Montana Department of Environmental Quality

Bitterroot River Nutrient Protection Plan

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The title page photograph is of the Bitterroot River at during high spring flow conditions. Rigorous streamside vegetation is shown stabilizing the streambanks and dissipating flood energy.

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ACRONYMS

BMP – Best Management Practice
cfs – cubic feet per second
CRA – Community Readiness Assessment
CWA – Clean Water Act
DEQ – Montana Department of Environmental Quality
EPA – United States Environmental Protection Agency
IR – Integrated Report
lbs/day – pounds per day
mg/L – milligram per liter (equivalent to parts per million, or ppm)
MPDES – Montana Pollution Discharge Elimination System
NHD – National Hydrography Database
TMDL – Total Maximum Daily Load
TMDL Document – A document produced by DEQ to describe the total maximum daily load of a pollutant that a waterbody can receive and still maintain all of its beneficial uses. The document typically also contains pollutant source assessment information and a restoration strategy.
TN – total nitrogen
TP – total phosphorus
WRP – Watershed Restoration Plan
WWTF – Wastewater Treatment Facility
14Q5 – A 14-day, 5 year average low flow condition

DOCUMENT SUMMARY

This document presents a voluntary nutrient protection plan for the mainstem Bitterroot River. The Bitterroot River remains unimpaired by nutrients, a condition unique for Montana rivers of similar size and setting. The Bitterroot River Nutrient Protection Plan identifies and helps minimize risks to this high-quality condition. It complements the Bitterroot Watershed Restoration Plan (Bitter Root Water Forum, 2020) by coarsely focusing on the entire watershed, including point and nonpoint sources.

The Protection Plan quantifies current nutrient concentrations in the river and compares the data to suggested target values. It also estimates risks to the high-quality condition from sources including:

- Natural background
- Nutrient impaired tributaries
- Municipal wastewater facilities
- Septic systems
- Other nonpoint sources

Natural background nutrient loading is the largest contributor of nutrients in the watershed, which is reasonably expected because the Bitterroot is not impaired by nutrients. Wastewater treatment facilities and septic systems are another major source of nutrient pollution; nitrogen primarily coming from septic systems and phosphorus primarily coming from wastewater treatment facilities.

Although nutrient impaired tributaries are one of the smaller sources of nutrients to the Bitterroot River, actions to restore these waters should be prioritized. In their impaired state, these tributaries do not fully support aquatic life nor primary contact recreation.

Nonpoint sources of pollution are a large contributor of nitrogen to the Bitterroot River, although phosphorus loading was estimated to be very low or even negative. It is more likely that phosphorus from nonpoint sources of pollution does reach the Bitterroot River, but that the range of error in source estimates are larger. Regardless, it is reasonable to expect that nonpoint sources of pollution are of greater concern for nitrogen because phosphorus is less mobile. Additionally, phosphorus is likely the limiting and more readily utilized nutrient in the Bitterroot River.

This Protection Plan analyzed two population growth scenarios: one where a given increase in population was placed on individual septic systems, and one where the same population increase was connected to municipal wastewater treatment. The results suggest that an increase in septic systems will more rapidly exhaust the river's capacity to take on additional nutrient load and continue supporting beneficial uses. Households should be hooked up to municipal or centralized wastewater treatment facilities wherever possible to protect the nutrient status of the Bitterroot River. Where this is not possible, households should be built with Level II or higher septic systems to minimize nutrients reaching the Bitterroot River.

Population growth and increased development is anticipated in the Bitterroot watershed, which will impact all categories of nutrient sources considered in this document. This Protection Plan provides recommendations for best management practices and effectiveness monitoring that ensure this development proceeds in the most sustainable way for maintaining water quality.

Finally, this document contains recommendations only and does not create any legally binding requirements. Any conclusions or recommendations contained herein are not intended to dictate future land use decisions, permit limits, impairment determinations, or Total Maximum Daily Load development.

1.0 INTRODUCTION

This document presents a voluntary protection plan for avoiding and minimizing nutrient pollution in the Bitterroot River. The protection plan concerns the entirety of the Bitterroot River watershed (**Fig. 1.1**).

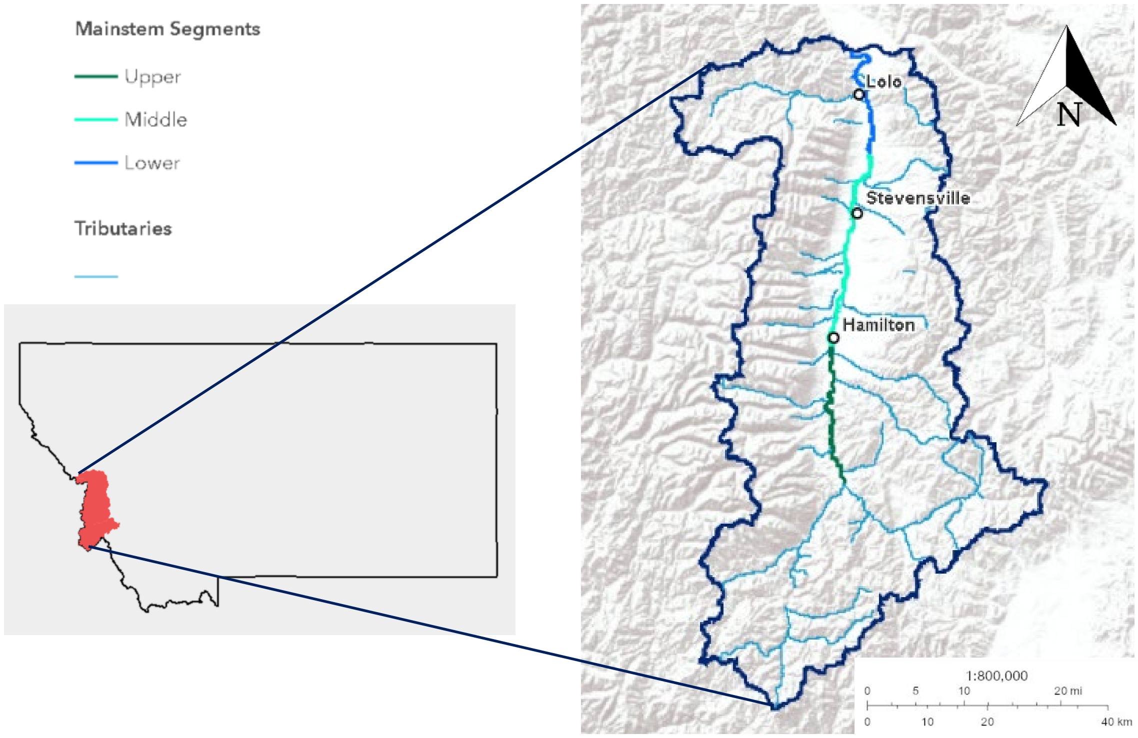

Figure 1.1. Location of the Bitterroot River watershed, including the three mainstem segments: the mouth of the Bitterroot River to Eightmile Creek near Florence, Eightmile Creek to Skalkaho Creek near Hamilton, and Skalkaho Creek to the confluence of the East and West Forks Bitterroot River.

1.1 Why we Write Protection Plans

Montana's Constitution is unique in the nation for ordaining a clean and healthy environment as an inalienable right and is one of only three constitutions in the nation that recognizes environmental interests for future generations. It directs that "the state and each person shall *maintain* and improve a clean and healthful environment" (emphasis added", and this need to maintain high quality water is reiterated in the federal Clean Water Act and Montana Water Quality Act.

Montana classifies its waterbodies according to present and future beneficial uses they are expected to support (§ 75-5-301, MCA), including:

1. Fish and aquatic life
2. Wildlife
3. Recreation
4. Agriculture
5. Industry
6. Drinking water

Each waterbody in Montana has a set of designated 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 designated uses, and every two years the Montana Department of Environmental Quality (DEQ) prepares a Water Quality Integrated Report (IR) which lists all impaired waterbodies and identified impairment causes. Impairment causes fall within two main categories: pollutant (e.g., nutrients) and non-pollutants (e.g., loss of streamside vegetation).

Waterbodies that have been monitored by the state are also referred to by their “assessment unit.” Assessment units can be the full length of a stream or the full extent of a lake or reservoir, or they may be 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. Due to its length, the Bitterroot River has three assessment units, or three stream segments (**Table 1.1**).

Montana’s biennial IR identifies all the state’s impaired waterbody segments in the 303(d) list. Total Maximum Daily Loads (TMDLs, or a water quality improvement plan) are required for each pollutant on the list. **Table 1.1** identifies all impairments along the mainstem Bitterroot from Montana’s 2020 303(d) List (DEQ, 2020; see **Section 5.3** for a discussion about impaired tributaries). While the Bitterroot River has impairments, it remains unimpaired by nutrients. As **Section 2.0** describes, this is unique for Montana rivers of similar size and setting, and protection planning helps identify and minimize risks to this high-quality condition.

Table 1.1. Water quality impairment causes for the mainstem Bitterroot River.

Waterbody (Assessment Unit)[1]	Waterbody ID (Assessment Unit ID)	Impairment Cause	Impairment Cause Status
BITTERROOT RIVER, East and West forks to Skalkaho Creek	MT76H001_010	Alteration in stream-side vegetation	Non-pollutant, no TMDL required
BITTERROOT RIVER, Skalkaho Creek to Eightmile Creek	MT76H001_020	Flow	Non-pollutant, no TMDL required
		Temperature	TMDL completed (DEQ, 2011)
BITTERROOT RIVER, Eightmile Creek to mouth (Clark Fork River)	MT76H001_030	Alteration in stream-side vegetation	Non-pollutant, no TMDL required
		Lead	TMDL completed (DEQ & EPA, 2014)
		Temperature	TMDL completed (DEQ, 2011)

[1]All assessment units within Montana’s Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD).

Protection plans can be developed by state or local entities. The Bitterroot River Watershed Restoration Plan (WRP; Bitter Root Water Forum, 2020) identifies the Bitterroot River as a priority for water quality protection. The primary difference between the Bitterroot WRP and this Protection Plan is the spatial and community scope. This Protection Plan coarsely focuses on the entire Bitterroot River watershed, whereas the Bitterroot WRP focuses on 13 priority streams. This Protection Plan also incorporates voluntary protection actions that can be taken by point sources and municipalities, whereas the Bitterroot WRP focuses on nonpoint source pollution issues and landowner-scale actions. Both types of plans are highly valuable for their varied stakeholder engagement and ability to inform ongoing and future planning efforts.

The goal of the Bitterroot River Nutrient Protection Plan is to document strategies and activities that avoid water quality degradation from nutrient stressors. The document also includes measures to evaluate success at implementing this plan, with the intent that these measures may be revisited in the future (e.g., every 5 years). This Protection Plan is non-regulatory and entirely voluntary. Engaging in water quality protection will help avoid costs of:

- lost revenue from recreation, property value, and other beneficial uses;
- expanded restoration efforts; and
- increased water treatment.

Many of the same activities recommended to protect the Bitterroot from nutrient pollution can lead to water quality restoration for the existing impairments identified in **Table 1.1**.

1.2 What this Document Contains

This document includes components required for an implementable protection plan, including:

1. A description of physical and social characteristics of the Bitterroot River watershed (**Sections 1.4** and **2.0**)
2. A discussion of suggested water quality targets and the identification of high quality water (**Section 3.0** and **4.0**)
3. Risks to the high quality condition (**Section 5.0**)
4. An estimate of a time frame over which a protection target is expected to be maintained (**Sections 6.0 and 8.1**)
5. A summary of ongoing and proposed activities to resist degradation of high quality water (**Section 7.0**)
6. Measures of success of maintaining high quality water (**Sections 7.0 and 8.0**)
7. Planned responses to observed changes in risks or high quality condition (**Section 9.0**)
8. A description of stakeholders who were involved in the development of this plan, and the public participation process used to develop the document

The document contains input from local stakeholders throughout. The concept of a protection plan was presented to Bitterroot stakeholders in the summer of 2020, and the draft document was shared with stakeholders the following winter amidst a 4-week public comment period. DEQ reached out to the following stakeholder groups:

- Bitter Root Water Forum
- Bitterroot Conservation District
- Bitterroot National Forest
- Bitterroot River Protection Association
- Cities of Stevensville, Hamilton, and Darby
- Clark Fork Coalition
- Lee Metcalf National Wildlife Refuge
- Lolo National Forest
- Lolo Watershed Group
- Missoula Conservation District
- Missoula County & Water Quality District
- Ravalli County Environmental Health
- Trout Unlimited
- University of Montana

1.3 Nutrient Sources and Effects of Pollution in the Bitterroot Watershed

Nitrogen and phosphorus are naturally occurring elements required for healthy functioning of aquatic ecosystems. Streams are dynamic systems that depend on a balance of nutrients from various sources. Healthy streams strike a balance between organic and inorganic nutrients from sources such as natural erosion, groundwater discharge, and instream biological decomposition. This balance relies on autotrophic organisms to consume nutrients (e.g., algae fixes nitrogen and phosphorus), on higher organisms in the food chain to consume those fixed nutrients (e.g. macroinvertebrates and fish), and on nutrient decomposition (e.g., changing organic, fixed nutrients back into inorganic forms). Human influences may alter nutrient cycling by adding excess nutrients or altering the food chain, damaging biological stream function and degrading water quality (**Figure 1.2**).

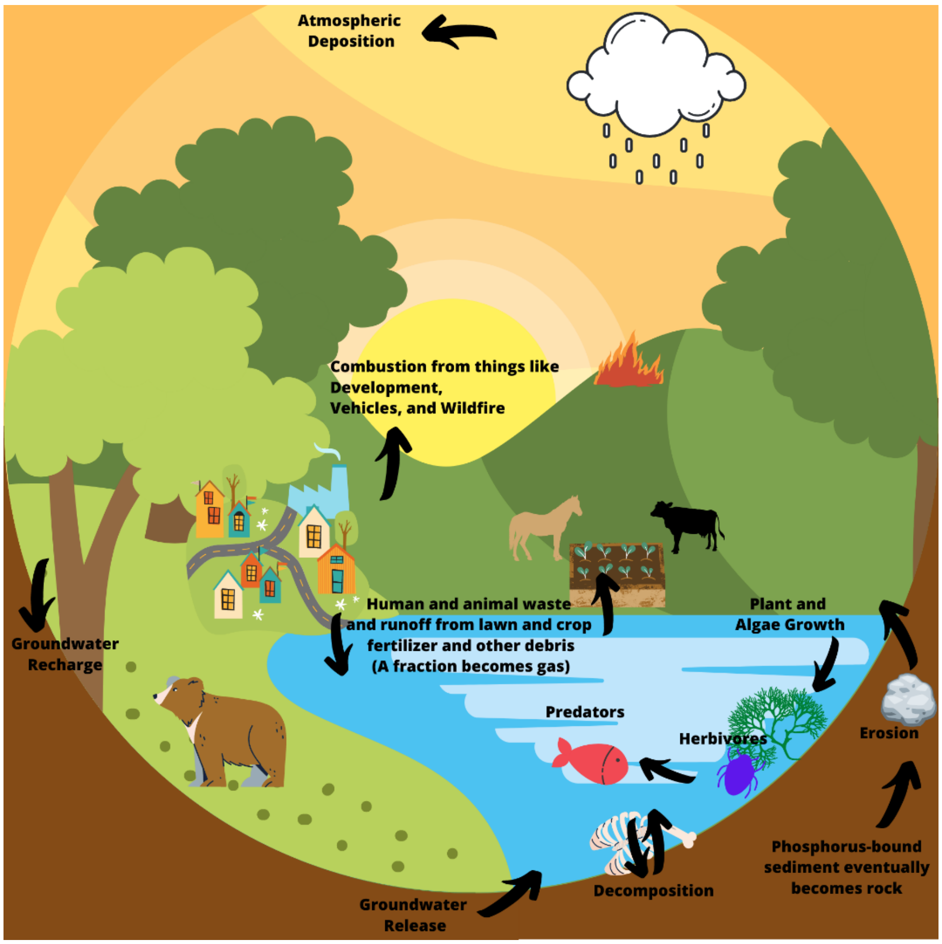

Figure 1.2. Diagram depicting how nutrients (nitrogen and phosphorus) cycle through a landscape. Too much or too little of any pathway, such as too much human or animal waste or too little vegetation, can overwhelm the balance.

Human-caused sources of nutrient pollution in the Bitterroot watershed include forestry and silviculture operations, road and streambank erosion, stormwater, fertilizers (e.g. from croplands, orchards, golf courses, and lawns), human and animal waste, and atmospheric contributions (e.g., wildfire smoke). A common trait of each of these nutrient sources is a loss of native vegetation, which results in soil erosion and less water storage in soil. Streamside vegetation is particularly effective at protecting streams and rivers from nutrients and other causes of pollution. Not only does it physically buffer surface water from pollution run off and secure streambanks against erosion, but the vegetation itself uptakes nitrogen and uses it for growth.

Recreation and agriculture are two major industries in the Bitterroot watershed that would likely be affected by an increase in nutrients. The Bitterroot River is a renowned fishery that routinely ranks among the top 10 in the state for angler days, with nearly 50% of those days driven by out-of-state visitors (FWP, 2017; 2015). Excess nitrogen in the form of dissolved ammonia (which is typically associated with wastewater) can be toxic to fish and other aquatic life. In addition, excess nitrogen and phosphorus can cause an overabundance of algal growth, which in turn depletes the supply of dissolved oxygen, killing fish and other aquatic life. Nuisance algae can reduce water clarity and shift the structure of macroinvertebrate communities, which may also negatively affect the fish that feed on macroinvertebrates. Certain types of algae blooms, known as cyanobacteria blooms, can produce toxins lethal to aquatic life, wildlife, livestock, and humans. Furthermore, algal growth in irrigation canals can severely limit carrying capacity to deliver water to water users. Changes in water clarity and aesthetics can harm property values and recreational uses, such as swimming, and boating (**Figure 1.3**; Wolf and Klaiber, 2017; Suplee et al. 2009).

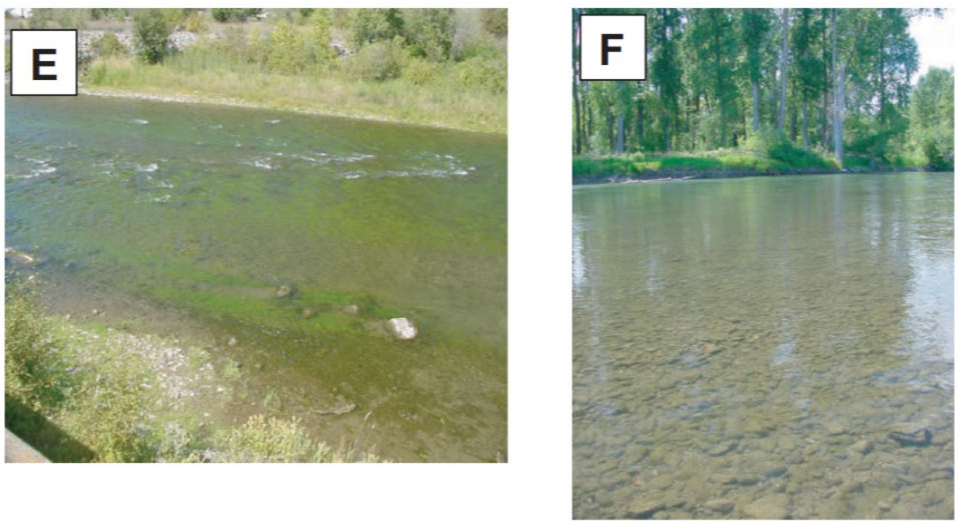

Figure 1.3. Image E represents the point at which a majority of survey respondents found conditions "undesirable" for recreation. Image F represents the highest concentration of chlorophyll-a that survey respondents found “desirable” for recreation. Images from Suplee et al. 2000.

Besides recreation and agricultural industries, nutrient pollution can have broad implications for general community welfare. Excess nitrogen in the form of nitrate in drinking water can inhibit normal hemoglobin function in infants; a scenario especially of concern for people with individual drinking water wells. Nuisance algae can also increase the cost of treating drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

2.0 BITTERROOT RIVER WATERSHED DESCRIPTION

Section 2.0 of the Bitterroot Watershed TMDL and Water Quality Improvement Plan (DEQ & EPA, 2014) provides a thorough description of physical, ecological, and cultural characteristics in the Bitterroot Watershed.

The mainstem Bitterroot River is unique amongst Montana rivers of similar size and setting. The watershed has one of the fastest growing populations in the state (DOC & REMI, 2020; **Figure 2.1**), several of its tributaries are impaired by nutrients, and yet the river mainstem is not (**Figure 2.2**). An increase in population brings changes in land use. For example, 87% of homes built in Ravalli County between 1990 and 2018 are situated outside of incorporated city boundaries (Hernandez, 2018). Rather than development linked into a municipal wastewater treatment system, these new residences use individual septic systems to treat human waste. Individual septic systems are excluded from state groundwater permitting requirements, county septic regulations vary across the state, and often there is no mechanism for ensuring aged systems are properly maintained or sited. Septic systems can affect the quality of nearby surface water or drinking water wells if not properly placed, functioning, or maintained. New development also co-occurs with an increase in impervious surfaces. During storm events, impervious surfaces can concentrate stormwater, thereby increasing erosion and delivery of pollutants to surface waters. Additionally, impervious surfaces prevent water from percolating below ground and recharging groundwater.

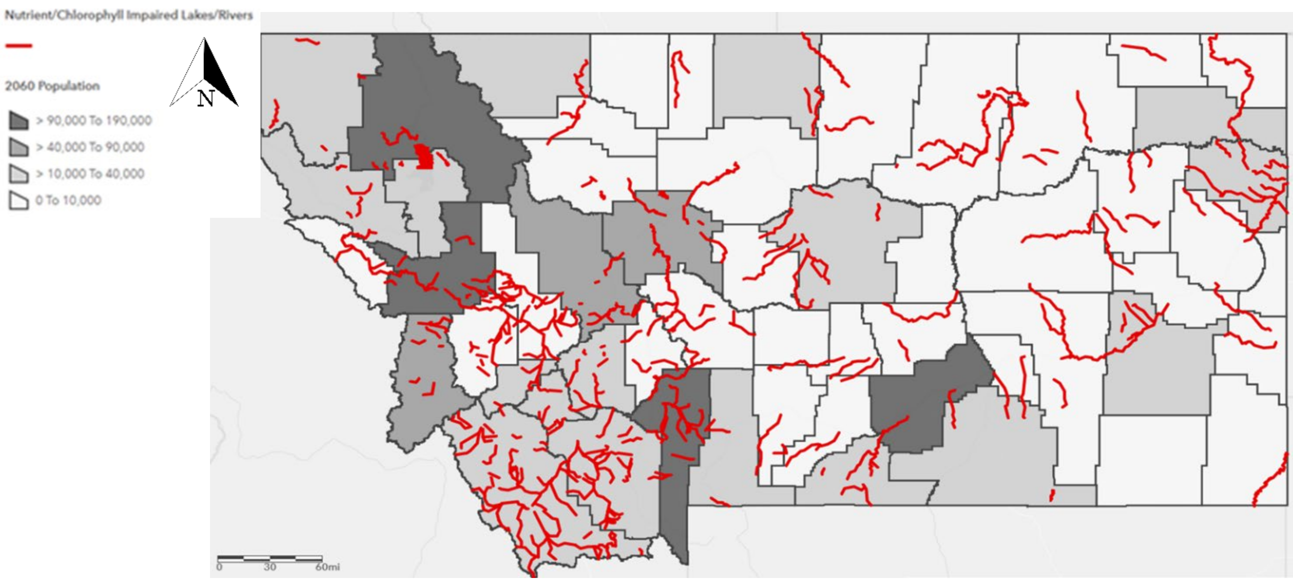

Figure 2.1. Projected population for 2060 by county (DOC & REMI, 2020), overlaid by rivers and lakes with nutrient or chlorophyll-*a* impairment. The Bitterroot River watershed, which is encompassed by Ravalli County and a small portion of southern Missoula County, is within some of the fastest growing counties in the state. It is rare for rivers of similar size and setting to not have a nutrient impairment.

Population growth and the accompanying land use changes are an inevitability for the Bitterroot River watershed. This protection plan is intended to provide proactive tools and information to ensure this development occurs in a way most protective of the Bitterroot River. By maintaining the high-quality condition of the Bitterroot River, municipalities can avoid high costs of increased drinking water and waste water treatment. Individual landowners may have less concern about their groundwater or irrigated water supply. Downstream communities, such as those along the nutrient-impaired Clark Fork River, may enjoy the nutrient diluting benefits of the Bitterroot River.

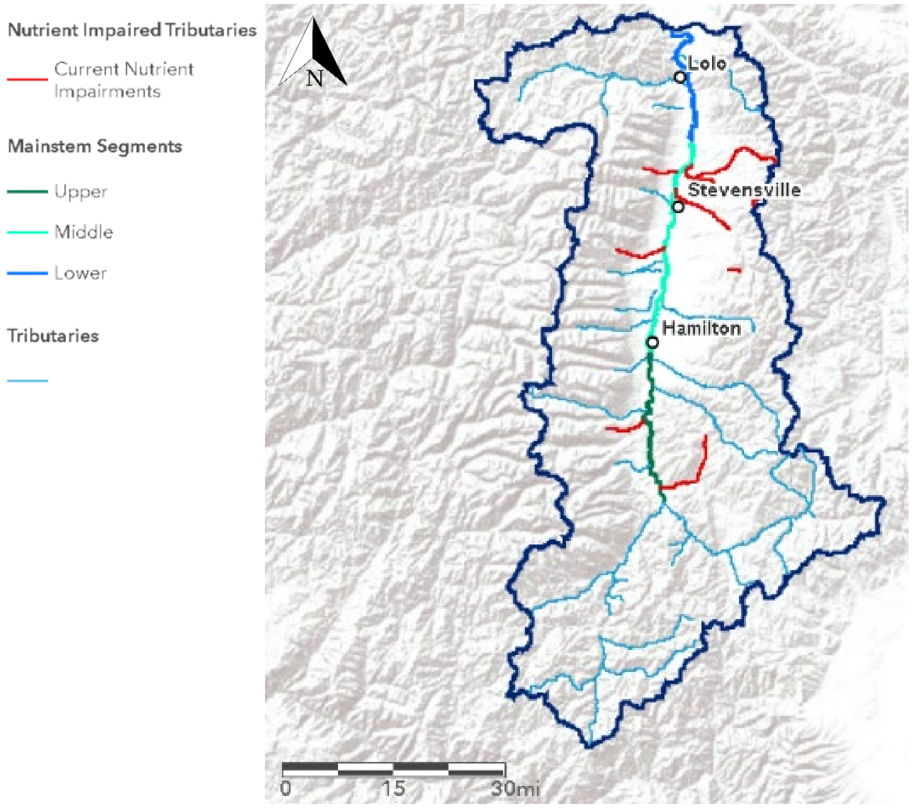

Figure 2.2. Bitterroot River watershed map showing tributaries that are currently impaired by nutrients.

3.0 INSTREAM NUTRIENT CONDITIONS OF THE BITTERROOT RIVER

Suggested ecoregional nutrient targets for the Northern Rockies Ecoregion are 0.3 mg/L total nitrogen and 0.03 mg/L total phosphorus (Suplee & Watson, 2013). Data from each of the three Bitterroot River segments (**Figure 3.1**) show nutrient concentrations consistently below suggested nitrogen and phosphorus concentration targets (**Figure 3.2**). This was true during the TMDL development period (2002-2012), and for a time period that includes more recent data (2007-2017). This demonstrates nutrient conditions in the Bitterroot River are high-quality and protective against algal growth that would compromise beneficial uses of the resource.

Between the two time periods evaluated, the 75th percentile nitrogen concentration increased for the three segments of the Bitterroot River. Although the difference is not statistically different ($p > 0.05$), the potential change is concerning because there is little capacity for the river to receive increased nitrogen and continue to support beneficial uses (**Figure 4.1**). The 75th percentile phosphorus concentration has decreased for the three segments of the Bitterroot, although the difference is not statistically significant. The 75th percentile nutrient concentration is emphasized because it presents a worst-case scenario compared to an average.

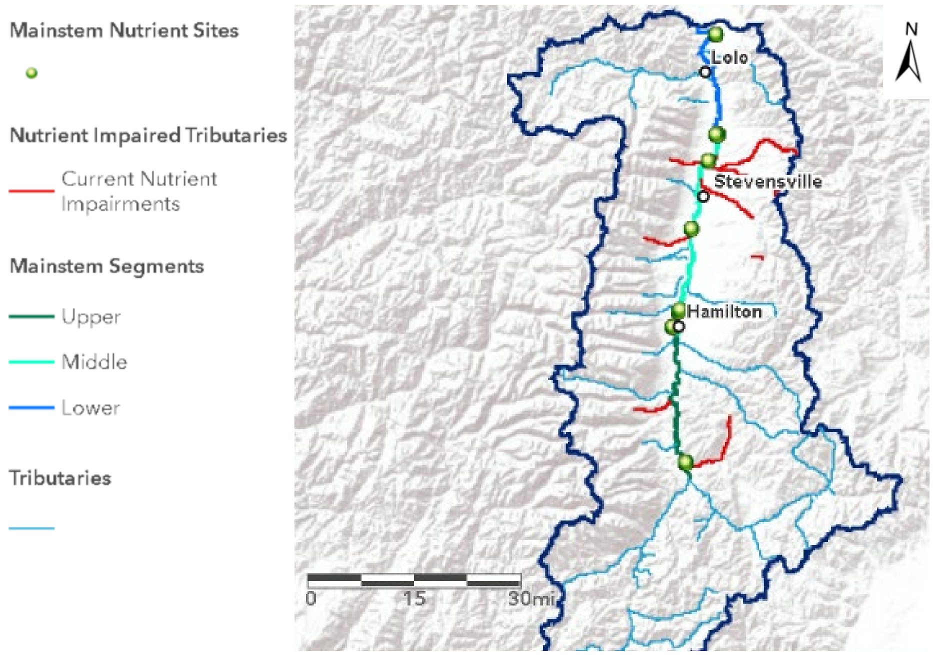

Figure 3.1. Mainstem nutrient sample locations relative to the Bitterroot River segments and tributaries.

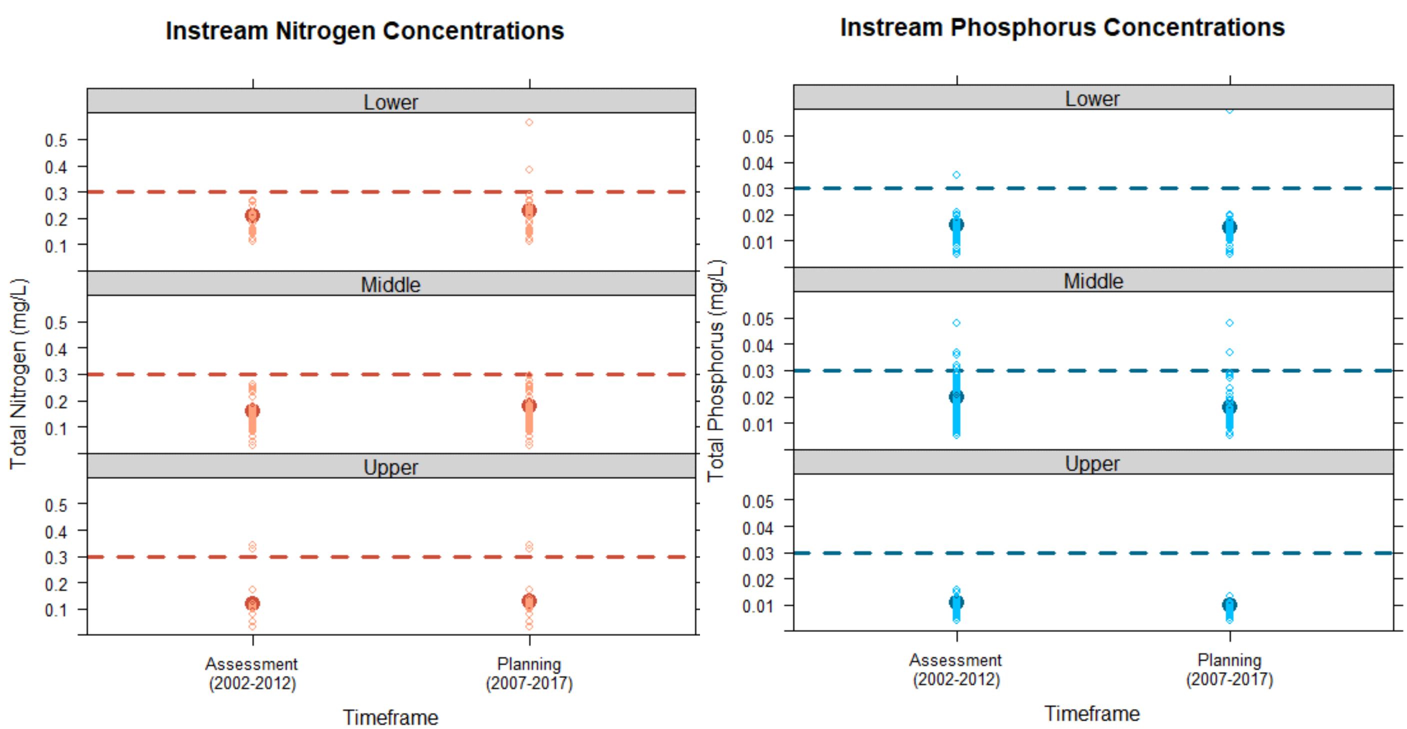

Figure 3.2. Nitrogen (red) and phosphorus (blue) concentrations in the Upper, Middle, and Lower Bitterroot River segments. Hollow data points represent samples taken within each segment, and solid data points show the 75th percentile concentration. Data was compared across two time periods, 2002-2012 during water quality assessment for TMDL development, and 2007-2017 to include more recent data. Dashed lines represent suggested nitrogen and phosphorus concentration targets.

Table 3.1. The sites from which nutrient data was evaluated for Figure 3.2

Assessment Unit (AU)		Number of Total Nitrogen Samples		Number of Total Phosphorus Samples	
		(2002-2012)	(2007-2017)	(2002-2012)	(2007-2017)
Upper	MT76H001_010, East and West forks to Skalkaho Creek	14	20	33	21
Middle	MT76H001_020, Skalkaho Creek to Eightmile Creek	41	59	122	60
Lower	MT76H001_030, Eightmile Creek to mouth (Clark Fork River)	22	29	60	35

During 2002-2017, algae data was only collected in 2012. The 75th percentile values for each segment are well below the algae biomass target (≤ 125 mg/m^2; **Table 3.2**). The relative concentration of nitrogen and phosphorus within algal cells can be used to estimate which nutrient might be limiting algal growth. A nitrogen to phosphorus (N:P) ratio in algal cells of <6 suggests nitrogen is limiting algal growth, whereas >10 suggests phosphorus is limiting algal growth (Hillebrand and Sommer, 1999). Algal nitrogen and phosphorus data is not available, but the concept may be roughly applied to water chemistry (Suplee and Watson, 2013). **Table 3.2** also shows average N:P ratios for nutrient concentration water column data collected during the assessment (2002-2012) and planning (2007-2017) time periods. The data suggest that phosphorus is the limiting nutrient.

Table 3.2. 75th percentile algae biomass on each segment of the Bitterroot River as measured in 2012, and average nitrogen to phosphorus ratios (N:P) of water column samples.

Assessment Unit (AU)		2012 75th Percentile Algae Biomass (mg/m^2)	Average Water Column N:P Ratio	
			2002-2012	2007-2017
Upper	MT76H001_010, East and West forks to Skalkaho Creek	21	20	18
Middle	MT76H001_020, Skalkaho Creek to Eightmile Creek	14	10	13
Lower	MT76H001_030, Eightmile Creek to mouth (Clark Fork River)	26	16	17

4.0 MAXIMUM SUSTAINABLE NUTRIENT LOAD VS. CURRENT CONDITIONS

A maximum sustainable nutrient load is the amount of pollution, expressed in units of mass per time, that may be delivered to a river or lake and still support beneficial uses (**Equation 4.1**).The maximum sustainable nutrient load is an entirely non-regulatory concept that is simply used to compare with current conditions to demonstrate the high-quality condition of the Bitterroot River and help prioritize voluntary protection actions.

Equation 4.1: Maximum Sustainable Load = (X) (Y) (5.4)

Maximum Sustainable Load = Maximum pollutant load in a stream that still meets beneficial uses, in units of lbs/day

X = suggested water quality target in mg/L (0.3 mg/L Total Nitrogen or 0.03 mg/L Total Phosphorus; Suplee & Watson, 2013)

Y = example streamflow in cubic feet per second (cfs)

5.4 = conversion factor

For this Protection Plan, DEQ selected an example flow value at the downstream end of each Bitterroot River segment using USGS StreamStats software July to October 14Q5 flow values (McCarthy et al., 2016; **Table 4.1**). The “14Q5” component of this StreamStats measure refers to a 14-day, 5 year average low flow condition. StreamStats considers a longer summer season (the “July to October” component) than the suggested nutrient targets (July 1^{st} through September 30^{th}). This is reasonable because stream flows are often lower in October than during summer, meaning the maximum sustainable load estimated using StreamStats’ July to October 14Q5 flow values will represent a worst-case scenario, such as drought conditions. As flow decreases, so will the maximum sustainable load.

Table 4.1. Example flow values used for calculating maximum sustainable, current, and natural background nutrient loads.

Bitterroot Segment (Assessment Unit ID)	Example flow used throughout this document
Lower (MT76H001_030)	561 cfs
Middle (MT76H001_020)	487 cfs
Upper (MT76H001_010)	336 cfs

The maximum sustainable nitrogen and phosphorus loads calculated using **Equation 4.1** and example flows in **Table 4.1** are shown in **Figure 4.1**

Water quality monitoring data from 2002-2017 was used to compare the current load with the maximum sustainable load in **Figure 4.1**. This is a similar dataset used to construct **Figure 3.2**, although only data collected from locations near the downstream end of each segment was used to calculate the current load where possible. This is due to load calculations hinging on the example flow values established for the downstream end of each segment. For the lower Bitterroot, this excludes data collected above the Highway 93 bridge in Missoula. For the middle Bitterroot, this only includes data collected at Florence Bridge. For the upper Bitterroot, due to less data availability, data from the entire segment was considered, although most data is from Darby bridge in the middle of the reach.

Assimilative capacity is the amount of pollutant loading that a waterbody can take on while continuing to meet suggested water quality targets. While **Figure 4.1** shows that each segment of the Bitterroot

River still has assimilative capacity to take on more nutrients, **Section 5.0** demonstrates how population growth may increase any or all nutrient loading sources. Local planners, landowners, and regulators should carefully consider the balance of managing population growth while still maintaining the high-quality condition of the Bitterroot River.

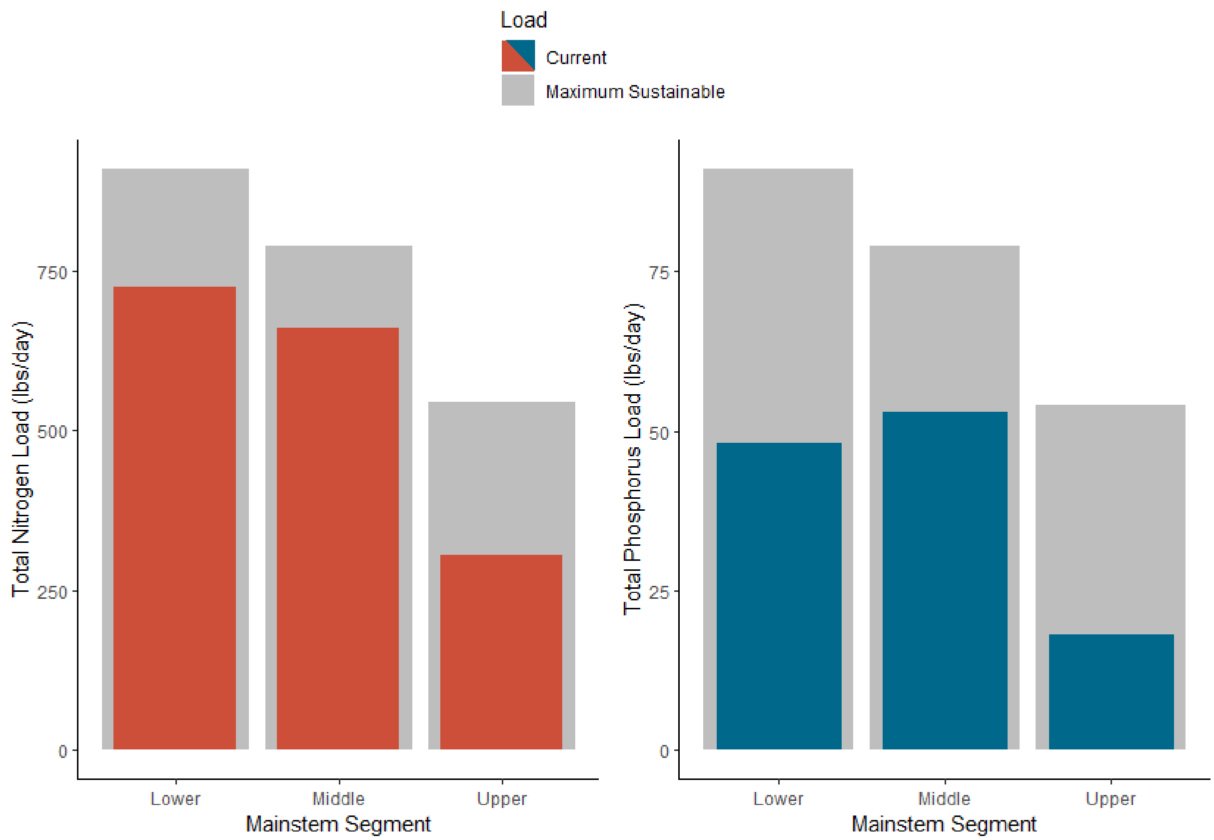

Figure 4.1. Maximum sustainable nutrient load compared to current nutrient load for each segment of the Bitterroot River.

5.0 Nutrient Sources and Estimation Methods

This section evaluates significant sources of nutrient pollution loading to the mainstem Bitterroot River, including natural background loading. Some sources are easily quantifiable. For example, municipal wastewater treatment facilities are required to monitor effluent nutrients as part of their Montana Pollutant Discharge Elimination System (MPDES) permit. Additionally, nutrient impaired tributaries were monitored and assessed during TMDL development in the watershed, and many continue to be monitored by stakeholder groups including DEQ, Clark Fork Coalition, and the Bitterroot River Protection Association. Other sources, such as nutrient loading from septic sources and other nonpoint sources are more difficult to estimate because of their ubiquitous spatial distribution and cumulative effect. Each subsection will discuss data sources and any modeling and assumptions for nutrient sources.

Due to the range of accuracy in estimated nutrient sources, the sources are presented relative to each other, rather than as a fixed value. By presenting these semi-quantified risks to the high-quality condition of the Bitterroot River, the goal is to show that addressing any or all of the nutrient source categories can go a long way to protecting the river. Similarly, any nutrient source category has the potential to tip the nutrient condition into an impairment status.

5.1. Method for Estimating Natural Background Nutrients

Natural background nutrient loading includes all non-human caused sources. The load from natural background sources of nutrients is based on 75th percentile concentration values from reference sites in the Middle Rockies, Northern Rockies, and Idaho Batholith Level III Ecoregions (**Fig. 5.1, Table 5.1**). Natural background nutrient concentrations for each ecoregion are applicable during the July 1 to September 30 growing season (Suplee and Watson, 2013). 75th percentile values are used here, as with throughout the document, because they depict more of a worst-case loading scenario than using a median or average value. Reference sites were chosen to represent stream conditions where human activities may be present but do not negatively harm stream uses. The effects of natural events such as flooding, fire, and beetle kill may be captured at these sites.

Natural background loads are calculated by multiplying an ecoregion area-based weighted average natural background concentration by the example growing season streamflow (**Table 4.1**), as in **Equation 5.1**.

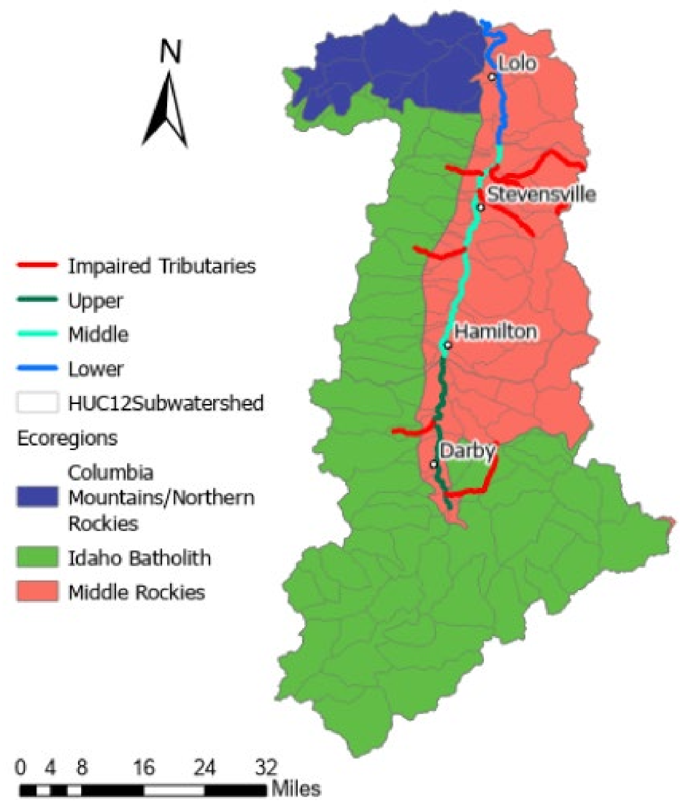

Figure 5.1. Map showing level 3 ecoregions, mainstem Bitterroot segments, and nutrient impaired tributaries.

Table 5.1 Natural background nutrient concentrations for each Level III Ecoregion in the Bitterroot Watershed.

Ecoregion	75th Percentile TN (mg/L)	75th Percentile TP (mg/L)
Northern Rockies	0.094	0.009
Idaho Batholith	0.095	0.008
Middle Rockies	0.141	0.020

Equation 5.1: Natural Background Load = (X) (Y) (5.4)

Natural Background Load = Nutrient load from sources regardless of human influence, in units of lbs/day

*X = Watershed area-based weighted average of 75th percentile ecoregional concentrations at reference sites (**Table 5.1; Fig. 5.1**).*

Y = example streamflow in cubic feet per second (cfs)

5.4 = conversion factor

5.2. Method for Estimating Nutrients from Impaired Tributaries

As shown in **Figure 2.2**, there are six nutrient impaired tributaries that confluence with the Bitterroot River. Bass, Sweathouse, North Burnt Fork, and Threemile Creeks confluence with the middle section of the Bitterroot River (MT76H001_020), and Rye and Lick Creeks confluence with the upper segment (MT76001_010). None of these tributaries receive water from a point source, indicating that nutrient impairment is due to nonpoint sources of pollution.

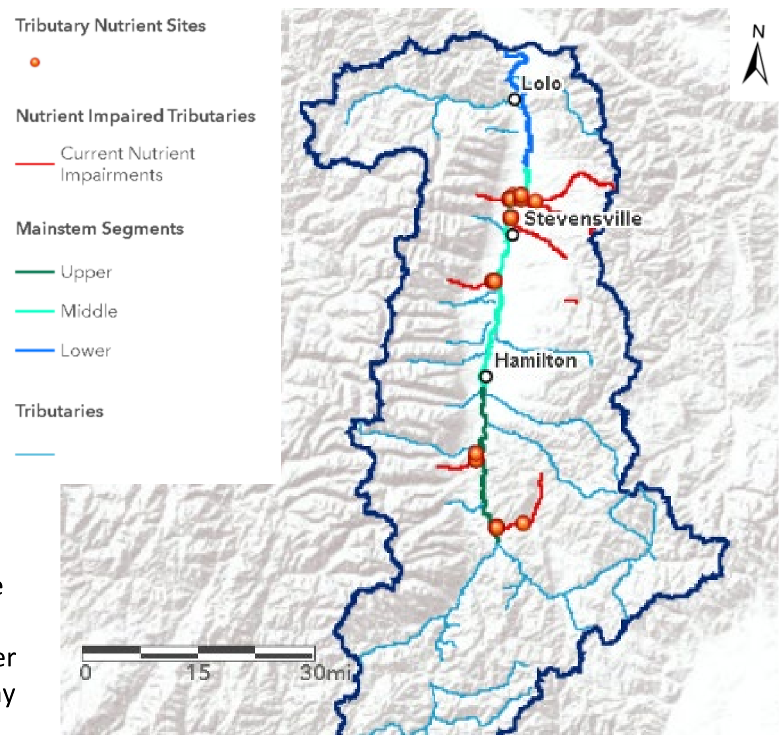

Figure 5.2. Map showing nutrient impaired tributary nutrient data sample locations relative to the Bitterroot River segments.

To estimate the nutrient load, DEQ selected an example flow value at the mouth of each tributary using USGS StreamStats software's July to October 14Q5 flow values (**Table 5.2**; McCarthy et al. 2016). As described in **Section 4.0**, this example flow value provides a worst-case scenario. The 75th percentile nutrient concentration from data collected between July 1 – September 30 of 2007 – 2017 was established as representative of current tributary conditions (**Figure 5.2**). This data was acquired from the EPA's Water Quality Portal and includes samples collected by DEQ, the Tristate Water Quality Council, and the Bitterroot River Protection Association. The 75th percentile nutrient concentration is used because it supports a worst-case scenario compared to an average. To avoid double counting natural background nutrient loading, the watershed area-based weighted average natural background ecoregional nutrient concentration was subtracted from the 75th percentile nutrient concentrations measured in the field.

The example flow value and 75th percentile nutrient concentrations were used in **Equation 5.2** to calculate the nutrient load attributed to tributaries impaired by nutrients.

Table 5.2. Example flow values used for calculating maximum sustainable nutrient load and natural background load.

Tributary (Assessment Unit ID)	Confluencing Bitterroot Segment	Example flow used throughout this document
Rye Creek (MT76H004_190)	Upper	9.75 cfs
Lick Creek (MT76H004_170)	Upper	0.61 cfs
Threemile Creek (MT76H004_140)	Middle	11.3 cfs
North Burnt Fork Creek (MT76H004_200)	Middle	19.8 cfs
Bass Creek (MT76H004_010)	Middle	8.60 cfs
Sweathouse Creek (MT76H004_210)	Middle	8.09 cfs

Equation 5.2: Nutrient-Impaired Tributary Load = (X - NB) (Y) (5.4)

Nutrient-Impaired Tributary Load = Human-caused nutrient load, in units of lbs/day, in the mainstem Bitterroot that is attributable to tributaries impaired by nutrients

X = 75th percentile nutrient concentration, in units of mg/L, measured near tributary confluence

*NB = Watershed area-based weighted average natural background ecoregional nutrient concentration (estimated in **Section 5.1**)*

Y = example streamflow in cubic feet per second (cfs)

5.4 = conversion factor

5.3. Method for Estimating Nutrients from Wastewater Treatment Facilities and Other Permitted Sources

There are 13 active point sources permitted under the Montana Pollutant Discharge Elimination System (MPDES) in the Bitterroot Watershed, according to EPA's Integrated Compliance Information System database as of August 2020.

5.3.1. Wastewater Treatment Facilities

Four municipal wastewater treatment facilities (WWTFs) serving Lolo (MT0020168), Stevensville (MT0022713), Hamilton (MT0020028), and Darby (MTG580011) are permitted to discharge to the Bitterroot River. Lolo discharges to the lower segment, and Darby to the upper segment. These permittees submit effluent discharge monitoring reports monthly, including average monthly nutrient loading, and therefore data is readily available for analysis.

The potential for continued population growth in the Bitterroot watershed makes WWTF contributions an important source to monitor. **Figure 5.3** shows monthly average effluent nutrient concentrations for the four facilities during the summer growing season (July – September). Particularly for phosphorus, nutrient concentrations have been decreasing.

Some of this improvement is likely due to facility optimization, a process of operator training, technical support, and modifying the use of existing treatment equipment to improve wastewater treatment. After "conventional" (without biological nutrient removal technology) wastewater treatment facilities statewide attended optimization trainings, effluent nutrients were reduced by nearly 2/3rd total nitrogen and 1/3rd total phosphorus (Weaver, 2016). No facility spent more than $10,000 on new equipment, and the largest expense for optimization was instrumentation. DEQ spent approximately $6,100 per facility to provide facility specific technical guidance and classroom trainings. To achieve similar results through infrastructure improvement would have cost each community several million dollars.

This process began in 2014 for Lolo WWTF, and 2015 for Hamilton WWTF. For $4.5 million, the Stevensville WWTF upgraded from a UV light disinfection system to a biological nutrient removal system in 2016. DEQ began working with Stevensville on optimizations in 2018. Darby's WWTF is a facultative lagoon whose permit does not allow discharge during the growing season. The Town of Darby was awarded Treasure State Endowment Program and American Rescue Plan Act funds in 2021 that will address repairs and install new equipment.

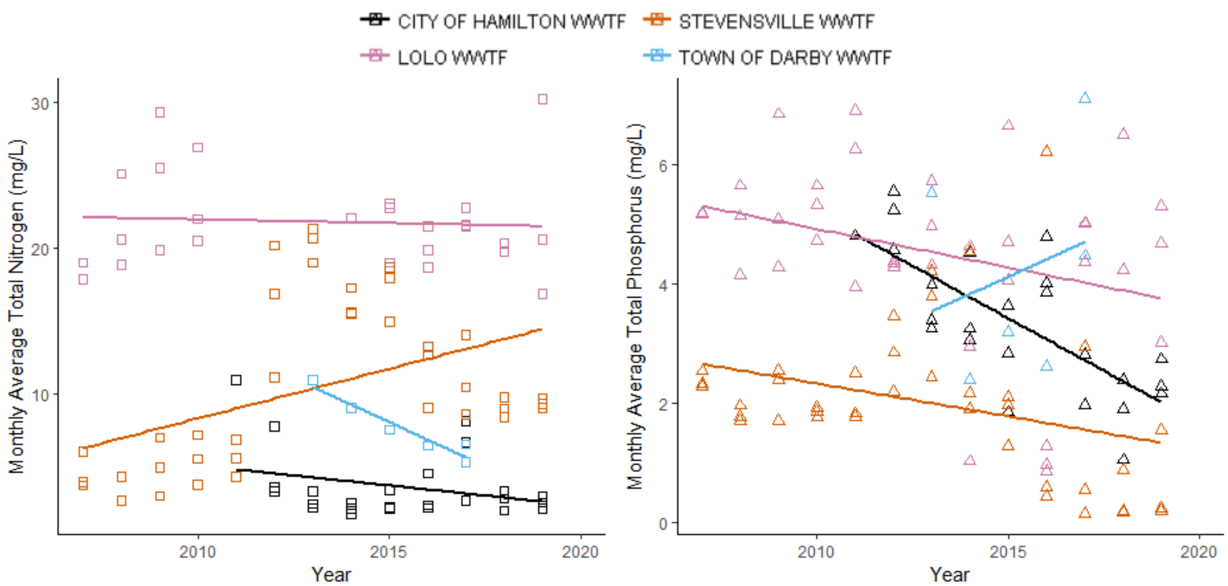

Figure 5.3. Nutrient concentrations in Bitterroot wastewater treatment facility effluent. Data shown are summer growing season (July – September) monthly averages from each facility's discharge monitoring reports.

Improvements in nutrient treatment are even more apparent when considering loads. **Figure 5.4** shows monthly average effluent nutrient loading for the 4 facilities during the summer growing season (July – September). The 75th percentile of the 5 most recent years of data shown in **Figure 5.4** was assumed to represent the current nutrient loading to the Bitterroot River**.** The maximum sustainable load ranges from 908 to 544 lbs/day total nitrogen and 91 to 54 lbs/day total phosphorus, the range depending on the segment of the Bitterroot River (**Figure 4.1**). This evaluation indicates that municipal wastewater treatment is a considerable, but not primary, source of nutrients in the Bitterroot watershed.

Figure 5.3. Nutrient loads in Bitterroot wastewater treatment facility effluent. Data shown are summer growing season (July – September) monthly averages from each facility's discharge monitoring reports.

5.3.2. Other Permitted Sources

In addition to wastewater treatment facilities, there are general permits for pesticide usage and for stormwater discharges associated with industrial activities. Nutrients from these sources are generally intermittent and considered to have a negligible nutrient contribution. There are no concentrated animal feeding operations (CAFOs) in the Bitterroot watershed.

The City of Missoula is permitted under a municipal separate storm sewer system (MS4) permit to discharge to the Bitterroot and Clark Fork Rivers. The City of Missoula periodically monitors a storm sewer outfall to the Bitterroot River on Pattee Creek during dry weather conditions (City of Missoula, 2018 & 2019). The average nutrient load of three separate sampling events (September 2017, October 2018, and August 2019) was extremely low: 0.38 lbs/day total nitrogen and 0.033 lbs/day total phosphorus.

There is also permit coverage available for stormwater discharge associated with construction activity. Due to the short-term impact and transient nature of these construction stormwater permits, nutrient pollution from these sources is considered negligible. Stormwater management should still be a consideration when planning for projects and development. The primary method to control stormwater pollution is the use of BMPs. Additional information can be found in Montana's Nonpoint Source Management Plan (Watershed Protection Section, 2017).

The permits discussed in this section (**5.3.2**) are considered negligible and are not directly incorporated into nutrient loading estimates.

5.4 Method for Estimating Nutrients from Septic Systems

Septic systems are typically considered a nonpoint source of pollution and can be a primary source of nutrient loading in Montana. Municipal wastewater systems only serve about 30% of Bitterroot residents. Septic systems, even when operating as designed, can contribute nutrients to surface water through subsurface pathways. A simple model, the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS), was used to provide coarse estimates of nutrient loads to the Bitterroot River (DEQ, 2014).

Key assumptions for this method are as follows:

- All septic systems are working properly (because a complete system failure is typically addressed very quickly).
- All septic systems are conventional systems consisting of a septic tank and drain field that service an individual household.
- All septic systems release nutrients at the same given rate (30.5 lbs/yr nitrogen and 6.44 lbs/yr phosphorus; DEQ, 2009).
- A portion of the nutrients released by septic systems is attenuated into soils and never reaches surface water. This portion varies based on soil type and distance from surface water.

The location of each septic system in the Bitterroot watershed was estimated from the Montana Structures Framework (http://geoinfo.msl.mt.gov/Home/msdi/structures_and_-addresses). Structures that fell within Darby, Hamilton, Stevensville, Lolo, and Missoula city limits were removed because it is assumed these structures are serviced by municipal wastewater treatment. Next, structures classified as dwelling, mobile home, or farm/ranch were retained, while structures listed as commercial establishments, government buildings, hospitals, schools, etc. were removed. The nutrient load from the population that visits these latter structures is likely already accounted for by the former.

The remaining structures that are linearly closest to the Bitterroot River were retained, regardless of the distance from the River. Nutrients from structures linearly closest to perennial tributaries are assumed to be accounted for by tributaries impaired by nutrients (**Section 5.2**) or nonpoint sources (**Section 5.5**).

The reduction in nutrient loading from each individual septic system by the time nutrients reach the Bitterroot River is estimated based on distance, soil type at the drain field, and soil type at the Bitterroot River (**Table 5.2, Figure 5.4**). The approach is similar for phosphorus but includes a reduction factor for calcium carbonate percent in the soil beneath the drain field (**Table 5.3**). These factors were attributed for each septic system using a GIS analysis of the Natural Resources and Conservation Service Soil Survey Geographic Database's (SSURGO) hydrologic soil group (HSG) and $CaCO_3$ classification system, and the National Hydrography Dataset (NHD).

The estimate for current nutrient loading from septic systems to the Bitterroot River is based off the 25th percentile nutrient reduction due to soil and distance to River parameters. Rather than consider the average or median nutrient reduction from soil and distance parameters, the 25th percentile provides more of a worst-case scenario estimate (i.e., the 75th percentile would provide a best-case scenario estimate that would be inconsistent with other source estimates in this document).

Table 5.2. MEANSS Septic System Nitrogen Loading Matrix

Percent Nitrogen Load Reduction[1]	Soil Type @ Drainfield[1]	Soil Type within 100' of surface water[2]	Distance to surface water (ft)
0	A	A	≤ 100
10	B		> 100 - 500
20	C	B	> 500 - 5000
30	D	C	> 5000 - 20,000
50		D	> 20,000

[1] The total nitrogen reduction is the sum of the individual reductions for each column of the table. For example, the nitrogen load reduction associated with a drainfield in a type C soil that drains to a surface water with type B soil, and is 200 feet from the nearest surface water would be 50 percent (e.g., 20% + 20% + 10% = 50%, or 30.5 lbs/year * 0.5 = 15.25 lbs/year removed prior to discharge to surface water).

[2] Soil drainage class:
A = excessively drained or somewhat excessively drained
B = well drained or moderately well drained
C = somewhat poorly drained
D = poorly drained or very poorly drained

Table 5.3. MEANSS Septic System Phosphorus Loading Matrix

Percent Phosphorus Load Reduction[1]	Soil Type @ Drainfield[2] ($CaCO_3$ ≤ 1%)	Soil Type @ Drainfield[2] ($CaCO_3$ > 1% and < 15%)	Soil Type @ Drainfield[2] ($CaCO_3$ ≥ 15%)	Distance to surface water (ft)
10	A	A	A	≤ 100
20			B	
40		B	C	
50				> 100 - 500
60	B	C	D	
80	C	D		> 500 - 5,000
100	D			> 5,000

[1] The total phosphorus reduction is the sum of the two reductions for soil type/$CaCO_3$ and distance. For example, the phosphorus load reduction associated with a drainfield that is in a type C soil with greater than 15 percent $CaCO_3$ (40 percent) and is 300 feet from the surface water (50 percent) would be 90 percent (40% + 50% = 90%, or 6.44 lbs/year * 0.9 = 5.8 lbs/year removed prior to discharge to surface water).

[2] Soil drainage class:
A = excessively drained or somewhat excessively drained
B = well drained or moderately well drained
C = somewhat poorly drained
D = poorly drained or very poorly drained

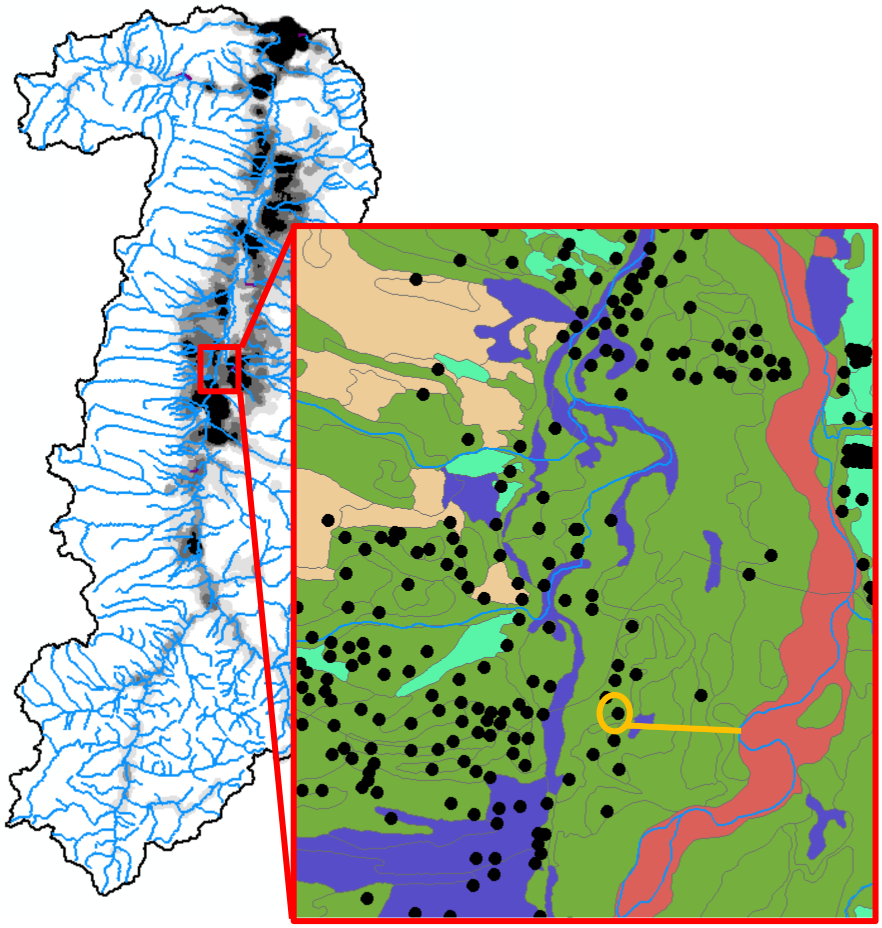

Figure 5.4. A representation of how septic systems contributing nutrients to the Bitterroot River were estimated. The background map shows a density diagram of structures. The inset image shows individual structures overlaying different soil types; the yellow line depicts one structure's distance from the mainstem Bitterroot. In the final analysis, only structures linearly closest to the Bitterroot River were retained.

The MEANSS model incorporates many assumptions and as a result there is wide uncertainty in watershed-scale loading estimates. To protect the Bitterroot River, more refined models or site-specific water quality studies could be used to reduce uncertainty in estimates of nutrient loading from septic systems.

5.5 Method for Estimating Nutrients from Nonpoint Sources, Excluding Septic Systems

Nonpoint source pollution is the largest contributor of water quality problems in Montana. Nonpoint sources include contributions from stormwater runoff, fertilizers for lawns and crops, erosive soils, erosion from roads and streambanks, fire retardants, atmospheric contributions, and livestock and animal waste (human waste is covered in **Sections 5.3 and 5.4**). Nonpoint sources of nutrient pollution are a difficult category to quantify, due to their numerous and dispersed nature. **Equation 5.3** was used to estimate nutrient loading from nonpoint sources of pollutants.

Equation 5.3: NPS Load = Current – NB – WWTF – (Tributaries) – Septic Systems

NPS Load = Nutrient load, in units of lbs/day, in the mainstem Bitterroot that is attributable to nonpoint sources of nutrients, excluding septic systems
*Current = Current nutrient load (**Section 4.0**)*
*NB = Natural background nutrient load (**Section 5.1**)*
*WWTF = Wastewater treatment facility load (**Section 5.3**)*
*Tributaries = Human-caused nitrogen- and/or phosphorus-impaired tributary load (**Section 5.2**)*
*Septic Systems = Septic system load (**Section 5.4**)*

5.6. Nutrient Sources Summary

Figure 5.5 shows the relative nitrogen and phosphorus loads estimated from natural background, nutrient impaired tributaries, wastewater treatment plants, septic systems, and other nonpoint sources (**Sections 5.1-5.5**). The figure is intended to show relative loading contributions and not absolute values due to the wide range of uncertainty associated with the approach to estimate some of these sources.

The largest source of nutrients overall comes from natural background sources of nutrients, which is reasonably expected because the Bitterroot River is not impaired by nutrients.

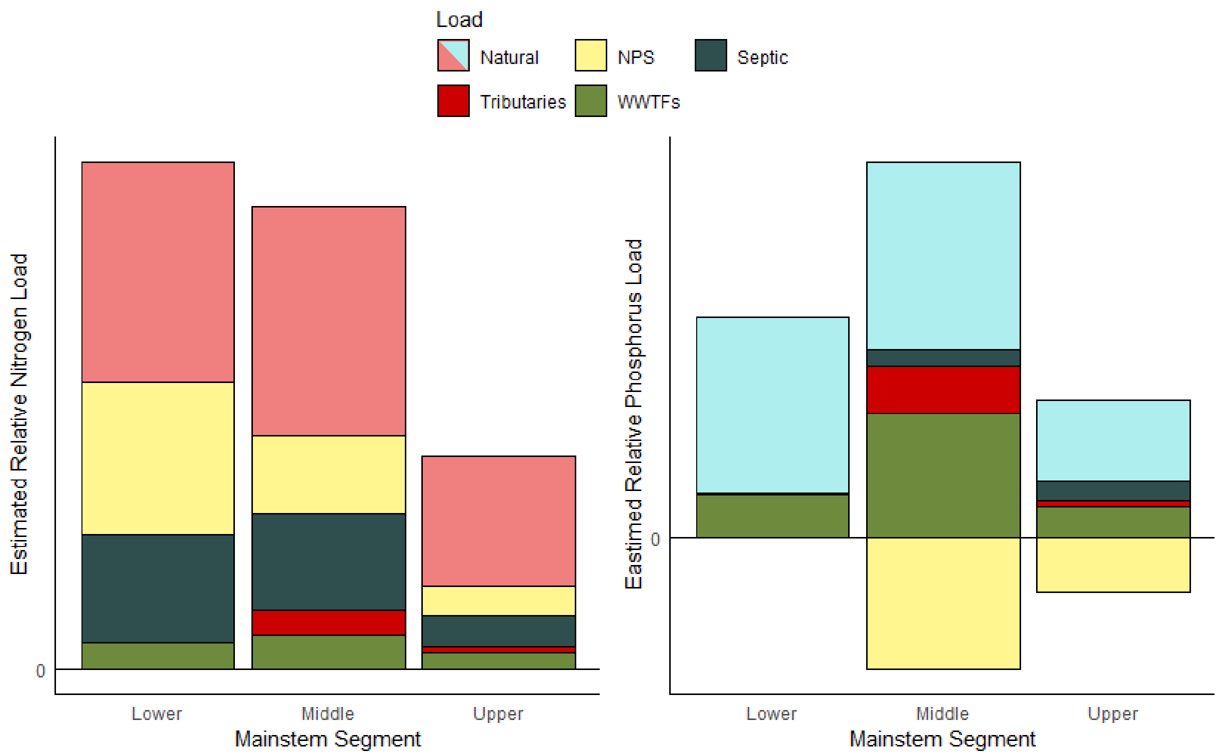

Figure 5.5. This figure shows the relative estimated nitrogen and phosphorus loads from natural background, nonpoint source (NPS), septic systems, tributaries impaired by nutrients, and wastewater treatment facilities (WWTFs).

Wastewater treatment facilities and septic systems are another major source of nutrient pollution; nitrogen primarily coming from septic systems and phosphorus primarily coming from wastewater treatment facilities. This is to be expected considering how the different waste treatment systems operate. Because phosphorus binds easily to soils, effluent phosphorous is treated quite well as it migrates away from the septic system, whereas nitrates are more mobile in groundwater. At WWTFs, denitrifying bacteria ultimately convert most nitrates into unreactive nitrogen gas that is released to the atmosphere. Septic systems, closed systems, are not designed to release gas.

Although nutrient impaired tributaries are one of the smaller sources of nutrients to the Bitterroot River, actions to restore these waters should be prioritized. In their impaired state, they do not fully support aquatic life nor primary contact recreation.

Nonpoint sources of pollution are a large contributor of nitrogen to the Bitterroot River, although phosphorus loading was estimated to be very low or even negative. It is more likely that phosphorus from nonpoint sources of pollution reach the Bitterroot River, but that the error range in source estimates are larger. Regardless, it is reasonable to expect that nonpoint sources of pollution are of greater concern for nitrogen because phosphorus is less mobile. Additionally, phosphorus is likely the limiting and more readily utilized nutrient in the Bitterroot River.

Results confirm that protecting the Bitterroot River from nutrient impairment will require widespread adoption of voluntary best management practices that reduce nutrient loading (see **Section 7.0** for recommendations). This approach would also reduce nutrient loading to nutrient impaired tributaries. Continued population growth will likely increase nutrient loading associated with septic systems (**Section 6.0**) and other nonpoint sources if not managed in a way to reduce nutrient loading, restore degraded wetlands and riparian areas, and protect existing high-quality resources.

6.0 Potential Scenarios

Wastewater treatment facilities are designed to treat a maximum capacity, or serve a certain population of citizens. Typically, the average effluent volume processed by a facility is below the design capacity, meaning that facilities are designed in anticipation of accommodating population growth. The Lolo, Stevensville, and Hamilton WWTF MPDES permits provide information about the current population served and the population the facility is design for. DEQ extrapolated from each facility's current nutrient effluent load (**Section 5.3**) what the expected nutrient load could be if each facility reached their maximum design population (**Table 6.1**).

Table 6.1. Data used for the nutrient loading scenario where a population increase is connected to municipal WWTFs.

Bitterroot Segment of Outfall Location	Facility	Current TN Load (lbs/day)[a]	Current TP Load (lbs/day)[a]	Current Population Served	Design Population	Design Population TN Load (lbs/day)	Design Population TP load (lbs/day)
Lower	Lolo[b]	38	6.3	2,248	2,500	42.3	10.2
Middle	Stevensville[c]	24.7	3.5	1,900	2,800	36.4	5.2
Middle	Hamilton[d]	24.3	23.4	4,400	5,200	28.7	27.7

[a]These values are the 75th percentile of summertime (July-September) monthly averages reported in discharge monitoring reports. This data is displayed in **Figure 5.3**. For Lolo and Hamilton, 2015-2019 is considered for current conditions. For Stevensville, 2014-2018.
[b]Current and design population acquired from 2014-2019 MPDES permit factsheet.
[c]Current and design population acquired from 2012-2017 MPDES permit factsheet.
[d]Current and design population acquired from 2011-2016 MPDES permit factsheet.

Next, DEQ calculated the expected nutrient load that could result if households associated with the same population increase were served by new individual septic systems instead of the WWTFs. The current number of septic systems and associated nutrient load from those systems was estimated in **Section 5.4**.

Table 6.2. Data used for the nutrient loading scenario where a population increase is placed on new individual septic systems.

Bitterroot Segment	Current Septic Systems	Current Population on Septic Systems[a]	Example Future Population on Septic Systems[b]	Example Future Septic Systems[c]	Current TN Load (lbs/day)[a]	Current TP Load (lbs/day)[a]	Example Future Population TN Load (lbs/day)	Example Future Population TP Load (lbs/day)
Lower	2,289	5,494	5,746	2,394	153	0	160	0
Middle	2,029	4,870	6,570	2,737	136	3.6	183	4.9

[a] See **Section 5.4** for a discussion of how the current number of septic systems and current nutrient loads were calculated. Example future septic systems are assumed to reduce nutrient loading by the same amount that MEANSS calculates.
[b]The population increase is equivalent to the difference between the WWTF's design population and current population served.
[c]It is assumed that an average of 2.4 people reside in each household (U.S. Census Bureau, 2019).

Figure 6.1 shows the increase in nutrient loads under these two scenarios: a population increase served by municipal WWTFs or served by new individual septic systems. Note that because the Town of Darby's facility is a lagoon system that rarely discharges during the growing season, it is not accurate to assume that an increase in nutrient load corresponds to an increase in population. Therefore, that facility, and the Upper Bitterroot River segment it is permitted to discharge to, was excluded from the analysis.

This exercise shows differing results for nitrogen and phosphorus loading to the Bitterroot River associated with two scenarios for wastewater treatment. For example, a population growth of 252 people served by new septic systems along the lower Bitterroot River results in a twofold increase in nitrogen loading compared to the same population served instead by the Lolo WWTF (i.e., from 38 to 42 versus 153 to 160 lbs/day). For the middle Bitterroot segment, a population increase of 1,700 people served by new septic systems would result in more than a threefold increase in nitrogen loading, compared to the same population served instead by the Stevensville and Hamilton WWTFs (i.e., from 49 to 65 versus 136 to 183 lbs/day). The exercise also shows that the same population growth treated by new septic systems would result in less phosphorus loading to the Bitterroot river, compared to the same population served by municipal WWTFs.

As technology improvements and process optimization continues, WWTF nutrient loads can reasonably be expected to continue decreasing, and the estimate of increased loading from WWTFs in **Figure 6.1** may be an overestimate. The estimated load from septic systems assumes a conventional tank and drain field system (**Section 5.4**), however if septic systems with higher levels of nitrogen treatment are installed, then the nitrogen increases estimated in **Figure 6.1** are likely an overestimate. Improved phosphorus treatment in septic systems is not anticipated to occur, so the phosphorus increases estimated in **Figure 6.1** are likely more accurate than for nitrogen.

It is also important to consider the mechanisms of how nitrogen and phosphorus are removed from wastewater. At WWTFs, denitrifying bacteria ultimately convert most nitrates into unreactive nitrogen gas that is released to the atmosphere. Septic systems, closed systems, are not designed to release gas. The MEANSS model accounts for naturally occurring denitrification that occurs after the wastewater migrates away from the drain field (**Section 5.4**), but it is typically not as effective a process as in a WWTF, particularly in coarse-grained soils that are common along the Bitterroot River. Phosphorus is not as mobile or volatile as nitrogen. At WWTFs, phosphorus molecules are bound to microorganisms or chemicals, settled out of the water column, and the resulting sludge is removed. However, not all phosphorus can be removed with this approach, and the excess is discharged in effluent. Septic systems themselves do not treat phosphorus; they rely on naturally occurring adsorption to soil particles. Therefore, most phosphorus associated with septic systems ends up bound in the soils, and for this reason, they result in less phosphorus loading to surface water.

Lastly, there is less of a difference between the maximum sustainable and current nitrogen load in the Bitterroot River than there is for phosphorus (**Figure 4.1**), indicating an increase in phosphorus loading may be more sustainable than an increase in nitrogen loading. For example, the increase in phosphorus loading to the middle Bitterroot River associated with the WWTF scenario is 6 lbs/day, approximately 23% of the remaining phosphorus load that segment could receive while still supporting beneficial uses. Conversely, the increase in nitrogen loading to the middle Bitterroot River associated with the septic scenario is 47 lbs/day, approximately 37% of the remaining nitrogen load that segment could receive while still supporting beneficial uses.

This exercise demonstrates the importance of hooking up new households to municipal or centralized WWTFs wherever possible to protect the nutrient status of the Bitterroot River. Where this is not possible, new households should be built with Level II or higher septic systems to minimize nutrients reaching the Bitterroot River.

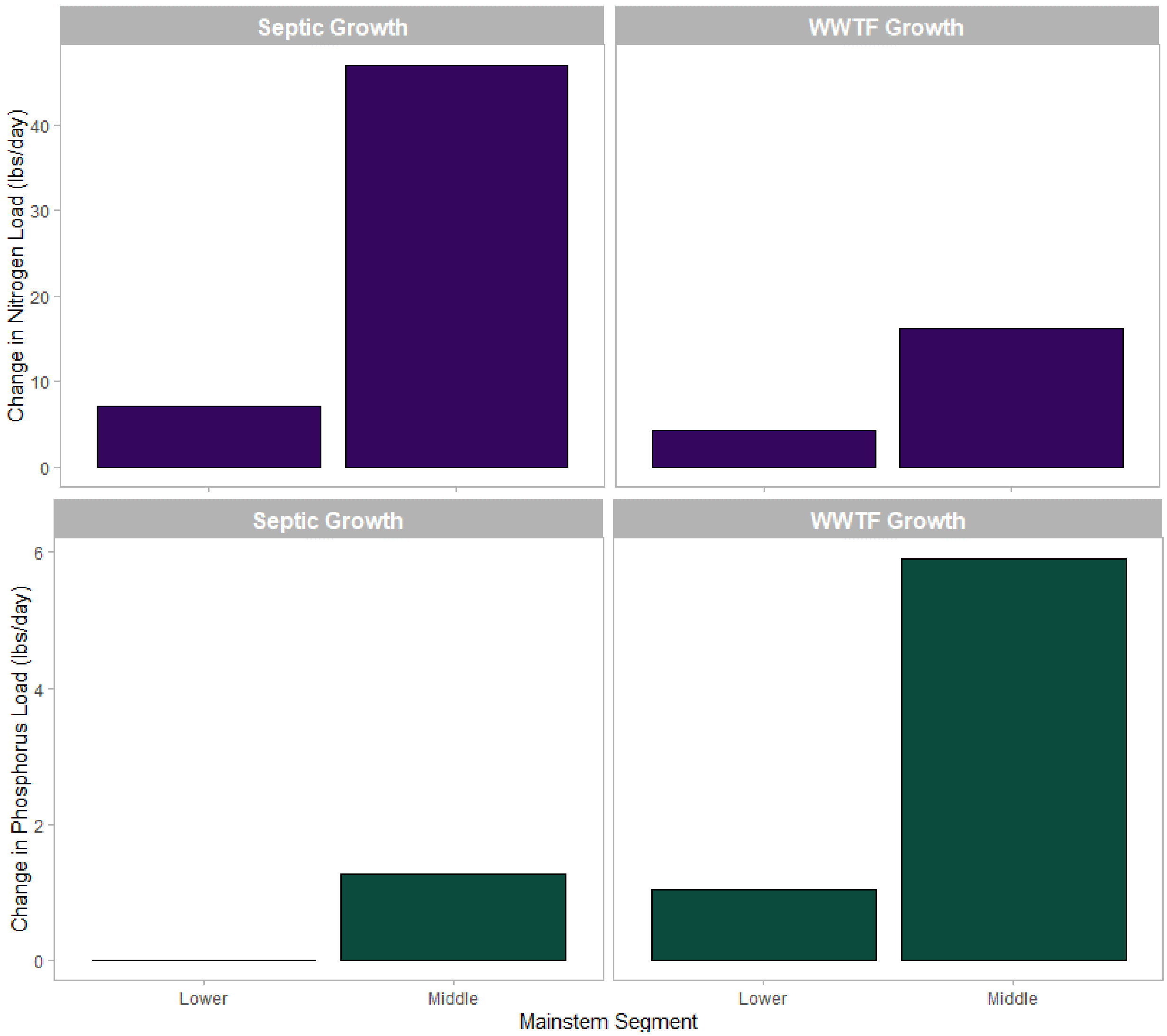

**Figure 6.1.	This figure shows the change in nutrient load from current conditions under two population growth scenarios. On the right, the expected increase in nitrogen (top) and phosphorus (bottom) load was estimated for the scenario where the population served increased to the facility design capacity. On the left, the expected increase in nutrient loading was estimated for the scenario where the same population increase is placed on new individual septic systems.**

7.0 Water Quality Improvement Activities & Measures of Success

This section describes an overall strategy and specific on-the-ground measures designed to protect beneficial uses and maintain suggested water quality targets in the Bitterroot River. The strategy includes general measures for reducing loading from each identified significant pollutant source. Recommendations in this protection plan are not required by the Clean Water Act or Montana statue and are primarily implemented through voluntary actions.

DEQ does not implement these actions and activities itself. Instead, successful implementation of this protection plan requires collaboration among land use planners, private landowners, land management agencies, and other stakeholders. DEQ and other entities provide technical and financial assistance to local organizations interested in protecting and improving their water quality. Please find a compilation of potential funding sources at deq.mt.gov/Portals/112/Water/WQInfo/Documents/Watershed%20Restoration/WatershedFunding_04082020.pdf.

7.1 Continue Implementing the Bitterroot Watershed Restoration Plan and Recommendations from the TMDLs

The Bitter Root Water Forum has maintained an up-to-date Watershed Restoration Plan for the Bitterroot Watershed (Bitter Root Water Forum, 2020). It prioritizes restoration action in 13 subwatersheds throughout the Bitterroot valley. It specifically addresses the mainstem Bitterroot and all nutrient-impaired tributaries covered in this document, except Lick, Bass, and Sweathouse Creek. The WRP recommends management measures that restore shade and instream flow on tributaries and within the Bitterroot River corridor itself, including:

- targeted riparian plantings with or without livestock exclusion fencing
- off stream water systems for livestock
- irrigation efficiency projects
- instream flow transactions
- upgrading or relocating septic systems currently near streams
- establishing conservation easements or riparian management zones on farms and ranchlands
- restoration activities that promote channel complexity, such as large woody debris or beavery mimicry, especially in channelized areas

Section 9.0 of the Bitterroot Watershed TMDLs (DEQ & EPA, 2014) provides recommendations specific to nutrient-impaired tributaries that address grazing, irrigation, cropland, timber harvest, urban development, roads, mining, riparian, floodplain, and wetland solutions. Many of these recommended actions can be taken along the Bitterroot mainstem to ensure it maintains its high-quality nutrient status. Particularly important for protecting water quality in the mainstem is restoring riparian areas, floodplains, and wetlands, and protecting those that already exist. Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants.

MEASURES OF SUCCESS
• Number of projects or best management practices implemented • Acres of new conservation easements along streams and wetlands • Miles of riparian fencing installed • Number of septic systems upgraded or hooked into centralized wastewater treatment systems • Miles of streambank with riparian vegetation restored

7.2 Prioritize Riparian and Wetland Projects by Existing Condition

DEQ has categorized wetlands and riparian areas in the Bitterroot watershed according to their condition (**Figures 7.1 and 7.2**). This resource (**Appendix A**) can be used to prioritize outreach and identify the most effective locations for best management practice implementation.

Wetlands, like riparian areas, can be extremely effective climate resiliency tools. They provide water storage for drought and flood mitigation, refugia for wildlife, and buffering streams, rivers, and lakes from nonpoint sources of pollutants. Beginning with tracking, then increasing, the acres of wetlands restored or protected is a measure of success for protecting the mainstem Bitterroot from nutrient impairment.

The Montana Wetland Program and Montana Natural Heritage Program developed a GIS model to help prioritize wetland restoration or protection activities. Individual wetlands were indexed based on their ecological importance and vulnerability to threat using a statewide geographic data model. The following factors were used to assign each wetland a value for ecological importance:

- Rarity
- Hydrologic complexity
- Patchiness of wetlands
- Patchiness of surrounding landscape
- Headwaters location
- Habitat significance for species of conservation concern

The following factors were used to assign each wetland a value for vulnerability to threat:

- Potential for the wetland's conversion to exurban development, human land use, or oil and gas development
- Risk based on Montana Natural Heritage Program's Human Disturbance Index
- Potential change in the wetland's water balance from climate change
- Potential for surrounding native land covers being converted to cropland

Based on the resulting ecological importance and vulnerability to threat, each wetland was categorized into priority action quadrants that identify approaches to protect and restore wetlands in the Bitterroot Watershed (e.g., high ecological priority and high vulnerability wetlands are a top priority to target for restoration and protection. Results for the Bitterroot watershed are shown in **Figure 7.1** (see **Appendix A** for a web map application).

MEASURES OF SUCCESS
• Number of projects implemented where riparian vegetation or wetlands are poor or under threat

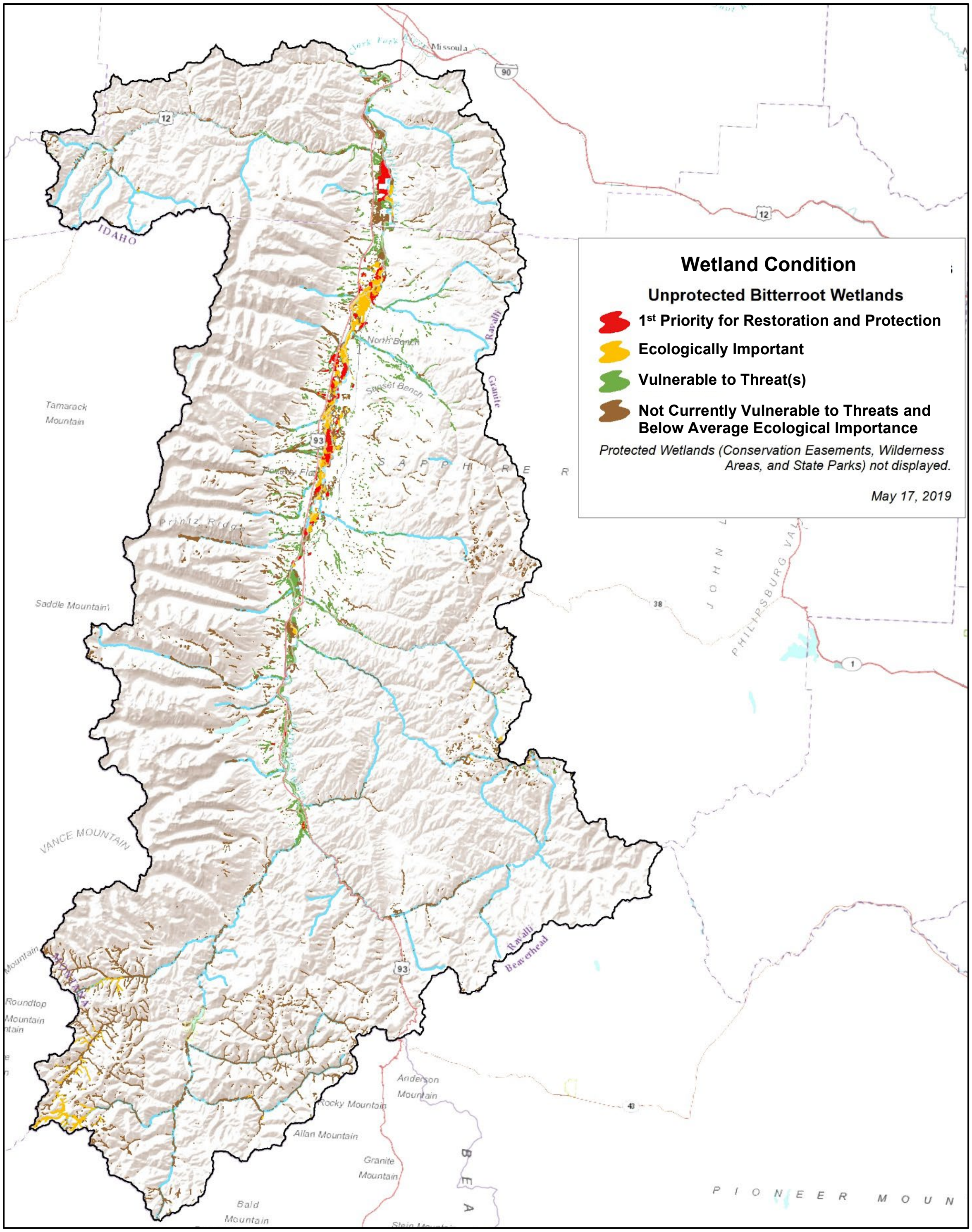

Figure 7.1. A map of wetland condition. Red corresponds to ecologically important wetlands that are vulnerable to threats and should be a priority for protection and restoration. Yellow corresponds to ecologically important wetlands that are not currently vulnerable to threats. Green corresponds to wetlands with below average ecological importance but are vulnerable to threats. Brown corresponds to wetlands that are not currently vulnerable to threats and have below average ecological importance.

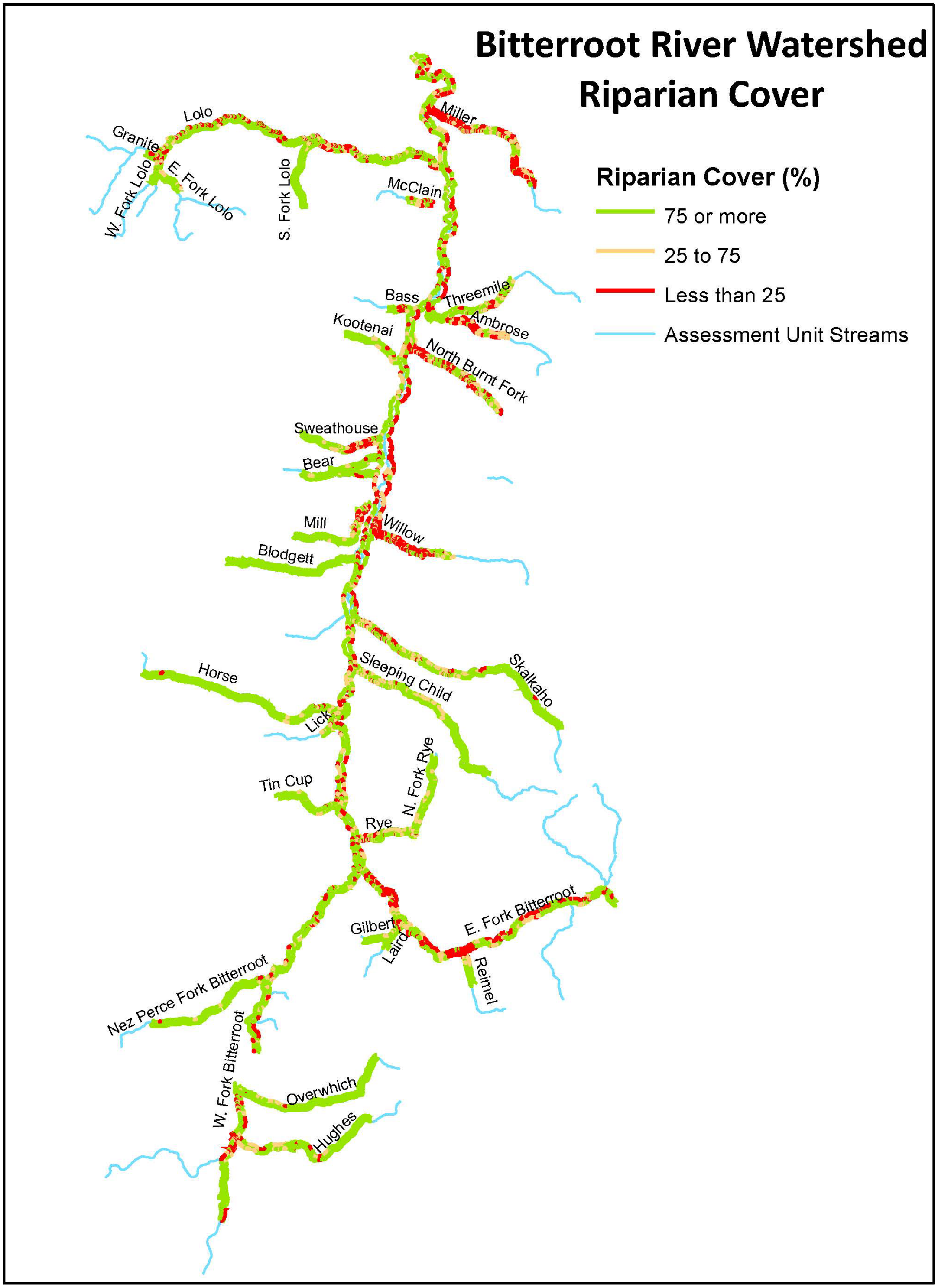

Figure 8.2. A map of riparian vegetation cover condition along impaired streams in the Bitterroot watershed.

7.3 Consider Local Regulation and Education to Ensure Water Quality-Friendly Development

New local zoning or regulations can protect the functions of floodplains and riparian and wetland areas where future development may occur. Requirements for protecting native vegetation buffers within a minimum of 50 feet of streams, or maintaining septic systems, can be effective mechanisms for maintaining or improving stream health. As large acreages are subdivided into smaller lots, the number of septic systems and impervious surfaces in the watershed increases. Plans for development of lands within the Bitterroot watershed should consider the effects of additional septic systems (**Section 6.0**) and consider ways of minimizing septic impacts to water quality such as installing Type II systems to decrease nitrogen loading, installing systems further away from streams to allow for more nutrients attenuation, or constructing a wastewater treatment facility (WWTF) to connect multiple residences.

Besides new local regulation, voluntary outreach activities can also be beneficial. For example, Ravalli County Environmental Health received a Water Quality Education and Outreach mini-grant in 2020 to inform new residential property owners about regular septic system maintenance (unfortunately, Ravalli County received a record number of septic permits and did not have the capacity to fulfill their outreach program). A similar audience could be provided with information about appropriate fertilizer application rates for lawns and gardens, preserving existing riparian vegetation, native vegetation for landscaping, maintaining a buffer to protect riparian and wetland areas, and practices to reduce the amount of stormwater originating from developed property.

MEASURES OF SUCCESS
• Number of distinct outreach campaigns. "Distinct" may be defined by a specific audience (e.g. new homeowners in Ravalli County), reached with a specific strategy (e.g. informational brochure) and calls to action (e.g. maintain septic system) • Number of County, City, or Homeowner Association level ordinances for water quality friendly development

7.4 Avoid Installing Rip Rap

The use of riprap or other "hard" approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although it is necessary in some instances, it generally redirects channel energy, exacerbates erosion in other places, disconnects floodplains and reduces native vegetation. Bank armoring should be limited to areas with a demonstrated threat to infrastructure. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the bank, reduce stream scouring energy, and provide shading and habitat. Limit threats to infrastructure by reducing floodplain development through local land use planning initiatives.

MEASURES OF SUCCESS
• Number of 310 inquiries for rip rap where a softer approach was used instead

7.5 Continue Developing Strategies to Address Water Shortages

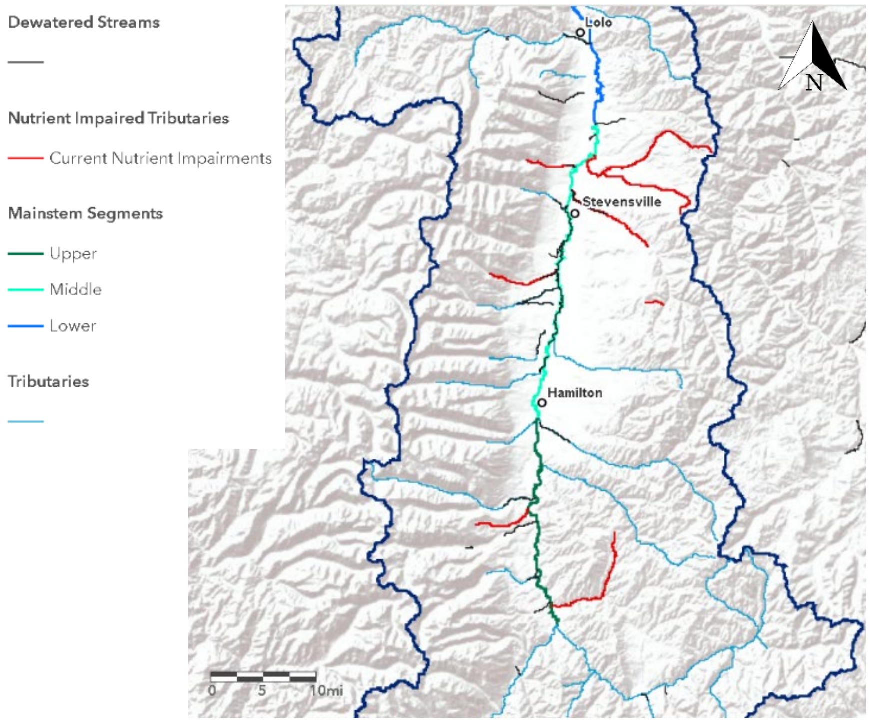

Figure 7.3. Chronically dewaters streams overlaying nutrient impaired tributaries and the three mainstem segments.

Water rights in the Bitterroot watershed, like many watersheds in Montana, are over-allocated. This results in many streams becoming dewatered during virtually all years, and especially during drought years. Most of the middle segment of the Bitterroot River is considered chronically dewatered, along with a few tributaries impaired by nutrients (FWP, 2015; **Figure 7.3**). Increasing year-round instream flows may help dilute nutrient pollution, meet temperature targets, and improve habitat quality and connectivity for aquatic organisms.

Multiple local organizations, such as the Bitter Root Water Forum, Bitterroot Conservation District, Clark Fork Coalition, and Trout Unlimited, work to implement strategies that address water shortages. Some potential projects include increasing reservoir storage, securing instream flow leases, and addressing ditch seepage and flood irrigation in a way that does not negatively impact groundwater recharge. Another strategy could be to compose a voluntary drought management plan where consumptive water users voluntarily reduce water use when instream flows reach pre-established thresholds (e.g., Big Hole Watershed Committee, 2016). This strategy helps distribute the impacts of drought years to junior and senior water rights holders and ensures instream flows are maintained.

MEASURES OF SUCCESS

- Number of instream flow leases secured
- Number of irrigation improvement projects
- Number of stakeholder meetings to address voluntary drought management
- Reduction in the number of days hoot owl restrictions (i.e., temporary fishing closures due to high water temperatures) are placed on the Bitterroot River

7.6 Continue Optimizing or Upgrading Treatment of Municipal Wastewater and Stormwater

Municipal wastewater treatment facilities in the Bitterroot watershed can continue the iterative process of facility optimization. Optimization uses existing facility infrastructure to improve nutrient treatment at a fraction of the cost of a traditional upgrade. DEQ encourages facility operators to continue attending DEQ's optimization trainings and hosting one-on-one site visits to gain insights specific to their facility.

Most municipalities in the Bitterroot watershed, excluding much of Missoula, are not regulated under a municipal stormwater permit. Where stormwater is not regulated, it is considered a nonpoint source of pollution, and voluntary actions may be implemented to reduce pollution loading. DEQ recommends municipalities monitor their stormwater infrastructure, especially outfalls that reach surface water, to determine where improvements may be made. Because stormwater in municipalities like Stevensville, Hamilton, and Darby are considered nonpoint sources, BMPs to improve stormwater treatment are eligible for nonpoint source §319 grant funding.

MEASURES OF SUCCESS
• Declining trend of effluent nutrient concentrations or loads from wastewater treatment facilities • Number of stormwater BMP projects implemented within towns and cities

7.7 Leverage Diverse Funding Sources

Protecting and restoring water quality can help mitigate impacts from future natural disasters, like drought and flooding. By protecting and restoring riparian areas and wetlands, these zones can provide space for flood water energy to dissipate, and for groundwater to be recharged, both of which can mitigate late season drought.

As Counties work to update Hazard Mitigation Plans that are necessary to receive emergency resources, incorporating floodplain and riparian restoration and protection can increase the pools of funding available to local communities.

MEASURES OF SUCCESS
• Riparian and wetland restoration and protection incorporated into hazard mitigation planning • Number of water quality projects funded with FEMA grants

8.0 Water Quality Monitoring Activities & Measures of Success

8.1 Maintain or Decrease Current Bitterroot River Nutrient Concentrations

A key concept required for an EPA-approved Protection Plan is a timeframe over which a protection target is expected to be attained and maintained. DEQ's previous 5-year trend analysis projects have generated robust datasets with sufficient power to detect changes in water quality (HydroSolutions, 2019). Beginning in 2019, DEQ and the Clark Fork Coalition initiated long-term nutrient monitoring on the mainstem Bitterroot River. Continued summer monitoring, annual status reports, and trend analyses every 5-years will provide an ideal measure of success for protecting the Bitterroot River. These reports and trend analyses may be found on the Clark Fork Coalition's webpage, clarkfork.org.

MEASURES OF SUCCESS
• Each year of mainstem nutrient monitoring results, or each 5-year trend analysis, show nutrient concentrations are maintaining current conditions • Nutrient concentrations remain below the suggested nutrient targets (**Section 3.0**)

8.2 Decrease Nutrient Concentrations in Tributaries Impaired by Nutrients

Decreasing nutrient concentrations in tributaries impaired by nutrients will benefit local and downstream conditions. Locally, streams will be better able to support aquatic life and other beneficial uses. Downstream, reduced nutrients will help protect the Bitterroot River from nutrient impairment.

Nutrient concentrations may be measured and tracked by collecting water column samples for laboratory analysis. DEQ provides volunteer monitoring technical and financial support for local organizations interested in this activity. In the Bitterroot watershed, the Bitterroot River Protection Association conducts volunteer monitoring on a number of tributaries. It is important that this data is collected and submitted to DEQ according to QA/QC protocols for its inclusion in any future impairment assessments.

Monitoring nutrient concentrations with water quality sampling in tributaries may not be the most effective use of resources until significantly more best management practices have been implemented. For example, the Bitterroot TMDLs state that agriculture is the primary land use and the most likely significant nutrient source to North Burnt Fork Creek (DEQ, 2014). To meet total nitrogen targets, human-caused sources of nutrients, primarily from agriculture, must be reduced by approximately 20%. Periodically, DEQ's Nonpoint Source Program will publish TMDL Implementation Evaluations (TIEs), which compile the monitoring, restoration, and planning work that has been implemented since TMDLs were published. If sufficient TMDL implementation has occurred, TIEs may include a recommendation for the stream to be reassessed. Therefore, an increase in the number of conservation practices implemented are a great measure of success towards improving nutrient condition in Bitterroot tributaries. For a compilation of known conservation practices implemented, see the Bitterroot Watershed Restoration Plan (Bitter Root Water Forum, 2020), or DEQ's §319 projects map (**Appendix A**). Nutrient load reductions reported with §319 projects are another great indicator of decreasing nutrient concentrations.

MEASURES OF SUCCESS
• Decreasing nutrient concentrations in tributaries impaired by nutrients • Monitoring data collected by local organizations submitted to DEQ • Number of TMDL Implementation Evaluations published by DEQ • Nutrient load reductions associated with §319 projects

8.3 Increase Riparian Vegetation Along the Mainstem and its Tributaries

Streamside vegetation, or "riparian" vegetation, can be extremely effective at buffering streams, rivers, and lakes from nonpoint sources of pollutants. It is possible to use publicly available imagery to account for varying riparian vegetation cover as a proxy for water quality conditions. This method is limited by the fact that some sources of nonpoint source pollution can be below ground or difficult to observe from air. DEQ evaluated riparian vegetation cover along impaired streams within the Bitterroot Watershed, primarily using 2017 aerial imagery (**Appendix A**). This information can help prioritize restoration efforts and track changes of riparian vegetation in the future.

DEQ intends to re-run this analysis in approximately 2027 using up-to-date aerial imagery, and an increase in riparian cover would be a great indicator of success. **Figure 8.1** shows the results of the initial 2017 analysis. Of Bitterroot tributaries that are impaired by nutrients, Ambrose (a tributary to Threemile), North Burnt Fork, and Lick Creeks have remarkably low amounts of riparian cover and would greatly benefit from passive or active riparian restoration activities. The Bitterroot River itself has over 60% "high" riparian cover, relatively high compared to other streams evaluated. However, there are portions along the Bitterroot River with much lower quality riparian cover, such as between Willow and North Burnt Fork Creeks (**Figure 8.2**).

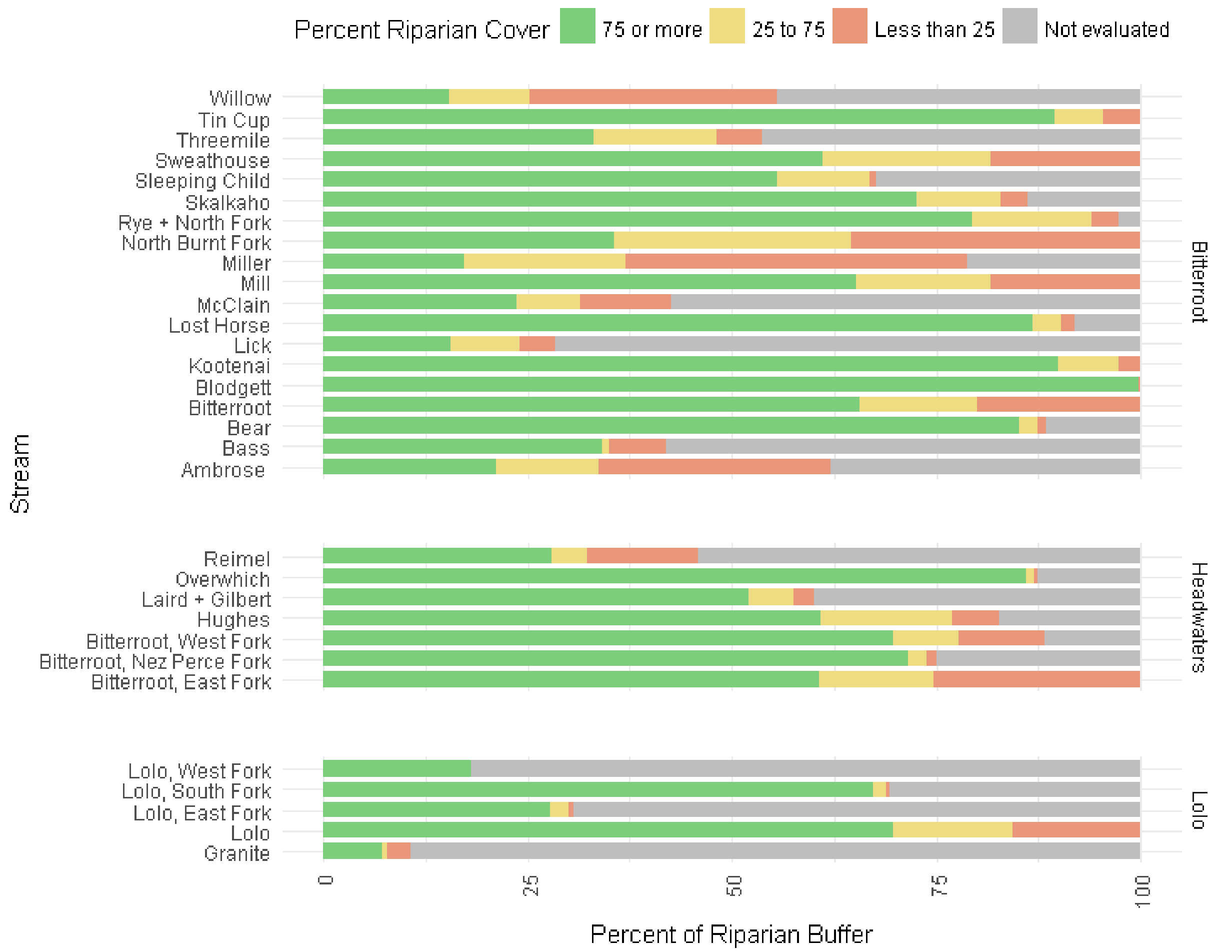

Figure 8.1. This graphic shows the proportion of stream evaluated by aerial imagery that was found to have high (>75%), moderate (25-75%) or low (<25%) vegetation coverage in the riparian buffer. Most unevaluated reaches are in heavily forested USFS property, where fine scale source assessment work is routinely conducted.

Note that the Bitterroot temperature TMDL recommends an effective increase in shade over the river of at least 0.5%. This aerial evaluation does not directly measure shade over the stream, although it may be a good indicator of progress towards achieving temperature targets.

MEASURES OF SUCCESS
• Increase in riparian vegetation cover since the 2017 riparian evaluation completed by DEQ, especially if that increase occurs along nutrient impaired tributaries or the mainstem Bitterroot

8.5 Social indicators

Reducing nonpoint sources of pollution in a way that results in measurable water quality improvement requires widespread understanding of the issue and action taken by individuals and communities to address the issue. Even after widespread adoption of nonpoint source pollution reduction activities, it will take time for these improvements to manifest in a water chemistry signature. For example, it takes time for a newly installed riparian vegetation buffer to establish and effectively buffer streams from pollution. Detectable water quality improvement will always be preceded by a change in community awareness and willingness to act on nonpoint source pollution issues.

Community Readiness Assessments (CRA) can help guide outreach strategies and measure social change (Oetting et al., 2001). CRAs can gauge how ready a community is to address a particular issue and provides recommendations for outreach specific to that stage. After implementing the recommended activities, the CRA may be rerun to detect change in readiness. In 2020, DEQ and the Bitter Root Water Forum completed a CRA focused on the issue of "the loss of riparian vegetation" within the Bitterroot rancher community. Results show that community is in a "Preplanning" phase, the 4^{th} of nine phases. DEQ seeks to use this CRA as a measure of success by rerunning interviews with key community informants again in approximately 2023.

MEASURES OF SUCCESS

- Raise awareness
  - An increase in the number of press releases, media articles, videos or social media content, and TV or radio public service announcements developed about nonpoint source pollution
  - An increase in participation at public forums or volunteer events
  - An increase in nonpoint source pollution related webpage views
- Increase actions taken
  - An increase in inquiries to local organizations seeking guidance for managing nonpoint source pollution on their property
  - An increase in legislative priorities or local ordinances aimed at reducing nonpoint sources of pollution
- Increase community readiness levels

9.0 Planned Responses to Changes in Condition

Tracking measures of success (**Sections 7.0-8.0**) will guide the effectiveness of Bitterroot River protection activities. An understanding of the ramifications of Bitterroot River nutrient impairment will be a useful framework for outreach to protect the Bitterroot River's high-quality status. For example, it may be easier to build buy-in to implement voluntary best management practices if local jurisdictions can communicate the risk of utility rate increases due to increased water treatment required to maintain human health. Additionally, hoot owl fishing closures (i.e., temporary fishing closures due to high water temperatures) can impact local economies that rely on the business of recreators on the Bitterroot River. Local experts and guides can communicate with the public that these hoot-owl restrictions originate at the watershed scale. Protecting and restoring riparian vegetation throughout the watershed can lower temperatures and help prevent future restrictions on the mainstem Bitterroot River. Similarly, when water shortages limit access to surface water rights, local experts can use this opportunity to promote restoration activities that increase stream channel complexity, store water on the landscape longer, and help reduce nutrient pollution. Ultimately, the management practices that protect water quality have short- and long-term economic benefits and can also improve the quality of living in the Bitterroot valley.

For DEQ's part in implementing this Protection Plan, the agency will continue support for the Bitterroot Mainstem long-term nutrient monitoring and ensure that results are reported to the public. If nutrient conditions begin to worsen, DEQ will issue a press release, reinvigorate outreach with stakeholders, and if possible, target outreach to stakeholders most likely to influence nutrient pollution. More specific studies may be necessary to determine the highest risk of nutrient pollution and future nutrient reassessment may be warranted as population and pollution sources increase. If reassessment indicates that one or more segments of the Bitterroot River have become impaired by nutrients, voluntary water quality improvement projects may rise in priority for available funding. However, the costs to restore water quality are notoriously larger than costs to protect water quality (Postel and Barton, 2005). Similarly, implementing certain projects may become more expensive the longer they are delayed. For example, the opportunity to implement an easement may become prohibitively expensive as land value increases.

This Protection Plan was written to emphasize the unique, high quality condition of the Bitterroot River. Implementing the recommendations in this Protection Plan will maintain and protect water quality, while also building resiliency for Bitterroot communities as climate, population, and water quality conditions fluctuate.

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APPENDIX A – PROJECT PRIORITIZATION MAP TOOL

View an interactive map (tinyurl.com/BitterrootProtectionPlan) of 2019 riparian vegetation cover and wetland status data to help prioritize future projects.