E. coli* exceedances in 2019. This TMDL will develop a wasteload allocation (WLA) to the Town of Lavina WWTP. The WLA is discussed in detail in **Section 5.8.6**.

There are several MPDES permits that are located in the watershed that are not direct dischargers to the Middle Musselshell River and are not likely sources of *E. coli* loading. These include two concentrated animal feeding operations (CAFOs). The Swanz Valley Ranch CAFO (MTG010231) discharges to Little Careless Creek (which has not been assessed for *E.coli* impairment), and the Golden Valley Ranch CAFO (MTG010156) which discharges to Fish Creek and is discussed in **Section 5.6.5**. The Swanz Valley Ranch has had significant non-compliance issues for each quarter for the last 4 years. *E. coli* samples collected downstream of Swanz Valley Ranch on Carless Creek (station BKK034) on 7/26/16 and 7/28/16 reported 17.1 and 48.1 cfu/100mL respectively. Two additional samples were collected at station BKK034 on 9/27/16 and 9/29/16 and reported *E. coli* concentrations of 38.8 and 151.5 cfu/100mL respectively. While one sample does exceed the water quality standard of 126 cfu/100mL, there is insufficient data to make an impairment determination. The distance from the Swanz Valley Ranch to the Middle Musselshell River is approximately 32 miles. Over this distance, there are fluctuating environmental conditions that hamper the survivability of *E. coli*. This combined with limited water quality data in Little Carless and Careless Creeks, it is difficult to attribute impacts from this facility on the Middle Musselshell River (MT40A001_020).

The Middle Musselshell River was sampled 19 times at three different locations between 7/13/2015 and 7/28/2016. *E. coli* water quality exceedances occurred at each of the monitoring locations. The general trend for data from both 2015 and 2016 indicate decreasing *E. coli* concentrations in the downstream direction, with the highest concentrations being recorded at sampling site M24MUSSR10 and lowest being recorded at M24MUSSR09. In all instances, flows were above average when samples exceeded the water quality standard. Given the lack of identifiable upstream sources, it is likely that *E. coli* loading is originating from diffuse nonpoint sources higher upstream in the watershed. No data was collected in the North Fork of the Musselshell or the American Fork in 2015, which makes it difficult to include these waterbodies (and their associated sources) as potential upstream sources. The sources identified above are likely the sources causing *E. coli* exceedances. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for the Middle Musselshell River are discussed in detail in **Section 5.8.6**.

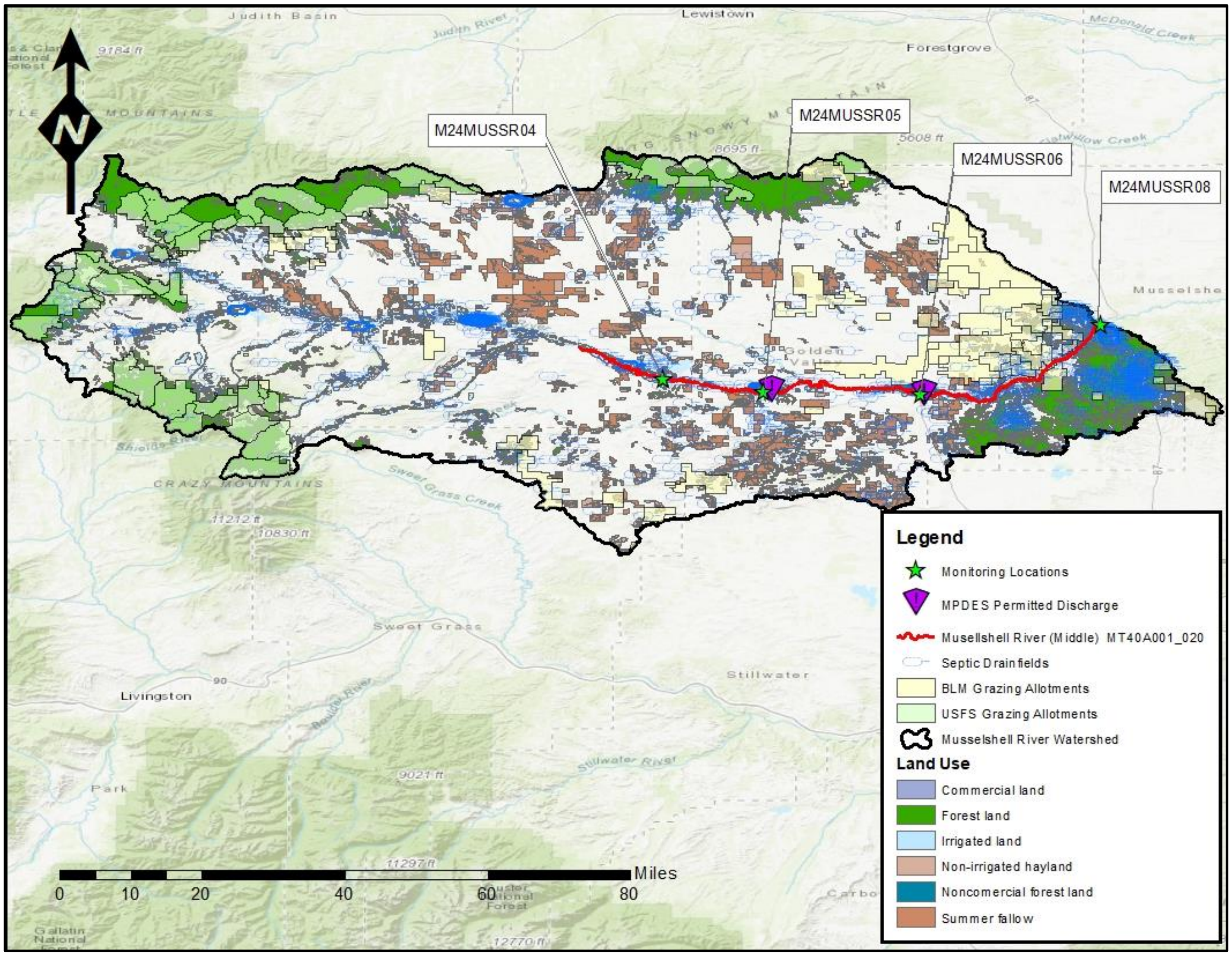

Figure 5-8. Water Quality Monitoring Sites and *E. coli* Sources in the Middle and Upper Musselshell Watersheds

5.6.8 Half Breed Creek Source Assessment

E. coli inputs to Half Breed Creek consist of nonpoint sources. The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. There are point sources in the watershed that include several MPDES permitted dischargers. These are comprised of an individual MPDES permit (MT0028983) and two general storm water construction permits (MTR000499 and MTR106575), all issued to Signal Peak Energy. Permit MT0028983 has eight outfalls, consisting entirely of stormwater runoff from the Bull Mountain coal mining facility. Permits MTR000499 and MTR106575 are stormwater industrial and stormwater construction permits for the Bull Mountain Mine. Discharges covered under all of these permits are expected to contain pollutants associated with coal mining. *E. coli* is not an expected pollutant from these discharges, as such these point sources will not receive a wasteload allocation (WLA) in the TMDL.

Half Breed Creek is in the middle of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 10% commercial land use (Bull Mountain Mine), 2% summer fallow, 2% non-irrigated hay land and about 1% irrigated land. Approximately 85% of the watershed is forested. Throughout Montana many of these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the Half Breed Creek watershed. Grazing land use in Half Breed Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-9**). The BLM has approximately 15,800 acres of land in federally managed grazing allotments; there are no USFS grazing allotments in this watershed. Cropland in the Half Breed Creek watershed is fairly limited and consists primarily of irrigated and dryland hay and pastureland that is made up of alfalfa and other hay (U.S. Department of Agriculture, National Agricultural Statistics Service 2019).

As discussed in **Section 5.6.1.2**, septic systems that are properly maintained do not pose a threat to water quality. Typically, those systems that are not maintained or are in a state of disrepair have the greatest potential to contribute *E. coli* pollution. There are no available records of septic systems that are failing in the Half Breed watershed. To consider a failing septic system as a source, it would need to produce an effluent stream capable of reaching a waterbody in order to provide a significant *E. coli* load. For this to occur, a septic system would need to be in close proximity to the waterbody to receive overland flow and contribute a load. Only 20 of the approximately 250 identified septic systems are within 100 feet of Half Breed Creek, one hundred feet being a conservative estimate of distance an effluent stream could (without infiltrating into surface soils or becoming diluted by other means) be expected to persist and reach Half Breed Creek. A somewhat conservative rate of failure for septic systems is from 10-20% (USEPA, 2002). Therefore, it could be assumed that of the 20 septic systems within 100 feet, only 3 or 4 of these systems might be failing and have the capability of contributing an *E. coli* load. That being said, the likely contributing load from failing septic systems is low. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

Half Breed Creek was sampled four times at two locations (M24HLFBC02 and M24HLFBC03). M24HLFBC02 was sampled once on 7/26/2016 and M24HLFBC03 was sampled on 7/28, 9/27 and 9/29 of 2016. Sample exceedances occurred at both M24HLFBC02 and M24HLFBC03 during late July sampling efforts, when flows were higher. The highest concentrations were recorded at M24HLFBC02 (closest to the mouth) on 7/26/2016. Since the highest concentrations occurred when stream flows were higher, it is likely that exceedances are linked to stream flows. Given that the highest concentrations were recorded closest to the mouth (M24HLFBC02), it is difficult to identify particular sources in the watershed. It is most likely that the nonpoint sources identified above are the sources causing *E. coli* exceedances. Therefore, *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for Half Breed Creek are discussed in detail in **Section 5.8.7**.

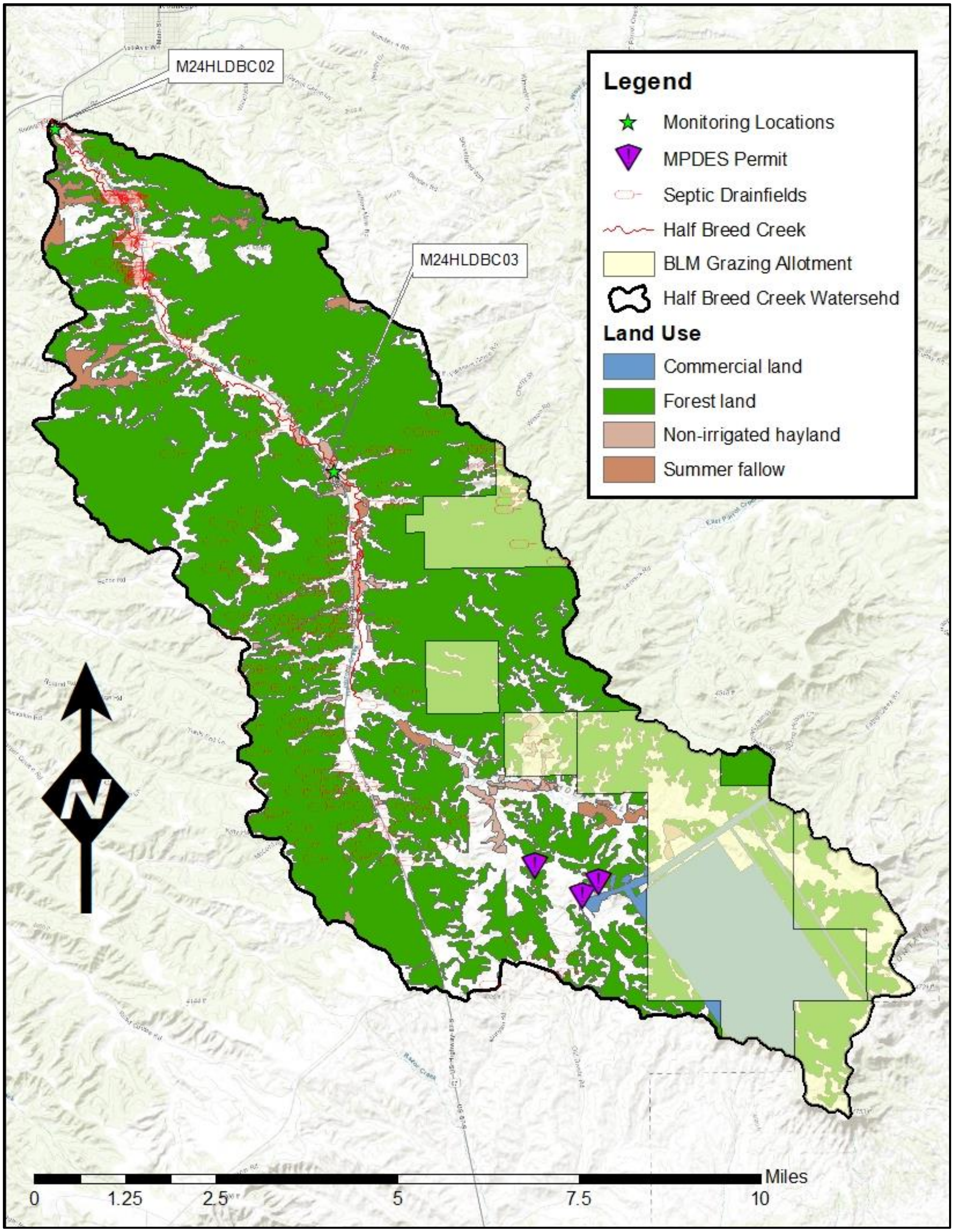

Figure 5-9. Water Quality Monitoring Sites and *E. coli* Sources in the Half Breed Creek Watershed

5.6.9 South Forth McDonald Creek Source Assessment

E. coli inputs to the South Fork of McDonald Creek consist of point and nonpoint sources. The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. The point source of *E. coli* in the watershed includes contributions from one MPDES permitted discharger. The MPDES permit (MT0030309) is issued to the Town of Grass Range to discharge treated municipal wastewater to the South Fork of McDonald Creek.

South Fork McDonald Creek is located in the lower third of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 6.5% summer fallow, 31% non-irrigated hay land and about 1.5% irrigated land. Approximately 61% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the SFMC watershed. Grazing land use in SFMC is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-10**). The BLM has approximately 11,070 acres of land in federally managed grazing allotments; there are no USFS grazing allotments in this watershed. Cropland in the SFMC watershed is fairly limited and consists primarily of irrigated and dryland hay and pastureland that is made up of alfalfa and other hay (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the SFMC watershed, they are few in number and fairly well dispersed. As such, they are not considered a significant source of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

The Town of Grass Grange is authorized to discharge treated domestic wastewater under individual MPDES permit MT0030309. The WWTP treats wastewater by means of two facultative lagoons and does not use disinfection prior to discharge to the South Fork of McDonald Creek. Discharge is to an unnamed perennial stream via one outfall (outfall 001), which flows directly to the South Fork of McDonald Creek. The discharge from the WWTP is a controlled release. During the period of record (POR) of September 2011 to September 2020, the facility had one discharge event in February/March of 2012. During this discharge the WWTP reported weekly average concentrations of *E. coli* of 235.0 and 3,700 cfu/100mL, and a discharge of wastewater at 0.0014 million gallons per day (mgd). As a result of the 2012 discharge event Grass Range WWTP had nine permit violations involving non-receipt of data, improper/incorrect reporting, improper operation and maintenance, failure to conduct analysis, and failure to maintain records. The WWTP has a permitted effluent limit not to exceed 126 CFU/100 mL from April 1 through October 1 and 630 CFU/100 mL from November 1 through March 31. There were no documented numeric water quality exceedances during the discharge. This TMDL will develop a wasteload allocation (WLA) to the Town of Grass Range WWTP. The WLA is discussed in detail in **Section 5.8.8**.

South Fork McDonald Creek was sampled two times at two locations (M2MCSF01 and M26MCSF02) on 9/28/2016. Given the limited amount of data (spatial and temporal), it is difficult to make any determinations as to the general location or origin of potential *E. coli* sources in the watershed. That being said, the nonpoint sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for the SFMC are discussed in detail in **Section 5.8.8**.

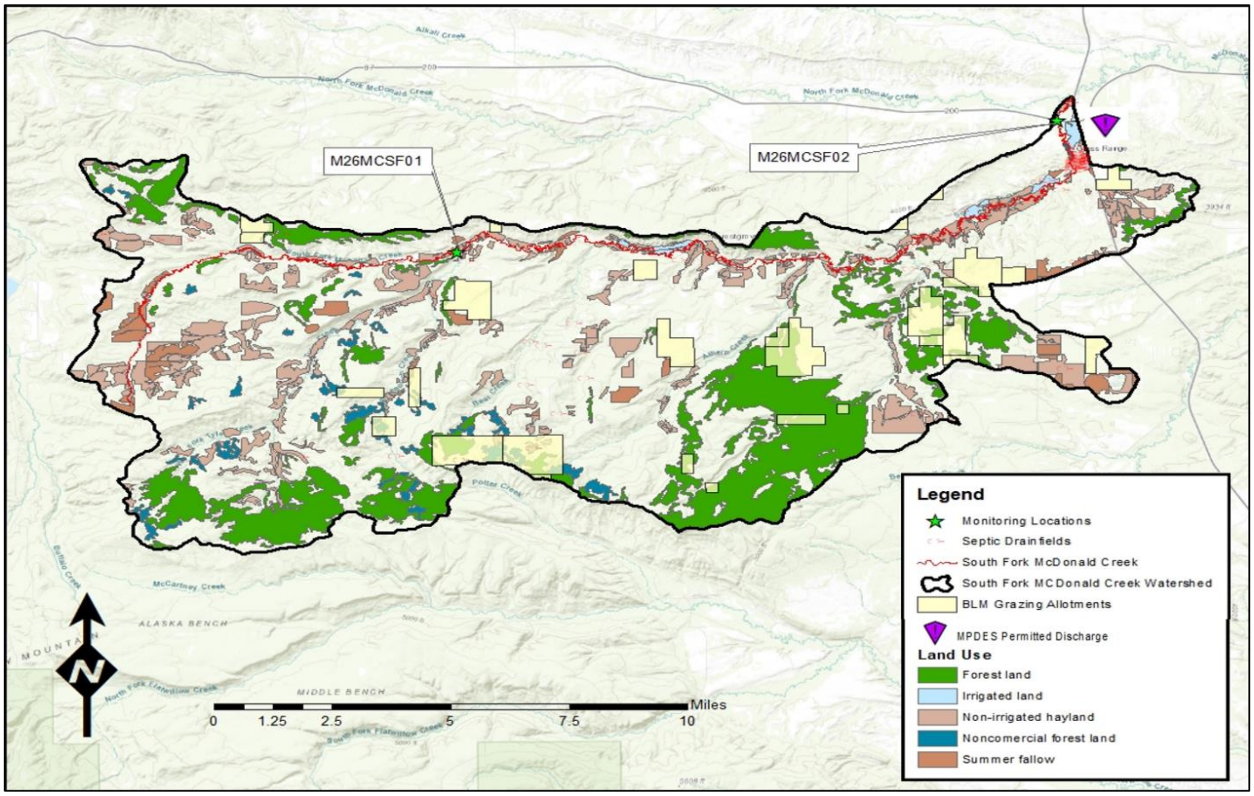

Figure 5-10. Water Quality Monitoring Sites and *E. coli* Sources in the South Fork McDonald Creek Watershed

5.6.10 McDonald Creek Source Assessment

E. coli inputs to McDonald Creek consist of point and nonpoint sources. The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. The point sources of *E. coli* in the watershed include contributions from one MPDES permitted discharger. The MPDES permit (MTG580041) is issued to the City of Winnett to discharge treated municipal wastewater to McDonald Creek.

McDonald Creek is located in the lower third of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 6.5% summer fallow, 31% non-irrigated hay land and about 1.5% irrigated land. Approximately 61% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the McDonald Creek watershed. Grazing land use in McDonald Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-11**). The BLM has approximately 11,070 acres of land in federally managed grazing allotments; there are no USFS grazing allotments in this watershed. Cropland in the McDonald Creek watershed consists primarily of irrigated and dryland hay and pastureland that is made up of alfalfa and other hay (U.S. Department of Agriculture, National Agricultural Statistics Service 2019).

As with the North Fork of the Musselshell (**Section 5.6.2**) and Half Breed Creek (**Section 5.6.7**), there are a number of septic systems in the McDonald Creek watershed that have the potential to contribute *E. coli*. There are no available records of septic systems that are failing in the McDonald Creek watershed. Only approximately 10 of the almost 130 identified septic systems are within 100 feet of McDonald

Creek. One hundred feet being a conservative estimate of distance an effluent stream could (without infiltrating into surface soils or becoming diluted by other means) be expected to persist and reach McDonald Creek. Using the conservative estimate of 10-20% septic system failure rate (USEPA, 2002), it could be assumed that of the 10 septic systems within 100 feet, only 1 or 2 of these systems might have the capability of contributing an *E. coli* load. That being said, the likely contributing load from failing septic systems is low. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

The Town of Winnett is authorized to discharge treated domestic wastewater under MPDES general permit number MTG580041. The WWTP treats wastewater by means of aerated lagoons and does not use disinfection prior to discharge to McDonald Creek. The discharge form the WWTP is intermittent (batch) and is directly to McDonald Creek via one outfall (outfall 001). From 2013 to 2019, the WWTP reported all discharges of wastewater at 0.0183 million gallons per day (mgd). The WWTP has a permitted effluent limit not to exceed 126 CFU/100 mL from April 1 through October 1 and 630 CFU/100 mL from November 1 through March 31. The WWTP discharges wastewater primarily during the winter months, however they do discharge at times when either the summer (April-October) or winter (November-March) *E. coli* standards apply. DEQ's permit files show multiple effluent quality exceedances of *E. coli*, total nitrogen (TN), total suspended solids (TSS), and pH from 2013 to 2020. This TMDL will develop a wasteload allocation (WLA) to the Town of Winnett WWTP. The WLA is discussed in detail in **Section 5.8.9**.

McDonald Creek was sampled four times at three locations (M26MCDLC01, M26MCDLC09, and M26MCDLC06). The upstream most sampling location (M26MCDLC01) was sampled twice on 7/27/2016 and 9/28/2016. The next downstream sampling location (M26MCDLC09) was sampled once on 9/28/2016. The lower most sampling location (M26MCDLC06) was sampled once on 9/28/2016. Sample exceedances occurred at both M26MCDLC01 and M26MCDLC09 during both the July and September 2016 sampling efforts. The highest concentration being seen at M26MCDLC09 on 9/28/2016.

Given that the highest concentration occurred at M26MCDLC09 (lower third of the watershed) and not at the upper most and lower most sampling locations, it is likely that *E. coli* loading is occurring as a result of sources located in the middle portion of the watershed. There are no point sources in this portion of the watershed and M26MCDLC09 is upstream of the potential sources associated with the Town of Winnett. That being said, the nonpoint sources identified above are the likely sources of *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for McDonald Creek are discussed in detail in **Section 5.8.9**.

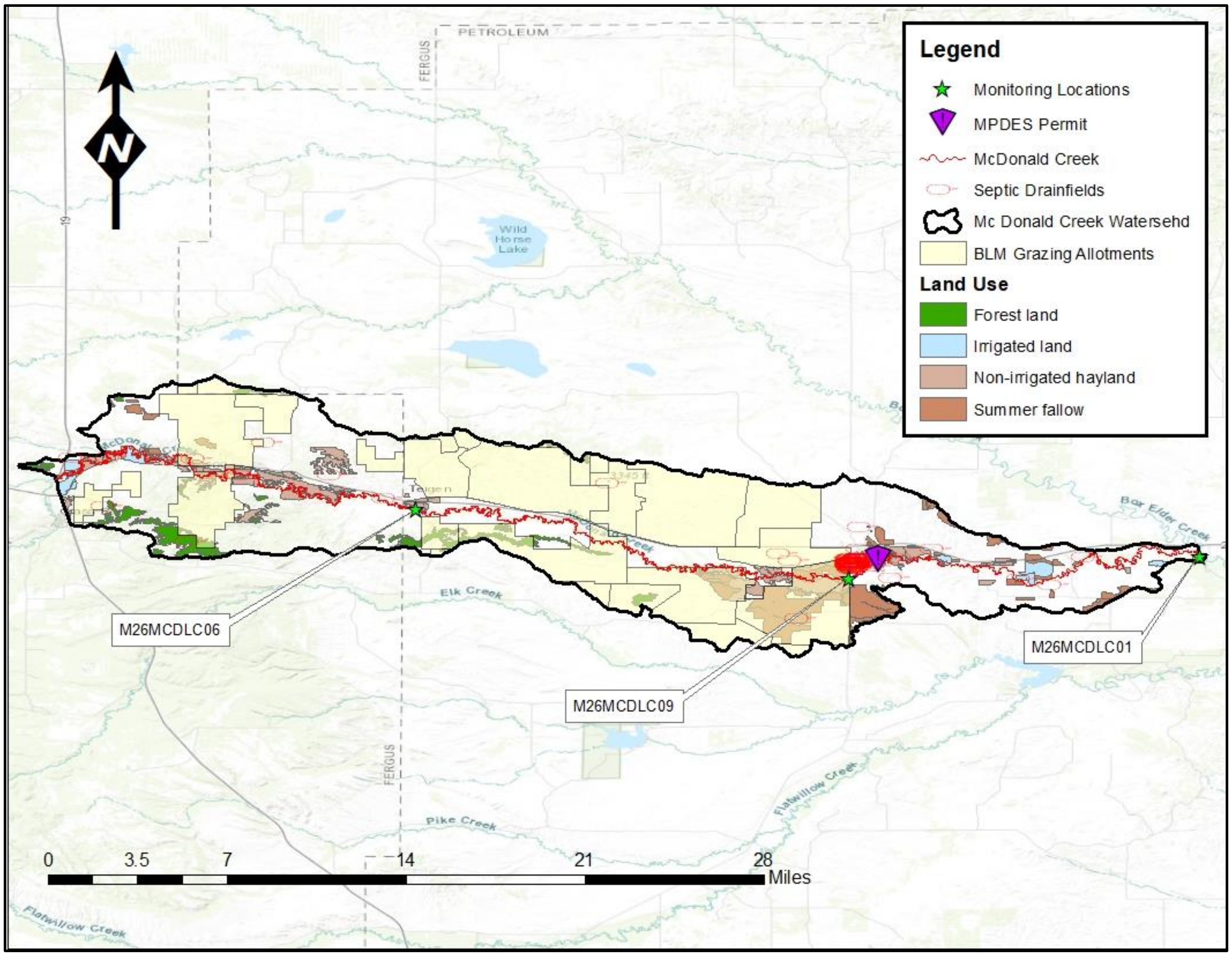

Figure 5-11. Water Quality Monitoring Sites and *E. coli* Sources in the McDonald Creek Watershed

5.6.11 Fords Creek Source Assessment

Nonpoint sources of *E. coli* inputs to Fords Creek are similar to those in the other portion of the Musselshell River. The primary sources of *E. coli* are limited to those that occur naturally and those associated with agricultural sources. There are no permitted sources in the Fords Creek watershed.

Fords Creek is located in the lower portion of the Musselshell watershed (**Figure 5-1**). Land use in the watershed is approximately 22% summer fallow, 22% non-irrigated hay land, and about 1% irrigated. About 55% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in the Fords Creek watershed. Grazing land use in Fords Creek is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-12**). The BLM has approximately 99,800 acres of land in federally managed grazing allotments; there are no USFS grazing allotments in this watershed. Cropland in the Fords Creek watershed is widespread and consists primarily of irrigated and dryland hay and pastureland (grass/pasture, alfalfa and other hay) and to a limited degree dryland small grains production (specifically wheat and barley) (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the Fords Creek watershed, they are few in number and fairly well dispersed. As such, they are not considered a significant source of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

Fords Creek was sampled one time on 9/28/2016 at sample site M26FORDC01. As there was only one sample and one monitoring location, it is difficult to distinguish those locations and sources in the watershed that might be contributing sources of *E. coli*. That being said, the sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for Fords Creek are discussed in detail in **Section 5.8.10**.

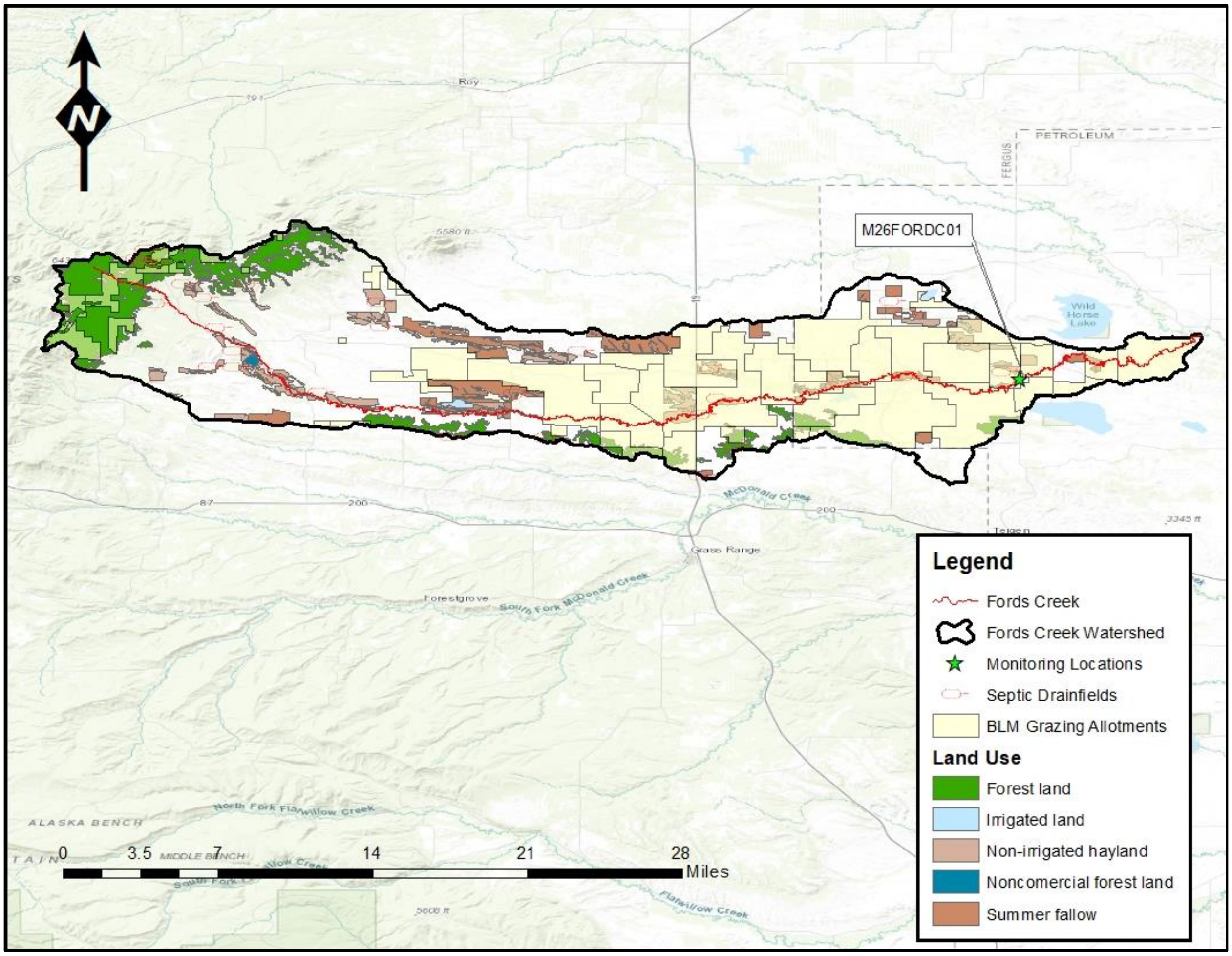

Figure 5-12. Water Quality Monitoring Site and *E. coli* Sources in the Fords Creek Watershed

5.6.12 Lower Musselshell River MT40C003_010 Source Assessment

E. coli inputs to the Lower Musselshell River (assessment unit MT40C003_010) consist of nonpoint sources. There are no MPDES point source discharges in the Lower Musselshell River watershed. The nonpoint sources of *E. coli* are those that occur naturally and those associated with agricultural sources. DEQ water quality monitoring efforts did not find exceedances of *E. coli* in tributaries of the Lower Musselshell River or the segment of the Musselshell River that is immediately upstream (MT40C001_010). Therefore, *E. coli* cumulative affects loading from these segments will not be assessed.

The lower Musselshell River is located in the downstream most portion of the Missouri River basin. This impaired section of the Lower Musselshell River (assessment unit MT40A003_010) is from the Highway 87 Bridge to the mouth (Fort Peck Reservoir).

The lower Musselshell River is the lowest river segment in the Musselshell basin. Land use in the watershed is approximately 30% summer fallow, 7% non-irrigated hay land, and about 3% irrigated. About 60% of the watershed is forested. Throughout Montana these land use types are commonly utilized for grazing, cattle production and the agricultural practices that support cattle operations. This is also the case in Lower Musselshell watershed. Grazing land use in this watershed is a mix of public land grazing allotments and privately-owned lands with grazing operations (**Figure 5-13**). The BLM has approximately 968,972 acres of land in federally managed grazing allotments; there are no USFS grazing allotments in this watershed. Cropland in the Lower Musselshell watershed is widespread and consists primarily of irrigated and dryland hay and pastureland such as grass/pasture, alfalfa and other hay (U.S. Department of Agriculture, National Agricultural Statistics Service 2019). While there are septic systems in the Lower Musselshell watershed, they are few in number and fairly well dispersed. As such, they are not considered a significant source of *E. coli* loading. Therefore, the most prolific sources of *E. coli* loading are agricultural nonpoint sources such as cattle grazing and land application of manure, etc.

The lower segment of the Musselshell River was sampled eight times at the same location (M28MUSSR01). Only one sample exceeded the *E. coli* standard on 7/27/2016. As there was only one monitoring location, it is difficult to distinguish those locations and sources in the watershed that might be contributing sources of *E. coli*. That being said, the sources identified above are the likely sources causing *E. coli* exceedances in the watershed. *E. coli* load allocations in the watershed are limited to those that are naturally occurring, and those that are human-caused. Specific load allocations for the Lower Musselshell River are discussed in detail in **Section 5.8.11**.

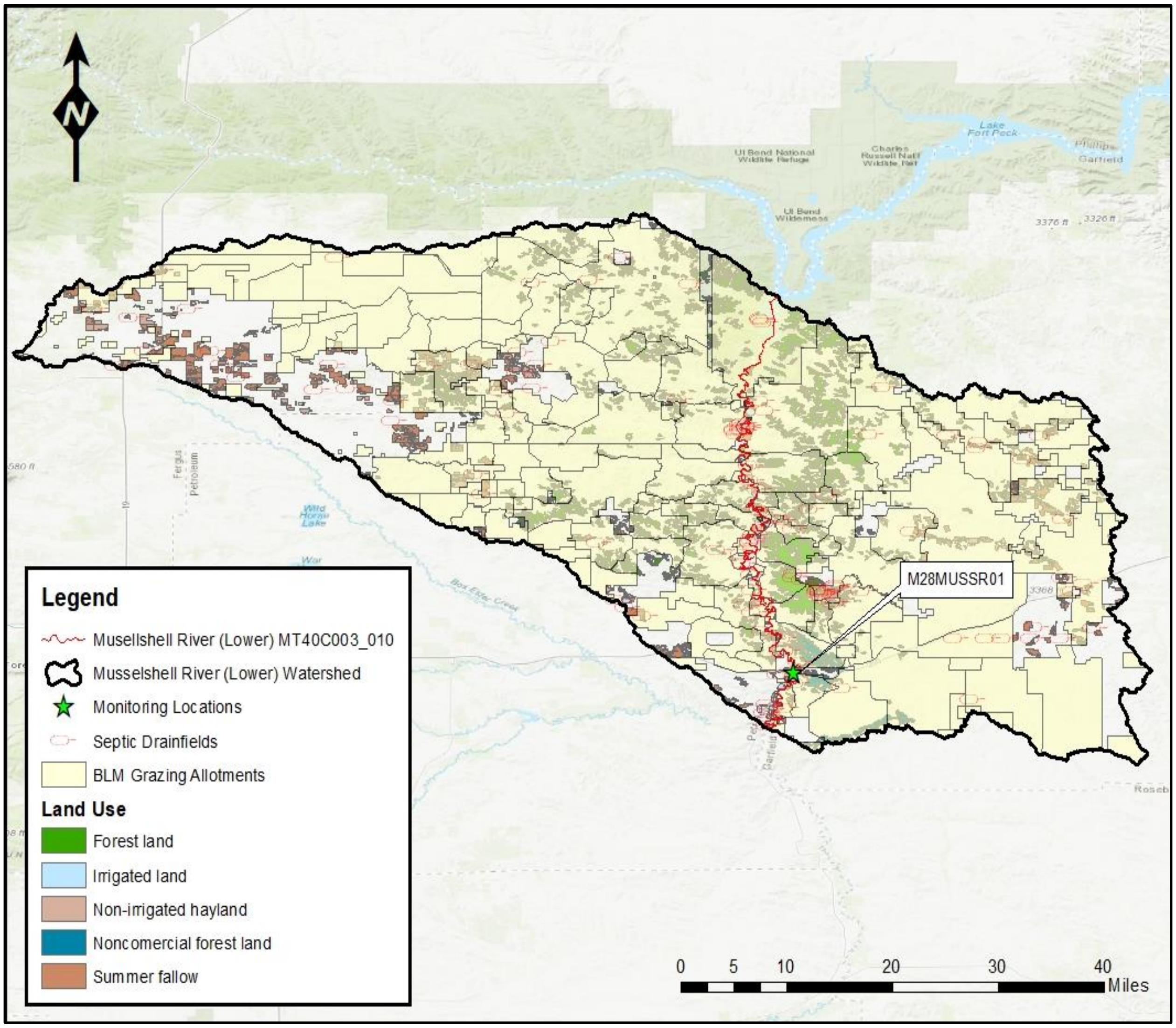

Figure 5-13. Water Quality Monitoring Site and *E. coli* Sources in the Lower Musselshell River Watershed

5.7 Approach to TMDL Allocations

As discussed in **Section 4.0**, the *E. coli* TMDL consists of the sum of all load allocations to individual sources and source categories (**Table 5-20**).

Because there are instances throughout the watershed where there are surface water point source discharges and nonpoint sources of *E. coli* there will be instances where Wasteload Allocations (WLAs) or Load Allocations (LAs) may be established. In those instances where there are no point sources, or there are point sources that are not expected to discharge *E. coli* no WLA will be developed and the *E. coli* TMDL is broken into a load allocation to natural background (*LA*) and a composite load allocation to all human-caused nonpoint sources ($COMP\ LA_H$) as seen in **Equation 5-2**.

Equation 5-2*: TMDL = LA_{NB} + COMP LA_H*

TMDL = Total maximum daily load

LA_{NB} = Load allocation to natural background sources (Mcfu/day)

COMP LA_H = Load allocation to human-caused nonpoint sources (Mcfu/day)

In those instances where there are point sources that have discharges containing E. coli, WLAs will be developed and the *E. coli* TMDL is broken into load allocations to natural background (LA_{NB},), wasteload allocations to the appropriate point sources (WLA) and a composite load allocation to all human-caused nonpoint sources (*COMP LA_H) as seen in* (**Equation 5-3**).

Equation 5-3*: TMDL = LA_{NB} + WLA + COMP LA_H*

TMDL = Total maximum daily load

LA_{NB} = Load allocation to natural background sources (Mcfu/day)

WLA = Wasteload Allocation to point sources (Mcfu/day)

COMP LA_H = Load allocation to human-caused nonpoint sources (Mcfu/day)

Under most circumstances, DEQ provides an implicit margin of safety (MOS) by using assumptions known to be conservative, and are discussed in depth in **Section 5.9**. Where an implicit MOS is applied, the MOS in the TMDL equation is equal to zero and not necessarily included in the equation.

Table 5-20. *E. coli* Source Categories and Descriptions for the Musselshell Watershed

Source Category	Source Descriptions
Natural Background	• Wild animal excrement
Nonpoint Sources (Diffuse sources)	• Agriculture (Manure applied or deposited) • Leaking septic and sewer systems • Domestic animal excrement • Broken sewer or domestic service lines
Point Sources (MPDES permitted dischargers)	• Municipal wastewater treatment systems • Concentrated animal feeding operations

5.7.1 Natural Background Allocation

Load allocations for natural background sources are based on the median of concentration values from sites in centrally located subbasins in the Musselshell watershed (**Table 5-15**). These sites were chosen to represent stream conditions in the Musselshell watershed where human activities may be present but do not negatively harm stream use. Natural background loads are calculated by multiplying the median reference (37 cfu/100 mL) concentration by the streamflow. The natural background load allocation is calculated as follows (**Equation 5-4**):

Equation 5-4: LA_{NB} = (X) (Y) (2.44 $X10^7$)/1,000,000

LA_{NB} = Load Allocation to natural background (Mcfu/day)

X = natural background concentration (37 cfu/100 mL)

Y = streamflow in cubic feet per second (cfs)

2.44 $X10^7$ = conversion factor

5.7.2 Human-Caused Source Allocation

The composite load allocation to human-caused nonpoint sources (COMP LA_H) is calculated as the difference between the allowable daily load (TMDL) and the sum of all the remaining sources (LA_{RS}). This includes both nonpoint source load allocations (LAs) and point source load allocations (WLAs). An example of this can be seen in **Equation 5-5**:

Equation 5-5: Comp LA_H = TMDL – SUM LA_{RS}
TMDL = Total maximum daily load (Mcfu/day)
COMP LA_H = Load to human-caused nonpoint sources (Mcfu/day)
SUM LA_{RS} = Sum of the load allocations (WLA and LA) to the remaining sources (Mcfu/day)

5.7.3 Point Sources Allocation

The wasteload allocation to point sources (WLA) is calculated as the product of the flow volume of the wastewater being discharged, the *E. coli* standard (or MPDES effluent limit) and a conversion factor (**Equation 5-6**):

Equation 5-6: WLA = (Flow) x (Discharge Concentration) x (Conversion Factor)
WLA = Load to point sources (Mcfu/day)
Flow = Volume of discharged wastewater from the point source (cfs)
Concentration = 126 cfu/100mL (MPDES summer E. coli permit limit)
Conversion Factor = ($2.44 X10^7$)

The only variable in **Equation 5-6** is the wastewater flow. By applying **Equation 5-6**, the wasteload allocation can be calculated for any discharge flow. If the discharge flow increases, then the WLA also increases proportional to the increase in discharge. If the discharge flow decreases, then the WLA decreases proportional to the decrease in flow. The concentration value used in the WLA calculation will be constant for each point source. However, these values may differ for each point sources, as they will be based on MPDES permit limit or other water quality criteria applied to the point source.

5.7.4 Total Existing (Above Target) Load

To estimate a total existing load for the purpose of estimating a required load reduction, the following equation will be used:

Equation 5-7: **Total Existing Load (Mcfu/day) = ((X) (Y) ($2.44 X10^7$))/1,000,000**
X = E. coli target concentration in cfu/100 mL (median of geometric mean, maximum)
Y = streamflow in cubic feet per second (cfs)
$2.44 X10^7$ = conversion factor

The target exceedance value used in this equation are unique to each waterbody, and are dependent on the data available for that waterbody. In those instances where there was enough data to calculate a geometric mean of target exceedance, a median of these values was used. In many instances there was not sufficient data to calculate a geometric mean and a single exceedance value (maximum exceedance) was used. The geometric mean of target exceedances or the single exceedance is used as these concentrations are greater than the target and when incorporated into the above equation indicate the TMDL is being exceeded and load reductions are necessary.

5.8 TMDL ALLOCATIONS FOR THE MUSSELSHELL WATERSHED

This section presents the TMDL, source allocations, and estimated reductions necessary to meet water quality targets for *E. coli* in the Musselshell TMDL Project Area. An *E. coli* TMDL has been developed for those waterbodies listed in **Table 5-14**.

It is important to acknowledge that different water quality targets and subsequent allocations are applicable at separate times of the year. The TMDLs explained in the following sections are based on the summer (April 1 through October 31) *E. coli* limit (126 cfu/100 mL). The example loading estimates and load allocations in the following sections are established for the summertime period, when contact recreation (swimming, fishing, etc.) is most likely to occur. TMDLs for the winter months (November 1 through March 31) should be based on the winter *E. coli* limit (630 cfu/100mL). The example TMDLs are based on water quality data and flow conditions measured in each of the impaired waterbodies.

It is also important to note that seasonal flow data were collected during sampling efforts not associated with *E. coli* sampling, rather it was collected during nutrient sampling (**Appendix A**). Loading estimates are conservative and should be protective of the beneficial use during other times of the year as well, given the nonpoint source or diffuse nature of the *E. coli* loading.

5.8.1 North Fork Musselshell River (MT40A002_012) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for the North Fork of the Musselshell River. There are no point sources in the North Fork of the Musselshell River, therefore there is no WLA calculated in this TMDL. This section additionally provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet water quality targets for the North Fork of the Musselshell River.

Estimating TMDL and Allocations

The total existing load is used to estimate load reductions by comparing it to the allowable load (TMDL) and computing a required percent reduction to meet the TMDL. No load reductions are given for natural background allocations; therefore, all necessary load reductions apply to the nonpoint sources within the watershed.

The following is the North Fork of the Musselshell *E. coli* TMDL for the summer period expressed at a median flow rate of 28.3 cfs. This median flow rate was derived from measured flow values on all sites on North Fork of the Musselshell River during the 2015-2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The North Fork of the Musselshell TMDL for E. *coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (28.3 cfs) (2.44 x10^7))/1,000,000 = 87,098 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 28.3 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**) this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (28.3 cfs) (2.44 X 10^7))/1,000,000 = 25,576 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 28.3 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (87,098 Mcfu/day) – (25,576 Mcfu/day) = 61,521 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 28.3 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value (sole exceedance value). In the North Fork of the Musselshell there were only two *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers two samples insufficient data to calculate a geometric mean, however one sample exceed the 10% of samples greater than 252 cfu/100 mL criteria (325.5 cfu/100mL). As there was insufficient data to calculate a geometric mean the single exceedance value will be used to calculate the existing load.

Total Existing Load = ((325.5 cfu/100mL) (28.3 cfs) (2.44 X10^7))/1,000,000 = 225,002 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 61,521 Mcfu/day, which is determined by subtracting out the 25,576 Mcfu/day background load from the TMDL (87,098 Mcfu/day). **Table 5-21** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 28.3 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 28.3 cfs. The North Fork of the Musselshell River *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-21. N.F. Musselshell River *E. coli* TMDL and Load Allocation at a Median Flow of 28.3 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
28.3	87,098	25,576	61,521

Based on the existing conditions in the North Fork of the Musselshell (data presented in **Table 5-3**), the percent load reductions required to meet the TMDL range from about 0 to 61 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (325.5 cfu/100mL) to the “summer” *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 28.3 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the North Fork of the Musselshell River is greater than the TMDL. Under these conditions, a 69% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.2 American Fork (MT40A002_120) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for American Fork. There are no point sources in the American Fork watershed, therefore there is no WLA calculated in this TMDL. This section additionally provides *E. coli* loading estimates for natural and human-caused source categories, and estimates reductions necessary to meet water quality targets for the American Fork.

Estimating TMDL and Allocations
The following is the American Fork *E. coli* TMDL for the summer period expressed at a median flow rate of 7.26 cfs. This median flow rate was derived from measured flow values of all sites on American Fork during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The American Fork TMDL for E. *coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (7.26 cfs) (2.44 x10^7))/1,000,000 = 22,320 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 7.26 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1)** this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (7.26 cfs) (2.44 X 10^7)) /1,000,000 = 6,554 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 7.26 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (22,320 Mcfu/day) – (6,554 Mcfu/day) = 15,765 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 7.26 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value (sole exceedance), as there were only two *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers two samples insufficient data to calculate a geometric mean however one sample exceed the 10% of samples greater than 252 cfu/100 mL criteria (613.1 cfu/100mL). As there was insufficient data to calculate a geometric mean, the single exceedance value will be used to calculate the existing load.

Total Existing Load = ((613.1 cfu/100mL) (7.26 cfs) (2.44 X10^7)) /1,000,000 = 108,607 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 15,766 Mcfu/day, which is determined by subtracting out the 6,554 Mcfu/day background load from the TMDL (22,320 Mcfu/day). **Table 5-22** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 7.26 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 7.26 cfs. The American Fork *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-22. American Fork *E. coli* TMDL and Load Allocation at a Median Flow of 7.26 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
7.26	22,320	6,554	15,765

Based on the existing conditions in the American Fork (data presented in **Table 5-4**), the percent load reductions required to meet the TMDL range from about 0 to 80 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (613.1 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 7.26 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the American Fork is greater than the TMDL. Under these conditions, an 85% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.3 Upper Musselshell River (MT40A001_010) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, the composite LA to human-caused sources, the composite load allocation to tributaries, and the point source WLAs for the Harlowton WWTP and composite WLAs for several CAFOs. Additionally, this section estimates reductions necessary to meet water quality targets for the Upper Musselshell River. The allocations to the Upper Musselshell River are expressed by the following formula:

$$\mathbf{TMDL = LA_{NB} + COMP\ LA_{H} + COMP\ LA_{Trib} + WLA_{Harlowton} + WLA_{COMP\ CAFO}}$$

Estimating TMDL and Allocations

The following is the Upper Musselshell River *E. coli* TMDL for the summer period expressed at a median flow rate of 42 cfs. This median flow rate was derived from measured flow values of all sites on the Upper Musselshell River during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling efforts due to short sample holding time requirements.

The Upper Musselshell River TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

$$\mathbf{TMDL = ((126\ cfu/100mL)\ (42\ cfs)\ (2.44\ x10^{7}))/1{,}000{,}000 = 129{,}125\ Mcfu/day}$$

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 42 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1)** this allocation is as follows:

$$\mathbf{LA_{NB} = ((37\ cfu/100mL)\ (42\ cfs)\ (2.44\ X\ 10^{7}))\ /1{,}000{,}000 = 37{,}917\ Mcfu/day}$$

The composite LAs to upstream sources are to those waterbodies that are considered to be contributing sources. Both the North Fork of the Musselshell and the American Fork are *E. coli* impaired waterbodies that have the potential to contribute loads to the Musselshell River. Because there is more than one tributary that has the potential to contribute an *E. coli* load, these loads will be composited. The composite load will be the sum of the average loads from the North Fork of the Musselshell and the

American Fork. The average load is calculated from *E. coli* concentrations and flow data collected during nutrient sampling. Average loads for the North Fork of the Musselshell and the American fork are 14.4 Mcfu/day and 44.0 Mcfu/day, respectively. The loads for both of these tributaries are detailed in **Table 5-17**. The composite load for both of these waterbodies is expressed as follows:

COMP LA_{Trib} = (14,407 Mcfu) + (44,022Mcfu) = 58,429 Mcfu/day

Using **Equation 5-6**, the wasteload allocation (WLA) for the Harlowton WWTP (**$WLA_{Harlowton}$**) for the summer months (April 1- October 31) can be calculated with the average design flow of the WWTP of 0.22 MGD (0.4 cfs) and the *E. coli* water quality standard (126 cfu/100mL) as follows:

$WLA_{Harlowton}$ = ((126 cfu/100mL) x (0.4 cfs) x (2.44 X 10^7)) /1,000,000 = 1,230 Mcfu/day

The intent of this **$WLA_{Harlowton}$** will be met by following permit effluent limits and conditions, including *E. coli* monitoring. If the 30-day average effluent concentration exceeds 126 cfu/100 mL, the MT DEQ MPDES permitting authority should perform a reasonable potential analysis to determine if the WWTP is contributing an excessive load. Additional data from the Upper Musselshell River, especially directly upstream of the WWTP outfall, should also be collected prior to performing a reasonable potential analysis.

As discussed in **Section 5.6.4**, the three CAFOs in the Upper Musselshell will receive a composite WLA. Under the stipulations of the associated MPDES permits, these sites are prohibited from continually discharging wastewater, are required to contain all process wastewater and stormwater, and use general practices to reduce pollutants in stormwater discharges. Due to the infrequent discharges from facilities, there is relatively low potential for *E. coli* loading. As such, the composite WLA will be set to zero.

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 42 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = TMDL – (LA_{NB} + COMP LA_{Trib} + $WLA_{Harlowton}$ + COMP WLA_{CAFO})

COMP LA_H = 129,124 Mcfu/day – (37,917 Mcfu/day + 58,429 Mcfu/day + 1,230 Mcfu/day + 0 Mcfu/day) = 31,548 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the sum of the LA_{NB}, COMP LA_{Trib}, $WLA_{Harlowton}$ and WLA_{COMP} from the TMDL.

The total existing load at a flow rate of 42 cfs is based on **Equation 5-7**. This equation uses the median of *E. coli* target exceedance value measured in the Upper Musselshell River (393.1 cfu/100mL). The geometric mean was used in this instance due to the abundance of *E. coli* data.

Total Existing Load = ((393.1 cfu/100mL) (42 cfs) (2.44 X10^7)) /1,000,000 = 402,899 Mcfu/day

Table 5-23 contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 42 cfs, along with the LAs, WLAs and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 42 cfs. The Upper Musselshell *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-23. Upper Musselshell River *E. coli* TMDL and Load Allocation at a Median Flow of 42 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Tributaries (COMP LA_{Trib}) (Mcfu/day)	Wasteload Allocation to the Harlowton WWTP ($WLA_{Harlowton}$) (Mcfu/day)	Wasteload Allocation to the CAFO COMP WLA_{CAFO} (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
42	129,125	37,917	58,429	1,230	0.0	31,548

Based on the existing conditions in the Upper Musselshell River (data presented in **Table 5-5**), the percent load reductions required to meet the TMDL range from about 0 to 68 percent. These reductions are calculated by comparing the geometric mean of *E. coli* values that exceeded the target (393 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 42 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the Upper Musselshell River is greater than the TMDL. Under these conditions, an 75% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.4 Fish Creek (MT40A002_070) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, the composite LA to human-caused sources, and the wasteload allocation to the MPDES permitted CAFO in the Fish Creek watershed. Additionally, this section estimates reductions necessary to meet water quality targets for Fish Creek.

Estimating TMDL and Allocations

The following is the Fish Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 0.9 cfs. This median flow rate was derived from measured flow values of all sites on Fish Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Fish Creek TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (0.9 cfs) (2.44 x10^7))/1,000,000 = 2,767 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 0.9 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1)** this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (0.9 cfs) (2.44 X 10^7))/1,000,000 = 812 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 0.9 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (2,766 Mcfu/day) – (812 Mcfu/day) = 1,954 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

As discussed in **Section 5.6.5** there is one CAFO in Fish Creek that will receive a WLA. Under the stipulations of the MPDES permit, these site are prohibited from continually discharging wastewater, are required to contain all process wastewater and stormwater and use general practices to reduce pollutants in stormwater discharges. Due to the infrequent discharges from facilities, there is relatively low potential for *E. coli* loading. As such, the WLA will be set to zero.

The total existing load at a flow rate of 0.9 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value, as there were four only *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers four samples insufficient data to calculate a geometric mean however three samples exceed the 10% of samples greater than 252 cfu/100 mL criteria. As there was insufficient data to calculate a geometric mean the maximum exceedance value (1413 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((1,413 cfu/100mL) (0.9 cfs) (2.44 X10^7)) /1,000,000 = 31,042 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 1,954 Mcfu/day, which is determined by subtracting out the 812 Mcfu/day background load from the TMDL (2,767 Mcfu/day). **Table 5-24** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 0.9 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 0.9 cfs. The Fish Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-24. Fish Creek *E. coli* TMDL and Load Allocation at a Median Flow of 0.9 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)	Wasteload Allocation to the CAFO WLA_{CAFO} (Mcfu/day)
0.9	2,767	812	1,954	0.0

Based on the existing conditions in Fish Creek (data presented in **Table 5-7**), the percent load reductions required to meet the TMDL range from about 0 to 89 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (1,413 cfu/100mL) to the “summer” *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 0.9 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in Fish Creek is greater than the TMDL. Under these conditions, a 92% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.5 Big Coulee Creek (MT40A002_130) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Big Coulee Creek. Additionally, this section estimates reductions necessary to meet water quality targets for Big Coulee Creek.

Estimating TMDL and Allocations

The following is the Big Coulee Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 0.5 cfs. This median flow rate was derived from measured flow values of all sites on Big Coulee Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Big Coulee Creek TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (0.5 cfs) (2.44 x10^7))/1,000,000 = 1,537 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 0.5 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**), this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (0.5 cfs) (2.44 X 10^7))/1,000,000 = 451 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 0.5 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (1,537 Mcfu/day) – (451 Mcfu/day) = 1,085 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 0.5 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value. In Big Coulee Creek there were four *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers four samples insufficient data to calculate a geometric mean; however, three samples exceed the 10% of samples greater than 252 cfu/100 mL criteria. As there was insufficient data to calculate a geometric mean the maximum exceedance value (1,300 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((1,300 cfu/100mL) (0.5 cfs) (2.44 X10^7))/1,000,000 = 15,856 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 1,085 Mcfu/day, which is determined by subtracting out the 451 Mcfu/day background load from the TMDL (1,537 Mcfu/day). **Table 5-25** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 0.5 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 0.5 cfs. The Big Coulee Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-25. Big Coulee Creek E. coli TMDL and Load Allocation at a Median Flow of 0.5 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
0.5	1,537	451	1,085

Based on the existing conditions in Big Coulee Creek (data presented in **Table 5-8)**, the percent load reductions required to meet the TMDL range from about 0 to 90 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (1,300 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 0.5 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in Big Coulee Creek is greater than the TMDL. Under these conditions, a 80% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.6 Musselshell River (Middle) MT40A001_020 TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, the composite LA to human-caused sources, the load allocation to the contributing upstream waterbodies (Upper Musselshell River, Fish Creek, and Big Coulee Creek), and the point source WLAs for the Towns of Ryegate and Lavina. Additionally, this section estimates reductions necessary to meet water quality targets for the Middle Musselshell River. The allocations to the Middle Musselshell River (Deadmans Basin Supply Canal to HUC boundary near Roundup) are expressed by the following formula:

$$\textbf{TMDL} = LA_{NB} + COMP\ LA_H + COMP\ LA_{Tribs} + WLA_{Ryegate} + WLA_{Lavina}$$

Estimating TMDL and Allocations

The following is the Middle Musselshell River *E. coli* TMDL for the summer period expressed at a median flow rate of 123 cfs. This median flow rate was derived from measured flow values of all sites on this segment of the Musselshell River during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling efforts due to short sample holding time requirements.

The Musselshell River TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

$$\textbf{TMDL} = ((126\ cfu/100mL)\ (123\ cfs)\ (2.44\ x10^7))/1{,}000{,}000 = 378{,}151\ Mcfu/day$$

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 123 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**), this allocation is as follows:

$$LA_{NB} = ((37\ cfu/100mL)\ (123\ cfs)\ (2.44\ X\ 10^7))/1{,}000{,}000 = 111{,}044\ Mcfu/day$$

The LA to upstream sources are to those waterbodies that are considered to be contributing sources. The Upper Musselshell River, Fish Creek, and Big Coulee Creek are the impaired waterbodies that have the potential to contribute loads to the middle segment of the Musselshell River. Because there is more than one tributary that has the potential to contribute a *E. coli* load, these loads will be composited.

Loads for these tributaries are detailed in **Table 5-19**. The composite load will be the sum of the load from the Upper Musselshell River (20,391 Mcfu/day), Big Coulee Creek (3,064 Mcfu/day), and Fish Creek (891 Mcfu/day) and is expressed as follows:

COMP LA_{Trib} = (20,391 Mcfu) + (3,064 Mcfu) + (891 Mcfu) = 24,346 Mcfu/day

Using **Equation 5-6**, the wasteload allocation (WLA) for the Ryegate WWTP (**$WLA_{Ryegate}$**) for the summer months (April 1- October 31) can be calculated with the average design flow of the WWTP of 0.05 MGD (0.08 cfs) and the *E. coli* water quality standard (126 cfu/100mL) as follows:

$WLA_{Ryegate}$ = ((126 cfu/100mL) x (0.08 cfs) x (2.44 X 10^7))/1,000,000 = 246 Mcfu/day

The intent of this **$WLA_{Ryegate}$** will be met by following permit effluent limits and conditions, including *E. coli* monitoring. If the 30-day average effluent concentration exceeds 126 cfu, the MT DEQ MPDES permitting authority should perform a reasonable potential analysis to determine if the WWTP is contributing an excessive load. Additional data from the Middle Musselshell River, especially directly upstream of the WWTP outfall, should also be collected prior to performing a reasonable potential analysis.

Using **Equation 5-6**, the summer wasteload allocation (WLA) for the Lavina WWTP (**WLA_{Lavina}**) can be calculated with the average summer design flow of 0.014 mgd (0.026 cfs) and the summer *E. coli* water quality standards of 126 cfu/100 mL as follows:

WLA_{Lavina} = ((126 cfu/100mL) x (0.026 cfs) x (2.44 X 10^7))/1,000,000 = 80 Mcfu/day

The intent of this **WLA_{Lavina}** will be met by following permit effluent limits and conditions, including *E. coli* monitoring. If the monthly average effluent concentration exceeds 126 cfu/100 mL from April 1 through October 1 and 630 cfu/100 mL from November 1 through March 31. A reasonable potential analysis should be conducted to determine if the WWTP is contributing an excessive load. Additional data from the Middle Musselshell River, especially directly upstream of the WWTP outfall, should also be collected prior to performing a reasonable potential analysis.

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 123 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = TMDL – (LA_{NB} + COMP LA_{Trib} + $WLA_{Ryegate}$ + WLA_{Lavina})

COMP LA_H = 378,151 Mcfu/day – (111,044 Mcfu/day + 24,346 Mcfu/day + 246 Mcfu/day + 80 Mcfu/day) = 242,435 Mcfu/day

Note that **COMP LA_H** will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The **COMP LA_H** will always represent the remaining available load after subtracting the sum of the **LA_{NB}**, **COMP LA $_{Trib}$**, **$WLA_{Ryegate}$** and **WLA_{Lavina}** from the TMDL.

The total existing load at a flow rate of 123 cfs is based on **Equation 5-7**. This equation uses the geometric mean of *E. coli* target exceedance values measured in the Middle Musselshell River. The geometric mean (308 cfu/100mL) was used in this instance due to the abundance of *E. coli* data.

Total Existing Load = ((308 cfu/100mL) (123 cfs) (2.44 X10^7))/1,000,000 = 930,822 Mcfu/day

Table 5-26 contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 123 cfs, along with the LAs, WLAs and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 123 cfs and the summer water quality standard of 126 cfu. The Middle Musselshell *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-26. Middle Musselshell River E. coli TMDL and Load Allocation at a Median Flow of 123 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Tributaries (COMP LA_{Trib}) (Mcfu/day)	Wasteload Allocation to the Ryegate WWTP ($WLA_{Ryegate}$) (Mcfu/day)	Wasteload Allocation to the Lavina WWTP (WLA_{Lavina}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
123	378,151	111,044	24,346	246	80	242,435

Based on the existing conditions in the Middle Musselshell River (data presented in **Table 5-6**), the percent load reductions required to meet the TMDL range from about 0 to 59 percent. These reductions are calculated by comparing the geometric mean of *E. coli* values that exceeded the target (308 cfu/100mL) to the “summer” *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 123 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the Middle Musselshell River is greater than the TMDL. Under these conditions, an 67% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.7 Half Breed Creek (MT40A002_090) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Half Breed Creek. Additionally, this section estimates reductions necessary to meet water quality targets for Half Breed Creek.

Estimating TMDL and Allocations

The following is the Half Breed Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 0.5 cfs. This median flow rate was derived from measured flow values of all sites on Half Breed Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Half Breed Creek TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (0.5 cfs) (2.44 x10^7))/1,000,000 = 1,537 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 0.5 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**) this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (0.5 cfs) (2.44 X 10^7))/1,000,000 = 451 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 0.5 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (1,537 Mcfu/day) – (451 Mcfu/day) = 1,086 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 0.5 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value. In Half Breed Creek there were four *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers four samples insufficient data to calculate a geometric mean; however, two samples exceed the 10% of samples greater than 252 cfu/100 mL criteria. As there was insufficient data to calculate a geometric mean, the maximum exceedance value (980 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((980 cfu/100mL) (0.5 cfs) (2.44 X10^7))/1,000,000 = 11,960 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 11,960 Mcfu/day, which is determined by subtracting out the 451 Mcfu/day background load from the TMDL. **Table 5-27** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 0.5 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 0.5 cfs. The Half Breed *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-27. Half Breed *E. coli* TMDL and Load Allocation at a Median Flow of 0.5 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
0.5	1,537	451	1,086

Based on the existing conditions in Half Breed Creek (data presented in **Table 5-9**), the percent load reductions required to meet the TMDL range from about 0 to 99percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (980 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 0.5 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in Half Breed Creek is greater than the TMDL. Under these conditions, an 87% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.8 South Fork McDonald Creek (MT40B002_070) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, the wasteload allocation (WLA) to the Grass Range WWTP, and the composite LA to human-caused sources for South Fork McDonald Creek. Additionally, this section estimates reductions necessary to meet water quality targets for the South Fork of McDonald Creek.

Estimating TMDL and Allocations

The following is the South Fork McDonald Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 5 cfs. This median flow rate was derived from measured flow values of all sites on the South Fork McDonald Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The South Fork McDonald Creek TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (5 cfs) (2.44 x10^7))/1,000,000 = 15,372 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 5 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**) this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (5 cfs) (2.44 X 10^7))/1,000,000 = 4514 Mcfu/day

Using **Equation 5-6**, the summer wasteload allocation (WLA) for the Grass Range WWTP (**$WLA_{GrassRange}$**) can be calculated with the average summer design flow of 0.038 mgd (0.07 cfs) and the summer *E. coli* water quality standards of 126 cfu/100 mL as follows:

$WLA_{GrassRange}$ = ((126 cfu/100mL) x (0.07cfs) x (2.44 X 10^7))/1,000,000 = 215 Mcfu/day

The intent of this **$WLA_{GrassRange}$** will be met by following permit effluent limits and conditions, including *E. coli* monitoring. If the monthly average effluent concentration exceeds 126 CFU/100 mL from April 1 through October 1 and 630 CFU/100 mL from November 1 through March 31, the MT DEQ MPDES permitting authority should perform a reasonable potential analysis to determine if the WWTP is contributing an excessive load. Additional data from the South Fork of McDonald Creek, especially directly upstream of the WWTP outfall, should also be collected prior to performing a reasonable potential analysis.

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 5 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = TMDL – (LA_{NB} + $WLA_{GrassRange}$)

COMP LA_H = 15,372 Mcfu/day – (4,514 Mcfu/day + 215) = 10,643 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 5 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value. In the South Fork McDonald Creek, there were two *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers two samples insufficient data to calculate a geometric mean; however, one sample exceeds the 10% of samples greater than 252 cfu/100 mL criteria. As there was insufficient data to calculate a geometric mean the maximum exceedance value (308 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((308 cfu/100mL) (5 cfs) (2.44 X10^{7}))/1,000,000 = 37,527 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 10,858 Mcfu/day, which is determined by subtracting out the 4514 Mcfu/day background load from the TMDL. **Table 5-28** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 5 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 5 cfs. The South Fork McDonald Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-28. S.F. McDonald Creek *E. coli* TMDL and Load Allocation at a Median Flow of 5 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)	Wasteload Allocation to the Grass Range WWTP ($WLA_{GrassRange}$) (Mcfu/day)
5	15,372	4,514	10,643	215

Based on the existing conditions in South Fork McDonald Creek (data presented in **Table 5-10**), the percent load reductions required to meet the TMDL range from about 0 to 98 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (308 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 5 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the South Fork McDonald Creek is greater than the TMDL. Under these conditions, a 67% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.9 McDonald Creek (MT40B002_010) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, the composite LA to human-caused sources and the WLA to the Town of Winnett WWTP. Additionally, this section estimates reductions necessary to meet water quality targets for McDonald Creek. The allocations to McDonald Creek are expressed by the following formula:

TMDL = LA_{NB} + COMP LA_H + $WLA_{Winnett}$

Estimating TMDL and Allocations

The following is the McDonald Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 6 cfs. This median flow rate was derived from measured flow values of all sites on McDonald

Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The McDonald Creek TMDL for E. *coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (6 cfs) (2.44 x10^7))/1,000,000 = 18,446 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 6 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**), this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (6 cfs) (2.44 X 10^7))/1,000,000 = 5,417 Mcfu/day

Using **Equation 5-6**, the summer wasteload allocation (WLA) for the Winnett WWTP (**$WLA_{Winnett}$**) can be calculated with the average summer design flow of 0.12 mgd (0.22 cfs) and the summer *E. coli* water quality standards of 126 cfu/100 mL as follows:

$WLA_{Winnett}$ = ((126 cfu/100mL) x (0.22cfs) x (2.44 X 10^7))/1,000,000 = 676 Mcfu/day

The intent of this **$WLA_{Winnett}$** will be met by following permit effluent limits and conditions, including *E. coli* monitoring. If the monthly average effluent concentration exceeds 126 CFU/100 mL from April 1 through October 1 and 630 CFU/100 mL from November 1 through March 31, the MT DEQ MPDES permitting authority should perform a reasonable potential analysis to determine if the WWTP is contributing an excessive load. Additional data from McDonald Creek, especially directly upstream of the WWTP outfall, should also be collected prior to performing a reasonable potential analysis.

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 6 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = TMDL – (LA_{NB} +WLA_{Winnet})

COMP LA_H = (18,446 Mcfu/day) – (5,417 Mcfu/day + 676 Mcfu/day) = 12,353 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 6 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value. In McDonald Creek there were four *E. coli* samples collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers four samples insufficient data to calculate a geometric mean however two samples exceed the 10% of samples greater than 252 cfu/100 mL criteria. As there was insufficient data to calculate a geometric mean the maximum exceedance value (770 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((770 cfu/100mL) (6 cfs) (2.44 X10^7))/1,000,000 = 112,742 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 13 ,029 Mcfu/day, which is determined by subtracting out the 5,417 Mcfu/day background load from the TMDL. **Table 5-29** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 6 cfs, along with the LAs and WLA, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 6 cfs. The McDonald Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-29. McDonald Creek *E. coli* TMDL and Load Allocation at a Median Flow of 6 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)	Wasteload Allocation to the Winnett WWTP ($WLA_{Winnett}$) (Mcfu/day)
6	18,446	5,417	12,353	676

Based on the existing conditions in McDonald Creek (data presented in **Table 5-11**), the percent load reductions required to meet the TMDL range from about 0 to 99 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (770 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 6 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the McDonald Creek is greater than the TMDL. Under these conditions, an 82% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.10 Fords Creek (MT40B002_021) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for Fords Creek. Additionally, this section estimates reductions necessary to meet water quality targets for Fords Creek.

Estimating TMDL and Allocations

The following is the Fords Creek *E. coli* TMDL for the summer period expressed at a median flow rate of 1 cfs. This median flow rate was derived from measured flow values of all sites on Fords Creek during the 2015 to 2016 nutrient monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Fords Creek TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (1 cfs) (2.44×10^7))/1,000,000 = 3,074 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 1 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**), this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (1 cfs) (2.44×10^7))/1,000,000 = 903 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 1 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (3,074 Mcfu/day) – (903 Mcfu/day) = 2,171 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 1 cfs is based on **Equation 5-7**. This equation uses the maximum *E. coli* target exceedance value. In Fords Creek there was one *E. coli* sample collected during the summer 2016 sampling effort. The DEQ *E. coli* assessment method (DEQ 2020b) considers one sample insufficient data to calculate a geometric mean however the one sample exceeded the 10% of samples greater than 252 cfu/100 mL criteria. As there were insufficient data to calculate a geometric mean, the sole exceedance value (1,733 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((1,733 cfu/100mL) (1 cfs) (2.44 X10^7))/1,000,000 = 42,283 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 2,171 Mcfu/day, which is determined by subtracting out the 903 Mcfu/day background load from the TMDL. **Table 5-30** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 1 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDLs and their allocations calculated below only apply at the flow of 1 cfs. The Fords Creek *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-30. Fords Creek *E. coli* TMDL and Load Allocation at a Median Flow of 1 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
1	3,074	903	2,171

Based on the existing conditions in Fords Creek (data presented in **Table 5-12**), the percent load reductions required to meet the TMDL range from about 0 to 99 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (1,733 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 1 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the Fords Creek is greater than the TMDL. Under these conditions, an 95% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.8.11 Musselshell River (Lower) (MT40C003_010) TMDL and Allocations

This section establishes the *E. coli* TMDL, natural background LA, and the composite LA to human-caused sources for the Lower Musselshell River (Flatwillow Creek to Fort Peck Reservoir). There are no direct tributaries or upstream segments of the Musselshell River that are considered impaired for *E. coli*, therefore no loads from sources such as this will be accounted for in load allocations discussed below. Additionally, this section estimates reductions necessary to meet water quality targets for the lower Musselshell River.

Estimating TMDL and Allocations

The following is the Lower Musselshell River *E. coli* TMDL for the summer period expressed at a median flow rate of 132 cfs. This median flow rate was derived from measured flow values of all sites on the Lower Musselshell River during the 2012, 2013, 2015, and 2016 monitoring efforts. Flow was not collected during the *E. coli* sampling effort due to logistics and a short sample holding time requirement.

The Lower Musselshell River TMDL for *E. coli* is based on **Equation 5-1** and is presented below.

TMDL = ((126 cfu/100mL) (132 cfs) (2.44 x10^7))/1,000,000 = 405,821 Mcfu/day

Equation 5-4 is the basis for the natural background load allocation for *E. coli*. To continue with the calculation at a flow rate of 132 cfs and a median background concentration of 37 cfu/100 mL (**Section 5.6.1.1**), this allocation is as follows:

LA_{NB} = ((37 cfu/100mL) (132 cfs) (2.44 X 10^7))/1,000,000 = 119,169 Mcfu/day

Using **Equation 5-5**, the human-caused *E. coli* load allocation at a flow rate of 132 cfs can be calculated for the summer (**COMP LA_H**) as follows:

COMP LA_H = (405.8 Mcfu/day) – (119.2 Mcfu/day) = 286,651 Mcfu/day

Note that COMP LA_H will change proportionally with flow consistent with how both the TMDL and natural background load allocations change with flow. The COMP LA_H will always represent the remaining available load after subtracting the LA_{NB} from the TMDL.

The total existing load at a flow rate of 132 cfs is based on **Equation 5-7**. This equation uses the only *E. coli* target exceedances. The DEQ *E. coli* assessment method (DEQ 2020b) considers one sample insufficient data to calculate a geometric mean however the one sample exceeded the 10% of samples greater than 252 cfu/100 mL criteria. As there were insufficient data to calculate a geometric mean the sole exceedance value (461 cfu/100mL) will be used to calculate the existing load.

Total Existing Load = ((461 cfu/100mL) (132 cfs) (2.44 X10^7))/1,000,000 = 1,485,110 Mcfu/day

The portion of the total existing load attributed to human-caused sources is 286,651 Mcfu/day, which is determined by subtracting out the 119,169 Mcfu/day background load from the TMDL. **Table 5-31** contains the results for the *E. coli* TMDL expressed at a median summer flow rate of 132 cfs, along with the LAs, and current loading for this same flow. It is important to note that the TMDL and allocations calculated below only apply at the flow of 132 cfs. The Lower Musselshell River *E. coli* TMDL and allocations must always be based on the above equations for any flow conditions.

Table 5-31. Lower Musselshell River *E. coli* TMDL and Load Allocation at a Median Flow of 132 cfs

Typical Flow (cfs)	TMDL (Mcfu/day)	Load Allocation to Natural Background (LA_{NB}) (Mcfu/day)	Composite Load Allocation to Human Caused (COMP LA_H) (Mcfu/day)
132	405,821	119,169	286,651

Based on the existing conditions in the Lower Musselshell River (data presented in **Table 5-13**), the percent load reductions required to meet the TMDL range from about 0 to 71 percent. These reductions are calculated by comparing the maximum *E. coli* value that exceeded the target (461 cfu/100mL) to the "summer" *E. coli* standard (126 cfu/100mL) used to compute the TMDL.

At the median summer flow of 132 cfs, and the maximum *E. coli* value that exceeded the target value, the current loading in the Lower Musselshell River is greater than the TMDL. Under these conditions, an 79% reduction of human-caused *E. coli* loads would result in the TMDL being met. The total existing load is dynamic and changes with variability in water quality conditions. Therefore, meeting instream *E. coli* concentration targets under all conditions will equate to meeting the TMDL.

5.9 Seasonality, Critical Conditions, 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), wasteload allocations (WLAs), and load allocations (LAs). TMDL development must also incorporate a margin of safety (MOS) to account for uncertainties between pollutant sources 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 MOS in the Musselshell TMDL Project Area *E. coli* TMDL development process.

5.9.1 Seasonality and Critical Conditions

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan, seasonality is an integral consideration. Water quality is recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Different water quality targets and subsequent allocations are applicable for two separate periods: the summer period (April 1 through October 31) where water temperatures are more conducive to bacterial colony growth, and the winter period (November 1 through March 31) where water temperatures suppress bacterial colony growth.
- *E. coli* data used to determine compliance with targets and to establish allowable loads were collected during the summer period to coincide with applicable *E. coli* targets and the time of highest recreational use. Data were collected for the summer period because *E. coli* targets are more restrictive during this period and therefore by meeting the summer period *E. coli* targets, it is assumed that the winter period *E. coli* targets will also be met.
- Flow values used in calculating the *E. coli* TMDLs and allocations in **Section 5.8** were collected within the summer period during nutrient sampling efforts and are considered representative of conditions during which the summer period *E. coli* targets apply.

TMDLs must take into account critical conditions for steam flow, loading, and water quality parameters as part of analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). In developing a TMDL, the critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody, a condition where the pollutant loading is greatest, but the waterbody continues to meet water quality standards. Critical conditions can be thought of as the combination of environmental factors (e.g., stream flow, air temperature, etc.) that result in the attainment of standards with a low frequency of occurrence.

During wet weather periods, *E. coli* concentrations are much higher than during dry periods, and often exceed the numeric targets. Therefore, wet weather conditions can be considered a critical condition for bacteria levels. However, during the summer, low-flow period there is much more exposure to pathogenic indicator bacteria through recreation. Therefore, summer recreation periods can also be considered a critical period. Since both wet and dry periods are critical conditions, TMDL targets are constant across these conditions and only vary according to the seasonally dependent standards displayed in **Table 5-2**.

5.9.2 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 2001). This plan addresses MOS implicitly in a variety of ways:

- The geometric mean or maximum *E. coli* value was used to calculate TMDLs and load allocations. Using a geometric mean provides a margin of safety by ensuring that allowable daily load allocations do not result in the exceedance of water quality targets.
- The median value of 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 anthropogenic *E. coli* loads during most conditions. This is because the application of a higher natural background load allocation equates to a higher percent load reduction from nonpoint sources needed to meet the TMDL.
- TMDLs and allocations were presented in this document using the geometric mean targets, which require a lower *E. coli* concentration to meet the target (126 cfu/100 mL) than the 10% exceedance target of 252 cfu/100mL. It is assumed that meeting the geometric mean target under most circumstances equates to meeting the 10% exceedance target.
- Bacterial decay rates were not factored in while developing the TMDL, therefore adding an implicit margin of safety to the TMDL.
- Seasonality (discussed above) and variability in *E. coli* loading is considered in target development, monitoring design, and source assessment.
- An adaptive management approach (discussed below) is recommended to evaluate target attainment and allow for refinement of load allocations, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development over time.

5.10 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, source assessments, loading estimates, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through 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 are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in assessing *E. coli* sources and needed reductions. The main sources of uncertainty are summarized below.

5.10.1 Water Quality Conditions
E. coli water quality data in the Musselshell watershed is at times limited (Example: Fords Creek). As such there may be instances where there is some uncertainty associated with conclusions identified in source assessment section (**Section 5.6.1**). Given that there are instances of uncertainty, future water quality monitoring is necessary to help better identify sources and their impacts on water quality. Future monitoring efforts should help reduce the uncertainty regarding data representativeness, improve the understanding of the effectiveness of Best Management Practice (BMP) implementation, and increase the understanding of the load reductions needed to meet the TMDL.

It was also assumed that background concentrations (**Section 5.6.1.1**) are less than the target values, and based on sample data, this appears to be true. However, it is possible that target values may be naturally exceeded during certain times or at certain locations in the watershed. Future monitoring should help reduce uncertainty regarding background *E. coli* concentrations.

5.10.2 Source Assessment
Source characterization and assessment to determine the major *E. coli* sources was conducted by using monitoring data collected from 2015 to 2016, which represents the most recent data for determining existing conditions, and by using aerial photos, Geographic Information System (GIS) analysis, field work, and literature reviews. That being said, uncertainties in source assessment can occur by using data that does not reflect the current condition of the waterbody, the misinterpretation of aerial photos, using outdated GIS data, using field data that may not be representative of the overall condition of the waterbody, and referencing literature that was developed for areas outside of the Musselshell River watershed.

Water quality monitoring data used for source assessment includes the time period from 2015 to 2016. Sources of pollutants or the level of contribution from those sources may have changed since data collection. Therefore, there is some additional uncertainty that the data used is reflective of the current conditions in the Musselshell watershed. BMP implementation efforts may also have taken place since the collection of this data. In the absence of more recent data, an assumption was made that the data used are representative of current conditions. Data collected accurately characterizes that particular site at the time of sample collection, but there is some uncertainty as to whether or not that site is representative of the overall waterbody condition. To address this, monitoring site locations and sample collection times were selected to generate the most representative samples.

When using aerial photography and GIS data, uncertainty may occur through the misinterpretation of aerial photos and using GIS data that may be inaccurate or outdated. To reduce uncertainty, multiple years of aerial photos were analyzed and only GIS data containing complete metadata and generated from reliable sources were used for source assessment.

5.10.3 Loading Estimates
Loading estimates are based on currently available data and are only representative of the pollutant load at the time of data analysis. It is important to recognize that pollutant loads are not static and can therefore be different than the loads reported in this document. This brings some uncertainty into load reductions, as achieving the load reductions stated in this document may or may not result in meeting in-stream water quality targets based on current conditions. For the purpose of determining existing *E. coli* loads, the median of the geometric mean target exceedance value or a maximum target exceedance value was used. In both instances, this reflects an existing load only when exceedances are occurring.

Future additional water quality monitoring may be able to identify when the TMDL is being met and when the TMDL is being exceeded, which can help guide BMP implementation efforts by identifying the most significant *E. coli* sources. Adaptive management can address uncertainties related to loading estimates through the re-evaluation of water quality conditions as BMPs are installed, land uses change, or pollutant sources and their contribution levels change.

6.0 Public Participation and Public Comments

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning required by Montana state law which directs the Department of Environmental Quality (DEQ) to consult with a watershed advisory group and local conservation districts during the TMDL development process. Technical advisors, stakeholders, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process for this project in the Musselshell TMDL Project Area.

6.1 Participants and Their Roles

Throughout completion of the *E. coli* TMDLs in this document, DEQ worked to keep stakeholders apprised of project status and solicited input from a TMDL watershed advisory group. A description of the participants and their roles in the development of the TMDLs in this document is contained below.

Montana Department of Environmental Quality
The Montana Water Quality Act (75-5-703, Montana Code Annotated (MCA)) directs DEQ to develop all necessary TMDLs. DEQ provided resources toward completion of these TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act. Section 303(d) of the Clean Water Act directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for reviewing and evaluating TMDLs to see that they meet all federal requirements.

Local Conservation Districts
DEQ consulted with the upper Musselshell, Lower Musselshell, Petroleum County, and Garfield County conservation districts during development of the TMDLs in this document, which included opportunities to provide comment during the various stages of TMDL development and an opportunity for participation in the watershed advisory group described below.

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

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

Communication with the advisory group was conducted through a series of group meetings, as well as via e-mail. Draft documents, meeting presentations were made available through DEQ's wiki for water quality planning projects (http://mtwaterqualityprojects.pbworks.com/). Opportunities for review and comment included a two-week review and comment period for a draft version of this TMDL document prior to the public comment period. During this period the Musselshell Watershed Coalition submitted comments, and they were incorporated into the TMDL document.

6.2 Response to Public Comments

Upon completion of a draft TMDL document, 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; DEQ then addresses and responds to all formal public comments.

The public comment period for this document was initiated on July 5, 2021, and closed on August 2, 2021. A public informational meeting was held virtually via Zoom at 5:00 p.m. on July 14, 2021. At the meeting, DEQ provided an overview of the TMDL document, answered questions, and solicited input and comment on the document. The public comment period and public meeting were announced in a June 30, 2021 press release from DEQ which was published on DEQ's website and was distributed to multiple media outlets across Montana. A public notice advertising the public comment period and public meeting was published in the following newspapers: Billings Gazette, The Times Clarion, and The Roundup Record-Tribune. Additionally, the announcement was distributed to the project's TMDL watershed advisory group, the Statewide TMDL Advisory Group, and other additional contacts via e-mail.

No formal written comments were received during the public comment period.

PART 3
WATER QUALITY IMPROVEMENT RECOMMENDATIONS

7.0 Water Quality Improvement Plan and Monitoring Strategy

This section describes an overall strategy and conservation practices (e.g., best management practices (BMPs)) designed to restore water quality beneficial uses and attain *E. coli* water quality standards in the Musselshell TMDL Project Area (Project Area).

7.1 Improvement and Monitoring Strategy overview

The strategy includes general measures for reducing loads from identified nonpoint sources of *E. coli* as well as approaches to further evaluate *E. coli* conditions in the Musselshell watershed. Effective monitoring is integral for evaluating conservation practices and provides a foundation of an adaptive management approach. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities, pollutant load reductions and status of TMDL target attainment. This strategy can also help determine if all significant sources have been identified. Data from long-term monitoring also provides technical justification to modify restoration strategies, targets, or allocations if appropriate.

This section is intended to help stakeholders develop a watershed restoration plan (WRP), if desired, that provides a locally developed voluntary action plan to reduce *E. coli* loads in the Musselshell watershed. The WRP may encompass broader goals than the water quality improvement strategy outlined in this document, such as goals related to other pollutant sources or weed management. The intent of the WRP is to serve as a locally supported “road map” for watershed activities that prioritizes projects to achieve watershed goals.

7.2 Role of DEQ, Other Agencies, and Stakeholders

DEQ does not implement TMDL pollutant-reduction projects for nonpoint source activities but does provide technical assistance to stakeholders interested in addressing nonpoint source pollution. Successful implementation of TMDL pollutant-reduction projects often requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ works with interested participants to use TMDLs as a basis for developing locally driven WRPs, provides funding to help support water quality improvement and pollution prevention projects, and helps identify other sources of funding.

Because most nonpoint source pollution reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration goals and meet TMDL targets and load reductions. Specific stakeholders and agencies that may be involved with restoration efforts for streams discussed in this document include:

- U.S. Forest Service (USFS)
- Bureau of Land Management (BLM)
- Natural Resources Conservation Service (NRCS)
- Montana Department of Natural Resources & Conservation (DNRC)
- Montana Fish, Wildlife & Parks (FWP)
- Montana Department of Environmental Quality (DEQ)
- Montana Trout Unlimited

- Musselshell Watershed Coalition
- Upper Musselshell Conservation District
- Lower Musselshell Conservation District
- Petroleum County Conservation District
- Garfield County Conservation District
- Montana State University Extension Water Quality Program

7.3 Adaptive Management and Uncertainty

The TMDL implementation goals and monitoring strategy presented in this section provide a starting point for the development of more detailed planning. Recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate plans to meet the water quality improvement goals outlined in this document.

In accordance with the Montana Water Quality Act (75-5-703 (7) and (9), Montana Code Annotated (MCA)), DEQ is required to assess the waters for which TMDLs have been completed and restoration measures or BMPs have been applied to determine whether compliance with water quality standards has been attained, water quality is improving, or if revisions to current goals are necessary. This aligns with an adaptive management approach that is incorporated into DEQ's assessment and water quality impairment determination process. DEQ's Watershed Protection Section administers and monitors TMDL implementation and works with local watershed groups to identify waterbodies where there have been sufficient activities to warrant an evaluation of current stream conditions.

Adaptive management, as discussed throughout this document, is a systematic approach for improving resource management by learning from management outcomes and allows for flexible decision making. There is an inherent amount of uncertainty involved in the TMDL process, such as quantifying source contributions (e.g., determining natural background) and characterizing spatial and seasonal loading conditions. Use of an adaptive management approach based on continued monitoring of project implementation helps manage resource commitments and achieve success in meeting the water quality standards and supporting water quality beneficial uses. This approach further allows for adjustments to restoration goals and/or allocations, as necessary.

Figure 7-1 below is a visual explanation of the iterative process of adaptive management (Williams et al., 2009).

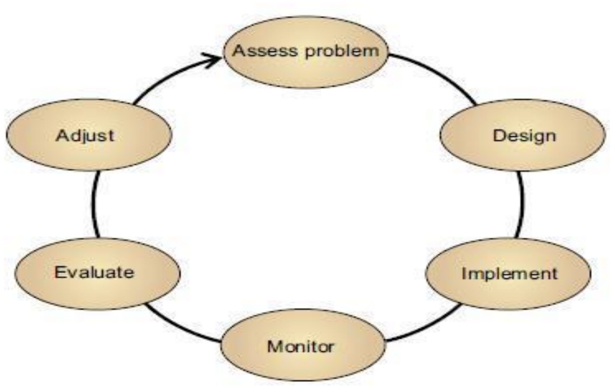

Figure 7-1. Diagram of the Adaptive Management Process

Prioritizing restoration and monitoring activities depends on funding opportunities and stakeholder priorities. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, DEQ will conduct a formal evaluation of the waterbody's impairment status and determine whether water quality standards (TMDL targets) are being met.

7.4 Water Quality Restoration Objectives

The water quality restoration objective for the Musselshell *E. coli* TMDL is to reduce *E. coli* loads to meet the water quality standards (TMDL targets) for recovery of beneficial uses for Musselshell River and its tributaries. Based on the assessment provided in this document, the TMDL can be achieved through implementation of appropriate BMPs for nonpoint sources.

Specific objectives for watershed restoration activities could be identified by local stakeholders through the development of a WRP or similar approach. A WRP can provide a strategy for water quality restoration and monitoring in the Musselshell watershed, focusing on how to achieve the TMDL presented in this document, as well as other water quality issues of interest to the local community and stakeholders. WRPs identify considerations that should be addressed during TMDL implementation. A WRP serves as a locally organized "road map" for watershed activities, prioritizing projects, and identifying funding and technical resources 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 federal Clean Water Act Section 319 (nonpoint source management programs) provides authority for congressional funding to Montana. The funds for nonpoint source projects have to be used to implement WRPs. If there is local interest in access to federal 319 funding, a WRP is necessary in order to access those funds.

The EPA requires nine minimum elements for a WRP. A complete description can be found at https://www.epa.gov/sites/production/files/2015-09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf and are summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

This TMDL document provides, or can serve as an outline, for many of the WRP required elements for addressing the *E. coli* water quality impairment. For example, information to address elements 1, 2 and 3 is provided in **Section 5.0**.

7.5 *E. coli* Restoration Approach

E. coli inputs to the waterbodies of the Musselshell watershed come from both point and nonpoint sources. Human caused nonpoint sources of *E. coli* in the Musselshell watershed consist primarily of agriculture (pasture, rangeland, and manure applied on cropland), naturally occurring sources and those other sources that are human caused (subsurface wastewater disposal, domestic pets, recreation etc.).Point sources include MPDES permitted facilities such was wastewater treatment facilities.

General recommendations for the management of grazing management and septic systems and other sources of human caused *E. coli* loading to Musselshell are outlined below. A WRP developed by local stakeholders would contain more detailed information on restoration priorities, milestones and specific BMP recommendations to address key pollutant sources. Monitoring is an important part of the restoration process and for evaluating BMP effectiveness. Specific monitoring recommendations are outlined in **Section 7.6**.

7.5.1 Agriculture Sources

Reduction of pollutants from upland agricultural sources can be accomplished by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. The main BMP recommendations for the Musselshell TMDL Project Area are riparian buffers, wetland restoration, and vegetated filter strips, where appropriate. These methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from local USDA Agricultural Service Centers and in Montana's Nonpoint Source Management Plan. http://deq.mt.gov/Portals/112/Water/WPB/Nonpoint/Publications/Annual%20Reports/2017NPSManagementPlanFinal.pdf

7.5.1.1 Grazing

Grazing has the potential to increase nutrient loads by direct and indirect (fertilization, runoff from pastures etc.) contributions of manure, altering riparian vegetation, but these effects can be mitigated with appropriate management. Development of riparian grazing management plans should be a goal for any landowner who operates livestock and does not currently have such plans. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. Reducing grazing pressure in riparian and wetland areas and improving forage stand health are the two keys to preventing nonpoint source pollution from grazing. Note that riparian grazing management does not necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

The following resources provide guidance to help prevent pollution and maximize productivity from grazing operations:

- USDA, Natural Resources Conservation Service Offices (find your local USDA Agricultural Service Center listed in your phone directory or on the Internet at https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/
- Montana State University Extension Service https://www.msuextension.org/

- DEQ Watershed Protection Section: Nonpoint Source Management Plan
  http://deq.mt.gov/Water/SurfaceWater/npspollution

7.5.1.2 Cropland
The primary strategy of cropland BMPs is to reduce nutrient inputs. The major factors involved in decreasing nutrient loads are reducing the rate of runoff, and intercepting runoff before it enters waterbodies. The main cropland BMP recommendations for the Musselshell TMDL Project Area are vegetated filter strips and riparian buffers. Both of these methods reduce the rate of runoff and promote infiltration of the soil (instead of delivering runoff directly to the stream). Effectiveness is typically about 70% for the filter strips and 50% for the buffers (DEQ 2017). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's Nonpoint Source Management Plan (DEQ 2017).

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

Reduction of riparian and wetland vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in watersheds throughout Montana. Although implementation of passive BMPs that allow riparian and wetland vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e., plantings) may be necessary in some instances. The primary advantage of riparian and wetland plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property.

In addition to the benefits described above, it should be noted that in some cases, wetlands act as areas of shallow subsurface groundwater recharge and/or storage areas. The captured water via wetlands is then generally discharged to the stream later in the season and contributes to the maintenance of base flows and stream temperatures. Restoring ditched or drained wetlands can have a substantial effect on the quantity, temperature, and timing of water returning to a stream, as well as the pollutant filtering capacity that improved riparian and wetlands provide.

7.5.2 Septic
With few exceptions, the Musselshell watershed does not have a high density of septic systems in close proximity to surface water. That being said, the number of septic system in the watershed is likely to increase with future residential development within the Musselshell TMDL PROJECT AREA. While no information is available regarding failing septic systems, the number of failing septic systems is likely very low and is not expected to be a significant contributor of *E. coli*. Septic systems should already have

minimum design/installation requirements and undergo periodic maintenance, which should serve as a basic BMP. Older systems should be upgraded, and all new systems should meet these minimum requirements.

Efforts to monitor and maintain septic systems are necessary to minimize the loading to surface waters. In addition, BMPs that include education and outreach to inform the public to the proper way to maintain their septic systems could reduce the total loading of *E. coli* and other pathogens to the nearby waterbodies.

7.6 Strengthening Source Assessment and Increasing Available Data

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, *E. coli* sampling events timeframes could be expanded to include 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.

The identification of pollutant sources in the Project Area was conducted through a combination of field observations, assessments of aerial photographs and GIS information, analyzing data, and the review of published scientific studies. Strategies for strengthening source assessments for *E. coli* are outlined below.

DEQ's water quality sampling for *E. coli* was distributed spatially along the Musselshell River and a number of its tributaries in order to delineate pathogen sources. Samples were collected over the course of two summer field seasons. The level of detail of the source assessment for this project resulted in allocations to broad source categories. Therefore, additional monitoring may be helpful to better partition pollutant loading in areas with multiple sources. The following monitoring would help improve the understanding of *E. coli* loading in Musselshell watershed:

- Additional monitoring of *E. coli* for all of the Musselshell River and its tributaries, to span multiple field seasons.
- Monitoring during both high and low flow conditions. As *E. coli* exceedances occurred during all flow regimes more concerted sampling efforts could be made to collect samples during high and low flow events to get a better understanding of the potential impacts on *E. coli* loads
- Additional monitoring of *E. coli* on North Fork of the Musselshell including locations upstream and downstream of the confluence with Story Creek.
- Additional monitoring of *E. coli* upstream and downstream of MPDES permitted facilities to better understand potential contributions from these facilities.
- Additional monitoring of *E. coli* for the tributaries of the Musselshell where there is significant impacts from grazing to riparian areas. Additional monitoring will yield a better understanding of the *E. coli* sources located throughout the watershed.
- Stream discharge should be measured during all E. coli sampling efforts.

Below is information that could help strengthen the source assessment and help guide monitoring activities.

• Thorough analysis of the number of septic systems in the watershed, their proximity to surface water and their state of repair.
• A more detailed understanding of grazing and manure management practices within the watershed.
- A better understanding of waste management relative to all sources of human caused *E. coli*.

7.7 Consistent Data Collection and Methodologies

For those stakeholders that monitor water quality, it is recommended that the same analytical methods, procedures and reporting limits are used in order that *E. coli* data be comparable to TMDL targets (DEQ 2020b). It is important to note that *E. coli* sampling and analysis can be complicated by the 6-hour holding time restriction. In addition, stream discharge should be measured at time of sampling.

DEQ is the lead agency for developing and conducting impairment status monitoring; however, other agencies or entities may work with DEQ to provide compatible data. Water quality impairment determinations are made by DEQ, but data collected by other sources can be used in the impairment determination process and to help evaluate overall progress of restoration efforts.

7.8 Potential Funding and Technical Assistance Sources

Prioritization and funding of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies and also a few non-governmental organizations can provide assistance with watershed or water quality improvement projects or wetlands restoration projects. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (http://deq.mt.gov/Portals/112/Water/WPB/Nonpoint/Publications/Annual%20Reports/2017NPSManagementPlanFinal.pdf) and information regarding additional funding opportunities can be found at https://www.fedcenter.gov/opportunities/grants/

DEQ issues a call for proposals every year to award Section 319 grant funds administered under the federal CWA. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. In order to receive funding, projects must directly implement a DEQ-accepted WRP and funds may either be used for the education and outreach component of the WRP or for implementing restoration projects. The recommended range for 319 funds per project proposal is $10,000 to $30,000 for education and outreach activities and $50,000 to $300,000 for implementation projects. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit http://deq.mt.gov/Water/SurfaceWater/npspollution

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APPENDIX A – MUSSELSHELL TMDL PROJECT AREA DATA

LIST OF TABLES

This appendix contains four data tables. **Table A-1** contains all the data DEQ used to assess each of the waterbodies for attainment of the E. coli water quality standards. **Table A-2** includes surface water flow data collected in conjunction with water column nutrient data for all the stream sampling locations discussed in the Musselshell River TMDL. Nutrient data are not included in this appendix, as the TMDL was written solely for E. coli impairments. **Table A-3** contains silvicultural data from 1997-2004. This data was used periodically throughout the TMDL document and identifies the silvicultural practices that have taken place in select watersheds in the TMDL project area. **Table A-4** contains wildland fire data from 1995-2015. This data was used to define any potential impact to water quality in watershed where there were significant wildland fires.

All tables are included to aid readers in finding data more easily. Note that bolded values are those that exceeded the water quality criteria. Also, where no value is given, no data was collected.

The following codes appear in some of the tables:

- “<” symbols indicate non-detect samples where the detection limit is populated as the value
- E = Estimated flow measurement

Table A-1: Musselshell TMDL Project Area *E. coli* Sampling Data and Impairment Determination

Station Name	Sample Collection Date	Station ID	*E. coli* Result Value (cfu/100ml) (LRL = 1cfu/100ml)	Geometric Mean (cfu/100ml)	Is the Geometric Mean > 126 cfu/100mL?	Are at least 10% of the total samples > 252 cfu/100mL?	Impairment Determination
Big Coulee Creek	7/26/2016	M24BIGCC01	**1299.7**	-	*insufficient data*	YES (1/2 = 50%)	Impaired
	7/28/2016		248.1				
	9/27/2016		**488.4**	-	*insufficient data*	YES (2/2 = 100%)	
	9/29/2016		**488.4**				
Fish Creek	7/26/2016	M24FISHC09	13	-	*insufficient data*	YES (1/2 = 50%)	Impaired
	7/28/2016		**1413.6**				
	9/27/2016		**461.1**	-	*insufficient data*	YES (2/2 = 100%)	
	9/29/2016		**1119.9**				
Fords Creek, East Fork to mouth	9/28/2016	M26FORDC01	**1732.9**		*insufficient data*	YES (1/1 = 100%)	Impaired
Half Breed Creek	7/26/2016	M24HLFBC02	**980.4**	-	*insufficient data*	YES (2/2 = 100%)	Impaired
	7/28/2016	M24HLFBC03	**461.1**				
	9/27/2016		240	-	*insufficient data*	NO (0/2 = 0%)	
	9/29/2016		218.7				
McDonald Creek	7/27/2016	M26MCDLC01	**275.5**	-	*insufficient data*	YES (1/1 = 100%)	Impaired

Table A-1: Musselshell TMDL Project Area *E. coli* Sampling Data and Impairment Determination

	9/28/2016	M26MCDLC09	**770.1**	**-**	*insufficient data*	YES (1/3 = 33.3%)	
	9/28/2016	M26MCDLC01	129.6				
	9/28/2016	M26MCDLC06	85.7				
South Fork McDonald Creek	9/28/2016	M26MCSFC01	160.7	-	*insufficient data*	YES (1/2 = 50%)	Impaired
	9/28/2016	M26MCSFC02	**307.6**				
American Fork	7/26/2016	M24AMERF01	**613.1**	-	*insufficient data*	YES (1/2 = 50%)	Impaired
	7/28/2016		203.5				
North Fork Musselshell River, Bair Reservoir to mouth	7/26/2016	M24MSNF06	98.3	-	*insufficient data*	YES (1/2 = 50%)	Impaired
	7/28/2016		**325.5**				
Musselshell River, Flatwillow Creek to Fort Peck Reservoir (MT40C003_010)	8/10/2015	M28MUSSR01	41.4	51.11	NO	NO (0/5 = 0%)	Impaired
	8/11/2015		75.9				
	8/12/2015		35.4				
	8/17/2015		79.8				
	8/18/2015		39.3				
	7/27/2016		**461.1**	-	*insufficient data*	YES (1/1 = 100%)	
	9/27/2016		109.5	-	*insufficient data*	NO (0/2 = 0%)	
	9/29/2016		22.1				
Musselshell River, Deadman's Basin Canal to HUC Boundary Near Roundup (MT40A001_020)	8/10/2015	M24MUSSR04	72.8	52.04	NO	YES (2/15 = 13.3%)	Impaired
	8/11/2015		18.5				
	8/12/2015		53.7				
	8/17/2015		69.7				
	8/18/2015		**344.8**				
	8/10/2015	M24MUSSR05	38.1				
	8/11/2015		26.6				
	8/12/2015		14.5				

Table A-1: Musselshell TMDL Project Area *E. coli* Sampling Data and Impairment Determination

	8/17/2015		33.6				
	8/18/2015		248.1				
	8/10/2015	M24MUSSR06	21.1				
	8/11/2015		10.8				
	8/12/2015		46.8				
	8/17/2015		88.8				
	8/18/2015		**275.5**				
	7/26/2016	M24MUSSR06	10.6	-	*insufficient data*	No	
	7/28/2016		24.2				
	7/26/2016	M24MUSSR04	18.7				
	7/28/2016		20.2				
	7/26/2016	M24MUSSR05	15.2				
	7/28/2016		25.7				
	7/26/2016	M24MUSSR08	11.6				
	9/27/2016		13.4	-	*insufficient data*	No	
	9/27/2016	M24MUSSR06	14.4				
	9/29/2016		35				
Musselshell River, North and South Fork confluence to Deadman's Basin Canal (MT40A001_010)	7/13/2015	M24MUSSR10	62	186.65	YES	YES (4/15 = 26.7%)	Impaired
	7/14/2015		**410.6**				
	7/15/2015		**488.4**				
	7/20/2015		98.5				
	7/21/2015		185				
	7/13/2015	M24MUSSR03	76.8	163.54	YES		
	7/14/2015		129.6				
	7/15/2015		127.4				
	7/20/2015		238.2				

Table A-1: Musselshell TMDL Project Area *E. coli* Sampling Data and Impairment Determination

	7/21/2015		**387.3**				
	7/13/2015	M24MUSSR09	46.5	107.83	NO		
	7/14/2015		98.3				
	7/15/2015		225.4				
	7/20/2015		46				
	7/21/2015		**307.6**				
	7/26/2016	M24MUSSR09	7.4	-	*insufficient data*	NO (0/4 = 0%)	
	7/28/2016		15.5				
	7/26/2016	M24MUSSR10	43.7				
	7/28/2016		95.9				

- Indicates that insufficient data were available to calculate a geometric mean

BOLD values indicate exceedance of the water quality standard

Table A-2: Musselshell TMDL Project Area Flow Data				
Org ID	**Station (Site) Name**	**Site ID**	**Activity Date and Time**	**Flow (cfs)**
MDEQ_WQ_WQX	Trail Creek near headwaters	M24TRILC04	7/13/2015 17:30	0.05
MDEQ_WQ_WQX	Trail Creek just upstream FS Road 2019 crossing	M24TRILC03	7/13/2015 16:25	0.85
MDEQ_WQ_WQX	Trail Creek just upstream FS Road 2019 crossing	M24TRILC03	8/3/2015 15:05	0.52
MDEQ_WQ_WQX	Trail Creek just upstream FS Road 2019 crossing	M24TRILC03	8/31/2015 11:52	0.27
MDEQ_WQ_WQX	Trail Creek	M24TRILC05	8/4/2015 9:11	0.62
MDEQ_WQ_WQX	Trail Creek	M24TRILC05	9/1/2015 8:50	0.14
MDEQ_WQ_WQX	Trail Creek	M24TRILC05	7/8/2016 9:13	0.04
MDEQ_WQ_WQX	Trail Creek	M24TRILC05	7/25/2016 11:50	0.25
MDEQ_WQ_WQX	Trail Creek just upstream of the mouth	M24TRILC02	8/3/2015 12:10	1.67
MDEQ_WQ_WQX	Trail Creek just upstream of the mouth	M24TRILC02	8/31/2015 16:13	1
MDEQ_WQ_WQX	Trail Creek just upstream of the mouth	M24TRILC02	7/7/2016 14:13	0.04
MDEQ_WQ_WQX	Trail Creek just upstream of the mouth	M24TRILC02	7/26/2016 7:59	0.08
MDEQ_WQ_WQX	Trail Creek just upstream of the mouth	M24TRILC02	8/29/2016 13:30	0.1
MDEQ_WQ_WQX	Musselshell River North Fork just downstream Trail Creek confluence	M24MSNF08	8/3/2015 13:20	36.99
MDEQ_WQ_WQX	Musselshell River North Fork just downstream Trail Creek confluence	M24MSNF08	8/31/2015 16:53	16.8
MDEQ_WQ_WQX	Musselshell River North Fork just downstream Trail Creek confluence	M24MSNF08	7/7/2016 9:12	26.99
MDEQ_WQ_WQX	Musselshell River North Fork just downstream Trail Creek confluence	M24MSNF08	7/26/2016 12:00	42.85
MDEQ_WQ_WQX	Musselshell River North Fork at Forest Rd crossing near Cooper Creek	M24MSNF07	7/13/2015 13:23	57.87
MDEQ_WQ_WQX	Musselshell River North Fork at Forest Rd crossing near Cooper Creek	M24MSNF07	8/4/2015 10:09	40.49
MDEQ_WQ_WQX	Musselshell River North Fork at Forest Rd crossing near Cooper Creek	M24MSNF07	9/1/2015 9:43	19.81

Table A-2: Musselshell TMDL Project Area Flow Data				
Org ID	**Station (Site) Name**	**Site ID**	**Activity Date and Time**	**Flow (cfs)**
MDEQ_WQ_WQX	Musselshell River North Fork at Hwy 12 crossing	M24MSNF06	7/13/2015 16:26	29.67
MDEQ_WQ_WQX	Musselshell River North Fork at Hwy 12 crossing	M24MSNF06	8/4/2015 11:18	21.23
MDEQ_WQ_WQX	Musselshell River North Fork at Hwy 12 crossing	M24MSNF06	8/1/2016 13:30	2.56
MDEQ_WQ_WQX	Musselshell River North Fork near mouth	M24MSNF09	8/4/2015 15:00	22.21
MDEQ_WQ_WQX	Musselshell River North Fork near mouth	M24MSNF09	9/1/2015 12:44	4.91
MDEQ_WQ_WQX	Musselshell River North Fork near mouth	M24MSNF09	7/7/2016 16:15	5.72
MDEQ_WQ_WQX	Musselshell River North Fork near mouth	M24MSNF09	8/29/2016 15:00	8.96
MDEQ_WQ_WQX	Fish Creek at Hwy 191 crossing	M24FISHC11	7/16/2015 8:46	5.98
MDEQ_WQ_WQX	Fish Creek at Hwy 191 crossing	M24FISHC11	8/5/2015 14:50	5.18
MDEQ_WQ_WQX	Fish Creek at Hwy 191 crossing	M24FISHC11	9/2/2015 13:17	1.38
MDEQ_WQ_WQX	Fish Creek at Hwy 191 crossing	M24FISHC11	8/4/2016 12:05	0.25
MDEQ_WQ_WQX	Fish Creek at county road 12E102SC crossing	M24FISHC03	8/5/2015 11:39	4.65
MDEQ_WQ_WQX	Fish Creek at county road 12E102SC crossing	M24FISHC03	9/2/2015 10:52	1.27
MDEQ_WQ_WQX	Fish Creek at Taber Road crossing below Simmons Creek	M24FISHC10	7/14/2015 18:15	5
MDEQ_WQ_WQX	Fish Creek at Taber Road crossing below Simmons Creek	M24FISHC10	9/21/2015 13:01	6.57
MDEQ_WQ_WQX	Fish Creek at Hwy 300 crossing	M24FISHC09	7/14/2015 19:03	
MDEQ_WQ_WQX	Fish Creek at Hwy 300 crossing	M24FISHC09	8/7/2015 8:58	5.6
MDEQ_WQ_WQX	Fish Creek at Hwy 300 crossing	M24FISHC09	9/21/2015 14:10	5.18
MDEQ_WQ_WQX	Fish Creek at Hwy 300 crossing	M24FISHC09	7/15/2016 8:23	1.23
MDEQ_WQ_WQX	Fish Creek at Hwy 300 crossing	M24FISHC09	8/2/2016 15:00	1
MDEQ_WQ_WQX	Big Coulee Creek at Big Coulee Road crossing	M24BIGCC03	7/14/2015 14:35	2
MDEQ_WQ_WQX	Big Coulee Creek at Big Coulee Road crossing	M24BIGCC03	7/11/2016 15:13	0.05
MDEQ_WQ_WQX	Big Coulee Creek at Harms Road crossing	M24BIGCC04	7/14/2015 12:57	1.74
MDEQ_WQ_WQX	Big Coulee Creek at Harms Road crossing	M24BIGCC04	8/7/2015 11:47	1.31
MDEQ_WQ_WQX	Big Coulee Creek at Harms Road crossing	M24BIGCC04	9/21/2015 15:00	1.66
MDEQ_WQ_WQX	Big Coulee Creek at Harms Road crossing	M24BIGCC04	7/11/2016 17:12	0.66

Table A-2: Musselshell TMDL Project Area Flow Data

Org ID	Station (Site) Name	Site ID	Activity Date and Time	Flow (cfs)
MDEQ_WQ_WQX	Big Coulee Creek at Harms Road crossing	M24BIGCC04	9/19/2016 14:36	0.97
MDEQ_WQ_WQX	Big Coulee Creek at Cushman Road crossing	M24BIGCC05	7/14/2015 11:51	0.71
MDEQ_WQ_WQX	Big Coulee Creek at Cushman Road crossing	M24BIGCC05	8/7/2015 10:55	0.7
MDEQ_WQ_WQX	Big Coulee Creek at Cushman Road crossing	M24BIGCC05	9/21/2015 16:01	0.95
MDEQ_WQ_WQX	Big Coulee Creek at Cushman Road crossing	M24BIGCC05	7/11/2016 18:38	0
MDEQ_WQ_WQX	Big Coulee Creek at Cushman Road crossing	M24BIGCC05	8/4/2016 8:15	0
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	8/5/2015 16:34	0.47
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	7/14/2015 10:25	0.69
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	8/28/2015 16:20	0.27
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	9/21/2015 16:50	1
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	7/11/2016 20:04	0.85
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	8/3/2016 7:58	0.5
MDEQ_WQ_WQX	Big Coulee Creek near mouth	M24BIGCC01	8/30/2016 13:06	0.03
R8MONTWQ	Painted Robe Creek 1.5 miles above Jansen Road crossing	PTRB-01A	9/29/2010 12:30	0.1
MDEQ_WQ_WQX	Painted Robe Creek at lower crossing on Painted Robe Road	M24PTRBC05	7/21/2015 13:28	0.2
MDEQ_WQ_WQX	Painted Robe Creek at lower crossing on Painted Robe Road	M24PTRBC05	8/18/2015 11:23	1
MDEQ_WQ_WQX	Painted Robe Creek at lower crossing on Painted Robe Road	M24PTRBC05	9/22/2015 9:10	0
R8MONTWQ	Painted Robe Creek at Buffalo Road crossing and Hwy 3	PTRB-02	9/29/2010 15:30	0.75
MDEQ_WQ_WQX	Painted Robe Creek at Hwy 3 crossing	M24PTRBC04	7/21/2015 12:36	0
MDEQ_WQ_WQX	Painted Robe Creek at Buffalo Way crossing	M24PTRBC07	7/21/2015 14:56	0
MDEQ_WQ_WQX	Painted Robe Creek at Buffalo Way crossing	M24PTRBC07	8/18/2015 10:40	0
MDEQ_WQ_WQX	Painted Robe Creek at Buffalo Way crossing	M24PTRBC07	9/22/2015 8:30	0
MDEQ_WQ_WQX	Painted Robe Creek about 2.5 miles upstream from mouth	M24PTRBC01	8/11/2015 10:28	0.02

Table A-2: Musselshell TMDL Project Area Flow Data

Org ID	Station (Site) Name	Site ID	Activity Date and Time	Flow (cfs)
R8MONTWQ	Painted Robe Creek at Three Pines Road crossing near mouth	PTRB-03	9/29/2010 17:15	0.36
MDEQ_WQ_WQX	Painted Robe Creek near mouth at Three Pines Rd crossing	M24PTRBC02	7/21/2015 11:28	0.07
MDEQ_WQ_WQX	Painted Robe Creek near mouth at Three Pines Rd crossing	M24PTRBC02	9/21/2015 17:47	0.5
MDEQ_WQ_WQX	Painted Robe Creek near mouth at Three Pines Rd crossing	M24PTRBC02	7/14/2016 12:56	0.02
MDEQ_WQ_WQX	Painted Robe Creek near mouth at Three Pines Rd crossing	M24PTRBC02	8/3/2016 9:00	0
MDEQ_WQ_WQX	Painted Robe Creek near mouth at Three Pines Rd crossing	M24PTRBC02	9/19/2016 15:48	0
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	7/14/2016 17:56	0.22
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	7/21/2015 9:03	0.65
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	8/18/2015 8:14	0.36
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	9/22/2015 10:30	0.37
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	8/2/2016 18:25	0.41
MDEQ_WQ_WQX	Half Breed Creek at Johnny's Coal Rd	M24HLFBC03	8/30/2016 15:00	0.04
MDEQ_WQ_WQX	Half Breed Creek at Hwy 87 crossing	M24HLFBC04	7/21/2015 10:03	0.8
MDEQ_WQ_WQX	Half Breed Creek at Hwy 87 crossing	M24HLFBC04	8/18/2015 8:50	1.0
MDEQ_WQ_WQX	Half Breed Creek at Hwy 87 crossing	M24HLFBC04	9/22/2015 11:11	0.8
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	7/15/2016 8:42	0.2
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	7/21/2015 7:50	0.8
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	8/11/2015 16:03	0.4
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	9/22/2015 12:14	0.7
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	8/3/2016 11:43	1.0
MDEQ_WQ_WQX	Half Breed Creek about 80 yards above mouth	M24HLFBC02	8/29/2016 15:45	
MDEQ_WQ_WQX	North Willow Creek downstream Griffith Road crossing	M25WILNC11	7/22/2015 9:08	0.0

Table A-2: Musselshell TMDL Project Area Flow Data

Org ID	Station (Site) Name	Site ID	Activity Date and Time	Flow (cfs)
MDEQ_WQ_WQX	North Willow Creek downstream Griffith Road crossing	M25WILNC11	7/13/2016 18:59	1.0
MDEQ_WQ_WQX	North Willow Creek downstream Griffith Road crossing	M25WILNC11	8/1/2016 19:11	0.0
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	7/22/2015 11:35	0.0
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	8/12/2015 15:27	0.0
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	9/22/2015 17:18	0.3
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	7/13/2016 13:12	0.0
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	8/1/2016 16:42	0.0
MDEQ_WQ_WQX	North Willow Creek at Fourmile Road crossing	M25WILNC07	8/31/2016 11:03	1.0
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	7/22/2015 14:10	0.0
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	8/12/2015 12:14	0.0
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	9/24/2015 11:24	0.0
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	7/13/2016 17:01	0.1
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	8/2/2016 10:53	0.0
MDEQ_WQ_WQX	North Willow Creek at Hwy 500 crossing near mouth	M25WILNC06	9/21/2016 9:17	0.0

Table A-3: North Fork Musselshell River Silvicultural Activities 1997-2004				
Administrative District	**Sale Name**	**Activity**	**Date Complete**	**Acres**
Judith Ranger District	DEAD CLYDE	Salvage Cut (intermediate treatment, not regeneration)	January 1, 1998	8
Judith Ranger District	DEAD CLYDE	Stand Clearcut (EA/RH/FH)	February 1, 1998	10
Judith Ranger District	DEADHORSE CREEK RHR SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	October 22, 2015	15.9
Judith Ranger District	HOOVER	Group Selection Cut (UA/RH/FH)	October 1, 1997	44
Judith Ranger District	HOOVER	Improvement Cut	October 1, 1997	56
Musselshell Ranger District		Salvage Cut (intermediate treatment, not regeneration)	August 25, 2011	37
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	33
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	32
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	37
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	40
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	18
Musselshell Ranger District	CROSSWINDS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	September 1, 1997	18

Musselshell Ranger District	DEAD CLYDE	Stand Clearcut (EA/RH/FH)	February 1, 1998	7
Musselshell Ranger District	DEADHORSE CREEK RHR SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	November 16, 2015	27
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	July 1, 1997	6
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	5
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	8
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	13
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	13
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	4
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	5
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	5
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	9
Musselshell Ranger District	FOOTHILLS SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 1997	5
Musselshell Ranger District	HENSLEY	Group Selection Cut (UA/RH/FH)	August 1, 2000	24
Musselshell Ranger District	HENSLEY	Group Selection Cut (UA/RH/FH)	October 1, 2003	28
Musselshell Ranger District	HENSLEY	Group Selection Cut (UA/RH/FH)	September 1, 2004	25
Musselshell Ranger District	SPRING BASIN	Two-aged Seed-tree Seed and Removal Cut (w/res) (2A/RH/FH)	January 1, 1998	21
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	January 1, 1998	10

Musselshell Ranger District	SPRING BASIN	Two-aged Seed-tree Seed and Removal Cut (w/res) (2A/RH/FH)	January 1, 1998	18
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	January 1, 1998	4
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	January 1, 1998	7
Musselshell Ranger District	SPRING BASIN	Two-aged Seed-tree Seed and Removal Cut (w/res) (2A/RH/FH)	January 1, 1998	10
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	February 1, 1998	17
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	June 1, 1998	25
Musselshell Ranger District	SPRING BASIN	Seed-tree Seed Cut (with and without leave trees) (EA/RH/NFH)	June 1, 1998	10
Musselshell Ranger District	SPRING BASIN	Two-aged Seed-tree Seed and Removal Cut (w/res) (2A/RH/FH)	July 1, 2004	16
Musselshell Ranger District	SPRING BASIN	Two-aged Seed-tree Seed and Removal Cut (w/res) (2A/RH/FH)	July 1, 2004	22
Musselshell Ranger District	WHITETAIL SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	August 23, 2011	28
White Sulphur Springs Ranger District	POWERLINE SALVAGE	Salvage Cut (intermediate treatment, not regeneration)	December 1, 2003	3

Table A-4: North Fork of the Musselshell River USFS Reported Wildland Fires 1995- 2015				
National Forest	Fire Name	Fire Cause	Containment Date	Fire Size
Lewis & Clark National Forest	ANT PARK #6	Lightning	1995-09-04	0.1
Lewis & Clark National Forest	ANT PARK #8	Lightning	1995-09-04	0.1
Lewis & Clark National Forest	BASIN	Lightning	2004-09-01	2
Lewis & Clark National Forest	CHECKERBOARD	Lightning	2007-07-07	0.1
Lewis & Clark National Forest	CHECKERBOARD CREE,	Lightning	1992-06-13	0.1
Lewis & Clark National Forest	COOPER CREEK	Lightning	2002-07-26	13
Lewis & Clark National Forest	CROSS CREEK	Lightning	1996-07-10	0.5
Lewis & Clark National Forest	FLAGSTAFF	Lightning	1993-05-04	0.1
Lewis & Clark National Forest	FRIEZ	Lightning	2006-07-03	0.2
Lewis & Clark National Forest	GREEN CANYON	Lightning	1994-08-06	3
Lewis & Clark National Forest	HOOVER	Lightning	1999-08-19	0.3
Lewis & Clark National Forest	HOOVER	Lightning	2005-07-15	0.1
Lewis & Clark National Forest	HOOVER GATE	Lightning	2006-08-10	0.1
Lewis & Clark National Forest	HOOVER SPRINGS	Lightning	2012-07-23	0.5
Lewis & Clark National Forest	JAMISON TRIAL	Lightning	1996-07-03	0.1
Lewis & Clark National Forest	KENTS GULCH	Lightning	1994-07-22	0.1
Lewis & Clark National Forest	KENTS GULCH	Lightning	2011-09-03	0.25
Lewis & Clark National Forest	LION CREEK	Lightning	2003-08-14	0.1
Lewis & Clark National Forest	LION CREEK	Lightning	2005-07-16	0.1
Lewis & Clark National Forest	LIONS	Lightning	2011-07-31	0.5
Lewis & Clark National Forest	LIONS	Lightning	2015-09-06	0.1
Lewis & Clark National Forest	LOST FORK	Miscellaneous	2001-10-05	2338
Lewis & Clark National Forest	MILL CREEK	Campfire	2011-10-03	0.25
Lewis & Clark National Forest	MILL LION	Equipment Use	1994-08-24	0.1
Lewis & Clark National Forest	MOUNT HOWE	Lightning	2012-08-10	0.1
Lewis & Clark National Forest	MUDDY MTN	Lightning	1994-08-10	0.1
Lewis & Clark National Forest	ORCUTT GULCH	Lightning	2002-06-29	0.1
Lewis & Clark National Forest	PASTURE GULCH	Lightning	2001-08-05	0.1
Lewis & Clark National Forest	POWER LINE	Miscellaneous	1999-10-31	2
Lewis & Clark National Forest	SPRING CREEK	Miscellaneous	2007-08-01	0.5

Table A-4: North Fork of the Musselshell River USFS Reported Wildland Fires 1995- 2015				
Lewis & Clark National Forest	SPRING CREEK	Miscellaneous	2010-09-24	0.1
Lewis & Clark National Forest	SPRING CREEK	Debris Burning	2012-07-11	0.5
Lewis & Clark National Forest	SPRING CREEK	Lightning	2015-09-13	0.1
Lewis & Clark National Forest	SPRING CREEK EAST	Lightning	2001-08-05	0.3
Lewis & Clark National Forest	STOHR CREEK	Lightning	1999-07-21	0.1
Lewis & Clark National Forest	TRAIL CREEK	Lightning	1996-08-17	0.1
Lewis & Clark National Forest	TRAIL CREEK	Lightning	1998-09-23	0.1
Lewis & Clark National Forest	TRAIL CREEK	Debris Burning	2004-07-01	0.01