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6.0 Nutrient TMDL Components

This section focuses on nutrients (total nitrogen (TN) and total phosphorus (TP) forms; nitrate (NO_3) and nitrite (NO_2) forms (referred to as nitrate throughout the remainder of this section); and chlorophyll-*a*) as a cause of water quality impairment in the Thompson TMDL Project Area (AKA Thompson Project Area). It includes 1) nutrient impairment of beneficial uses; 2) specific stream segments of concern; 3) currently available data on nutrient impairment assessment in the watershed; 4) target development and a comparison of existing water quality targets; 5) description of nutrient sources; and 6) identification and justification for nutrient TMDLs and TMDL allocations.

6.1 Effects of Excess Nutrients on Beneficial Uses

TN and TP are natural background chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, which is affected by nutrient additions, consumption by autotrophic organisms, cycling of biologically fixed nitrogen and phosphorus into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Additions from natural landscape erosion, groundwater discharge, and instream biological decomposition maintain a balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways, causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with human sources) can be toxic to aquatic life. Elevated nitrates in drinking water can inhibit normal hemoglobin function in infants. Besides the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes dissolved oxygen, which can kill fish and other forms of aquatic life. Nutrient concentrations in surface water can lead to blue-green algae blooms (Priscu 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans.

Aside from toxicity, nuisance algae can shift the macroinvertebrate community structure, which also may affect fish that feed on macroinvertebrates (USEPA 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al. 2009). Nuisance algae can increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization 2003).

6.2 Stream Segments of Concern

There are nine waterbody segments in the Thompson Project Area that are present on the 2012 303(d) List for phosphorus and/or nitrogen impairments (**Table A-1**): Henry Creek, Lazier Creek, Little Bitterroot River, Little Thompson River, Lynch Creek, McGinnis Creek, McGregor Creek, Sullivan Creek, and Swamp Creek (**Figure 6-1**). Based on data collected as part of this project, DEQ has concluded Henry Creek, McGinnis Creek, and McGregor Creek are no longer impaired for nutrients. These changes in impairment status are the result of the assessment process and will be updated on the 2014 303(d) List.

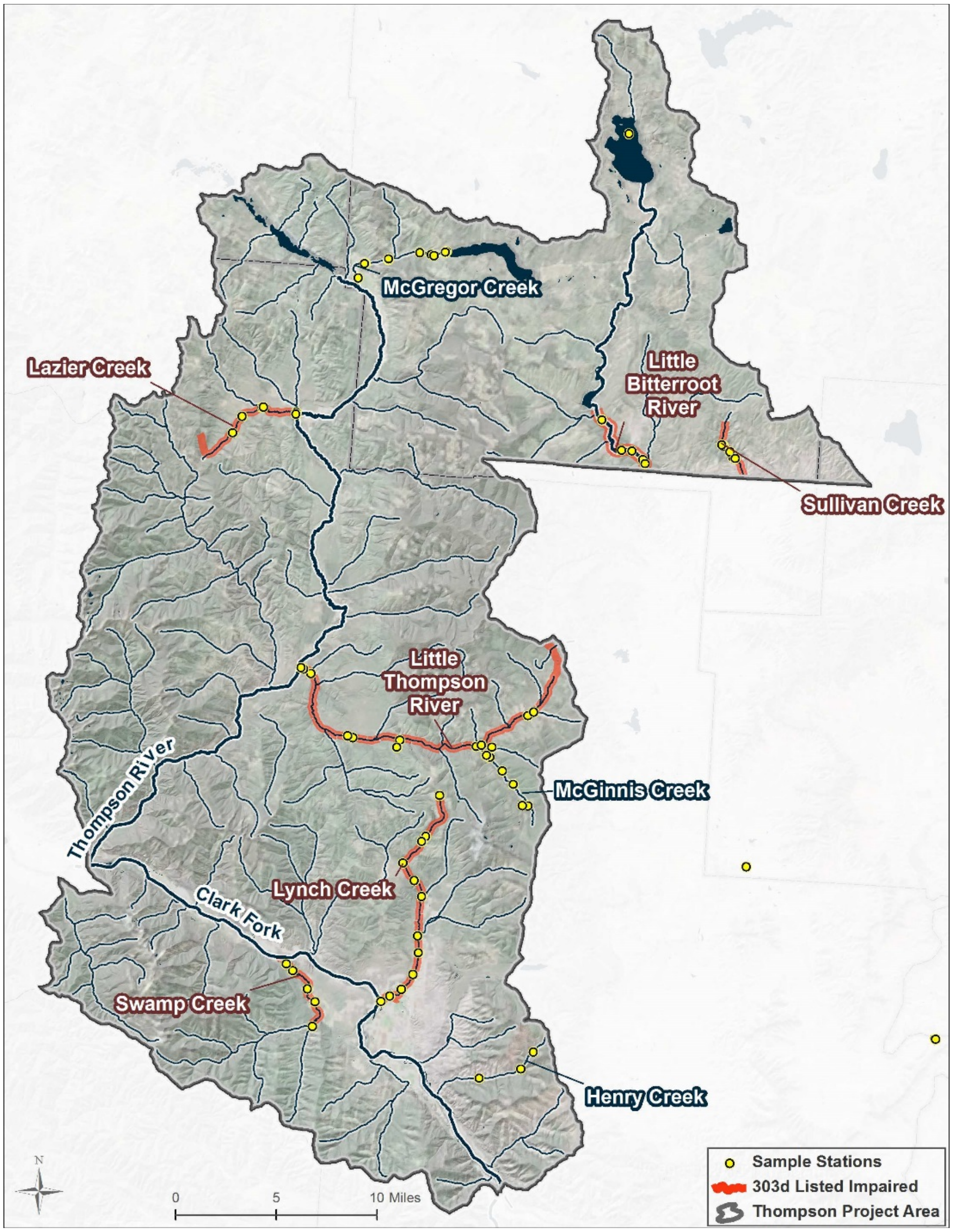

Figure 6-1: Nutrient impaired streams in the Thompson TMDL Project Area for which TMDLs will be written and associated sampling locations.

6.3 Information Sources and Assessment Methods

The following information sources were searched and/or used to describe water quality and nutrient loading conditions in the project area:

- Monitoring and assessment data were compiled by DEQ for the impaired waterbodies in the Thompson Project Area (2004-2012). Most data were collected between 2009 and 2012 to help support TMDL development.
    - Because sediment and nutrient sources are commonly linked, site visit notes from sediment and habitat sampling conducted in September 2011 to support sediment

TMDL development (**Section 5.0**) were also used to describe channel conditions and potential nutrient sources (Atkins 2013)

- United States Geological Survey (USGS), National Water Information System (NWIS) database of surface water chemistry and discharge
- United States Environmental Protection Agency (EPA) STORET database of surface water chemistry and stream discharge
- Federal and state government agency geographical information system (GIS) data for geology, topography, land cover, and land-use layers
- Montana DEQ Clean Water Act Information Center - Water Quality Standards Attainment Records (DEQ 2012)

Sample locations were generally such that they provided a comprehensive upstream to downstream view of nutrient levels (**Figure 6-1**). The location of sample collection also allowed for analysis of potential source impacts (e.g., changes in land use or septic influence). All data used in TMDL development were collected during the growing season for the Northern Rockies Level III Ecoregion (July 1 – September 30). Benthic algae samples were collected from 2007 through 2012. These samples were analyzed for Chlorophyll-*a* concentration and ash free dry mass (AFDM). AFDM is a measurement that captures both living and dead algal biomass and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* measures only living algae). Macroinvertebrate samples were collected from 2004 through 2012.

Growing season nutrient data used for impairment assessment purposes and TMDL development are included in **Appendix F**. Other nutrient data from the watershed is publicly available through EPA's STORET and DEQ's EQuIS water quality databases.

The above information and water quality data are used to compare existing conditions to waterbody restoration goals (targets), to assess nutrient pollutant sources, and to help determine TMDL allocations.

6.4 Water Quality Targets

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed further in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Thompson Project Area following DEQ's draft assessment methodology (Suplee 2011). To be consistent with DEQ's draft assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

6.4.1 Nutrient Water Quality Standards

Montana's water quality standards for nutrients (nitrogen and phosphorous) are narrative and are addressed via narrative criteria. Narrative criteria require state surface waters to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: 1) produce conditions that create concentrations or combinations of material toxic or harmful to aquatic life, and 2) create conditions that produce undesirable aquatic life (ARM 17.30.637 (1) (d-e)). DEQ is currently developing numeric nutrient criteria for TN and TP that will be established at levels consistent with narrative criteria requirements. These draft numeric criteria are the basis for the nutrient TMDL targets and are consistent with EPA's guidance on TMDL development and federal regulations.

6.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae (a form of aquatic life that at elevated concentrations is undesirable), chlorophyll-*a* concentrations, and AFDM. The target concentrations for nitrogen and phosphorus are established at levels believed to prevent the harmful growth and proliferation of excess algae. Since 2002, DEQ has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms). DEQ is developing draft numeric nutrient standards for total nitrogen (TN), total phosphorus (TP), chlorophyll-*a*, and AFDM based on 1) public surveys defining what level of algae was perceived as "undesirable" and 2) the outcome of nutrient stressor-response studies that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee et al., 2008). Although dissolved fractions of phosphorus and nitrogen do not have draft numeric nutrient criteria because uptake by aquatic organisms can make their concentrations highly variable, DEQ has determined that nitrate is an important constituent to evaluate in conjunction with TN and TP (Suplee and Watson 2013).

Nutrient targets for TN and TP (which are also draft numeric criteria), chlorophyll-*a*, and AFDM are based on Suplee and Watson (2013) and can be found in **Table 6-1**. The nitrate target is based on research by Suplee (2013) and can also be found in **Table 6-1**. DEQ has determined that the values for nitrate, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Thompson Project Area. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses. When the draft criteria for TN and TP become numeric standards they will be in DEQ's DEQ-12 circular.

The nutrient target suite for streams in the Northern Rockies Level III Ecoregion also includes two biometric indicators: macroinvertebrates and diatoms. For macroinvertebrates, the Hilsenhoff Biotic Index (HBI) score) is used. The HBI value increases as the amount of pollution tolerant macroinvertebrates in a sample increases; the macroinvertebrate target is an HBI score equal to or less than 4.0 (Suplee and Sada de Suplee 2011) (**Table 6-1**). Benthic diatoms, or periphyton, are a type of algae that grow on the stream bottom, and there are certain taxa that tend to increase as nutrient concentrations increase. The diatom target is a periphyton sample with a ≤51% probability of impairment by nutrients (Suplee and Sada de Suplee 2011) (**Table 6-1**).

Because numeric nutrient chemistry is established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season (July 1–September 30 for the Northern Rockies Level III Ecoregion) when algal growth will most likely affect beneficial uses. Targets listed here have been established specifically for nutrient TMDL development in the Thompson Project Area and may or may not be applicable to streams in other TMDL project areas. The target values for total nitrogen and total phosphorus will be used to develop TMDLs. TMDLs will not be written specifically for nitrate or chlorophyll-*a*. Nitrate impairments are addressed by TN TMDLs and chlorophyll-*a* impairment is addressed by TN and TP TMDLs. See **Section 9.1** for the adaptive management strategy as it relates to nutrient water quality targets.

Table 6-1. Nutrient Targets for the Thompson TMDL Project Area

Parameter	Northern Rockies Level III Ecoregion Target Value
Nitrate[(1)]	<0.1 mg/L
Total Nitrogen[(2)]	≤ 0.275 mg/L
Total Phosphorus[(2)]	≤ 0.025 mg/L

Table 6-1. Nutrient Targets for the Thompson TMDL Project Area

Parameter	Northern Rockies Level III Ecoregion Target Value
Chlorophyll-*a*[2]	≤ 125 mg/m^2
Ash Free Dry Mass[2]	≤ 35 g/m^2
Hilsenhoff's Biotic Index[3]	< 4.0
Periphyton[3]	< 51%

(1) Value is from Suplee (2013).
(2) Value is from Suplee and Watson (2013).
(3) Value is from Suplee and Sada de Suplee (2011).

6.4.3 Existing Conditions and Comparison to Targets

For each waterbody segment included on Montana's 2012 303(d) List for nutrients (**Table A-1**), DEQ evaluates recent water quality data relative to the water quality targets to make a TMDL development determination. DEQ has recently completed several years of water sampling in the Thompson TMDL Project Area for the purpose of assessing the nutrient impairment determinations. These data provide the basis for the nutrient target evaluations below.

Evaluation of nutrient target attainment is conducted by comparing existing water quality conditions to the water quality targets in **Table 6-1** following the methodology in the DEQ guidance document, *Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels* (Suplee and Sada de Suplee 2011). This approach provides DEQ with updated impairment determinations used for TMDL development. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment will be evaluated for impairment from nitrate, TN, and TP using data collected within the past 10 years. Additionally, nutrient samples collected prior to 2005 were analyzed for Total Kjeldahl Nitrogen (TKN), which has since been replaced by DEQ with Total Persulfate Nitrogen as the preferred analytical method for total nitrogen; DEQ determined that samples analyzed for TKN may have a high bias relative to identical samples analyzed for Total Persulfate Nitrogen and are excluded from the data review. As mentioned in **Section 6.2**, Henry Creek, McGinnis Creek, and McGregor Creek showed no nutrient impairment, and therefore TMDLs are not being developed for them and assessment information is not included in this document.

The assessment methodology uses two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is not attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* exceeds benthic algal target concentrations (125 mg/m^2 or 35 g $AFDM/m^2$). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, macroinvertebrate and periphyton biometrics are considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading. Human-caused sources of nutrients must be present for a stream to be considered impaired.

Note: to ensure a higher degree of certainty for removing an impairment determination and making any new impairment determination, the statistical tests are configured differently for an unlisted nutrient form than for a listed nutrient form. This can result in a different number of allowable exceedances for nutrients within a single stream segment. Such tests help assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample. When applying the T-test for assessment and sample values were below detection limits, one-half the detection limit was used.

6.4.3.1 Lazier Creek (MT76N005_060)

Lazier Creek is on the 2012 303(d) List as impaired by TN, TP, nitrate/nitrite. The impaired segment of Lazier Creek begins at the headwaters and flows 7.8 miles until its termination at the confluence with the Thompson River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Lazier Creek are provided in **Tables 6-2 and 6-3**, respectively. Nutrient samples for Lazier Creek were collected between 2004 and 2012. Fourteen nitrate samples were collected and values ranged from < 0.01 to 0.08 mg/L with none of the samples exceeding the nitrate target of 0.1 mg/L. Note that one of the values was excluded because it exceeded the TN concentration of that sample (which indicates a potential data quality issue). Thirteen TN samples were collected and values ranged from < 0.04 to 0.1 mg/L with none of the samples exceeding the TN target of 0.275 mg/L. Values ranged from <0.005 to 0.024 mg/L for the 14 TP samples with no samples exceeding the TP target of 0.025 mg/L.

There were eight chlorophyll-*a* samples, three AFDM samples, four periphyton samples, and three macroinvertebrate samples collected from Lazier Creek. Chlorophyll-*a* values ranged from 22 to 69 mg/m² and none of the samples exceed the target of 125 mg/m². AFDM ranged from 18 to 54 g/m² with two exceedances of the 35 g/m² target. Two periphyton samples exceeded the 51% target. HBI values ranged from 2.67 to 5.37 with two exceedances of the 4.0 target. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be consuming excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient impairment listings and failure of multiple biological targets (**Table 6-3**), all nutrient listings (i.e., nitrate, TN and TP) will be retained. Therefore, TMDLs will be written for TN and TP. The TN TMDL will address the nitrate listing. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-2. Nutrient Data Summary for Lazier Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	14	< 0.01	0.08	0.015
TN, mg/L	2011-2012	13	< 0.04	0.1	0.059
TP, mg/L	2004-2012	14	< 0.005	0.024	0.011
Chlorophyll-*a*, mg/m²	2011-2012	8	22	69	36
AFDM, g/m²	2012	3	18	54	36
Periphyton, %	2004-2011	4	25	68	47
Macroinvertebrate HBI	2004-2011	3	2.67	5.37	4.19

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-3. Assessment Method Evaluation Results for Lazier Creek

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	14	0.1	0	PASS	PASS	PASS	FAIL	FAIL	FAIL	YES
TN	13	0.275	0	PASS	PASS					YES
TP	14	0.025	0	PASS	PASS					YES

6.4.3.2 Little Bitterroot River (MT76L002_060)

The Little Bitterroot River is on the 2012 303(d) List as impaired by TN, TP, nitrate/nitrite, and chlorophyll-*a*. The impaired segment of the Little Bitterroot River begins at Hubbart Reservoir and flows 5.2 miles to the Flathead Reservation boundary (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for the Little Bitterroot River are provided in **Tables 6-4 and 6-5**, respectively. Nutrient samples for the Little Bitterroot River were collected from 2004 through 2012. Nine nitrate samples were collected with values that ranged from < 0.01 to 0.13 mg/L. One of the samples exceeded the nitrate target of 0.1 mg/L. The values of the eight TN samples ranged from 0.33 to 0.63 mg/L with all samples exceeding the TN target of 0.275 mg/L. Nine TP samples ranged from 0.027 to 0.078 mg/L with all samples exceeding the TP target of 0.025 mg/L.

Two chlorophyll-*a* samples, one AFDM sample, four periphyton samples, and three macroinvertebrate samples were collected from the Little Bitterroot River. Chlorophyll-*a* values ranged from 32 to 124 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM sample was 20 g/m^2 and did not exceed the target of 35 g/m^2. There was one exceedance of the 51% periphyton target. HBI values ranged from 4.72 to 5.61 with all three samples exceeding the target of 4.0.

The short length of Little Bitterroot River between Hubbart Reservoir and the Flathead Reservation resulted in a slightly smaller sample size than desired, but the data strongly support the existing nutrient impairment listings for nitrate, TN, and TP (**Table 6-5**). Although the chlorophyll-*a* target was not exceeded, the minimum sample size needed to evaluate if chlorophyll-*a* is still causing impairment was not met. TMDLs will be written for TN and TP. DEQ will address the nitrate listing with the TN TMDL and the chlorophyll-*a* listing with the TN and TP TMDLs.

Table 6-4. Nutrient Data Summary for the Little Bitterroot River

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	9	< 0.01	0.13	0.048
TN, mg/L	2011-2012	8	0.33	0.63	0.421
TP, mg/L	2004-2012	9	0.027	0.078	0.051
Chlorophyll-*a*, mg/m^2	2004, 2011	2	32	124	78
AFDM, g/m^2	2011	1	20	20	20
Periphyton, %	2004-2012	4	38	53	45
Macroinvertebrate HBI	2011	3	4.72	5.61	5.17

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-5. Assessment Method Evaluation Results for the Little Bitterroot River

Nutrient	Sample Size	Target Value (mg/l)	Target Exceed ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	9	0.1	1	FAIL	n/a*	PASS	PASS	FAIL	FAIL	YES
TN	8	0.275	8	FAIL	FAIL					YES
TP	9	0.025	9	FAIL	FAIL					YES

*Minimum sample sizes were not met, but impairment is apparent and there were enough exceedances to fully assess and keep listed.

6.4.3.3 Little Thompson River (MT76N005_040)

The Little Thompson River is on the 2012 303(d) List as impaired by TP. The impaired segment of the Little Thompson River begins at the headwaters and flows 19.92 miles until its termination at the confluence with the Thompson River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for the Little Thompson River are provided in **Tables 6-6 and 6-7**, respectively. Nutrient samples were collected for the Little Thompson River from 2003 through 2012. Twenty nitrate samples were collected and values ranged from < 0.005 to 0.02 mg/L with none of the samples exceeding the target of 0.1 mg/L. Sixteen TN samples were collected and values ranged from < 0.01 to 0.26 mg/L with none of the samples exceeding the target of 0.275 mg/L. Twenty TP samples were collected and values ranged from 0.006 to 0.022 mg/L with no samples exceeding the target of 0.025 mg/L.

Eight chlorophyll-*a* samples, 6 AFDM samples, 8 periphyton samples, and 12 macroinvertebrate samples were collected from the Little Thompson River. Chlorophyll-*a* values ranged from 5 to 25 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM samples ranged from 5 to 45 g/m^2 with one of the observations exceeding the target of 35 g/m^2. There were two exceedances of the 51% periphyton target. HBI values ranged from 1.63 to 4.23 with three of the samples exceeding the target of 4.0. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be consuming excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient listing and failure of multiple biological targets (**Table 6-7**), the TP impairment listing will be retained. Because nutrient concentrations in the water column were below target values, it is unclear whether excess phosphorus and/or nitrogen is causing the impairment. Therefore, TN will be added to the 2014 303(d) as an impairment cause and TMDLs will be written for TN and TP. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-6. Nutrient Data Summary for the Little Thompson River

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	20	< 0.005	0.02	0.0056
TN, mg/L	2007-2012	16	< 0.01	0.26	0.089
TP, mg/L	2004-2012	20	0.006	0.022	0.013
Chlorophyll-*a*, mg/m^2	2007-2012	8	5	25	15
AFDM, g/m^2	2011-2012	6	5	45	17
Periphyton, %	2004-2011	8	25	95	46
Macroinvertebrate HBI	2003-2011	12	1.63	4.23	3.38

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

Table 6-7. Assessment Method Evaluation Results for the Little Thompson River

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	20	0.1	0	PASS	PASS	PASS	FAIL	FAIL	FAIL	NO
TN	16	0.275	0	PASS	PASS					YES
TP	20	0.025	0	PASS	PASS					YES

6.4.3.4 Lynch Creek (MT76N003_010)

Lynch Creek is on the 2012 303(d) List as impaired by TN and TP. The impaired segment of Lynch Creek begins at the headwaters and flows 13.33 miles until its termination at the confluence with the Clark Fork River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Lynch Creek are provided in **Tables 6-8 and 6-9**, respectively. Nutrient samples for Lynch Creek were collected from 2004 through 2012. Twenty-six nitrate samples were collected with values ranging from < 0.01 to 0.32 mg/L. One of the samples exceeded the target of 0.1 mg/L. Twenty-four TN samples were collected and values ranged from < 0.05 to 0.91 mg/L with six of the samples exceeding the target of 0.275 mg/L. Twenty-six TP samples were collected and values ranged from 0.013 to 0.038 mg/L with eight samples exceeding the TP target of 0.025 mg/L.

Twelve chlorophyll-*a* samples were collected from Lynch Creek between 2009 and 2011 and six AFDM samples were collected from Lynch Creek in 2011. Chlorophyll-*a* values ranged from 1 to 53 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM samples ranged from 4 to 37 g/m^2 with one of the observations exceeding the target of 35 g/m^2. There were 10 periphyton samples collected from Lynch Creek between 2004 and 2011 with 4 exceedances of the 51% target. There were seven macroinvertebrate samples collected from Lynch Creek between 2004 and 2011. HBI values ranged from 2.03 to 7.17. Two of these samples exceeded the target of 4.0.

Assessment results (**Table 6-9**) support the existing Lynch Creek impairment listings for TN and TP. As a result TMDLs will be written for TN and TP.

Table 6-8. Nutrient Data Summary for Lynch Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	26	< 0.01	0.32	0.03
TN, mg/L	2009-2012	24	< 0.05	0.91	0.198
TP, mg/L	2004-2012	26	0.013	0.038	0.022
Chlorophyll-*a*, mg/m^2	2009-2011	12	1	53	12
AFDM, g/m^2	2011	6	4	37	10
Periphyton, %	2004-2011	10	28	95	55
Macroinvertebrate HBI	2004-2011	7	2.03	7.17	3.7

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient	Sample Size	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	26	0.1	1	PASS	PASS	PASS	FAIL	FAIL	FAIL	NO
TN	24	0.275	6	FAIL	PASS					YES
TP	26	0.025	8	FAIL	PASS					YES

6.4.3.5 Sullivan Creek MT76L002_070

Sullivan Creek is on the 2012 303(d) List as impaired by TP. The impaired segment of Sullivan Creek begins at the headwaters and flows 3.9 miles to the Flathead Indian Reservation (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Sullivan Creek are provided in **Tables 6-10 and 6-11**, respectively. The sample dataset is very small because of the short length of the waterbody segment and limited surface flow, and it precluded the use of the statistical tools during assessment. Nutrients were sampled in Sullivan Creek from 2004 through 2012. Five nitrate samples were collected and all observations were < 0.01 mg/L with none of the samples exceeding the target of 0.1 mg/L. Three TN samples were collected and values ranged from 0.11 to 1.28 mg/L with one sample exceeding the target of 0.275 mg/L. Five TP samples were collected and values ranged from 0.014 to 0.061 mg/L with two samples exceeding the TP target of 0.025 mg/L.

One chlorophyll-*a* sample, one AFDM sample, two periphyton samples, and two macroinvertebrate samples were collected from Sullivan Creek. The chlorophyll-*a* value was 19 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM sample was 6 g/m^2 and did not exceed the target of 35 g/m^2. Neither periphyton sample was exceeding the 51% target. The HBI values were 6.5 and 2.1 with one of these samples exceeded the target of 4.0.

Although the small sample size precluded a formal assessment, the exceedance of the HBI, TN, and TP targets indicate nutrient impairment. Since Sullivan Creek is currently listed for impairment by TP, that cause will be retained. There are insufficient data to determine if TN is also causing impairment in Sullivan Creek, but based on the magnitude of the exceedance (i.e., more than four times the target), a protective TMDL will be written for TN. Water quality samples have been collected by the Confederated Salish and Kootenai Tribes downstream of this segment within the Flathead Reservation. Although that data cannot be used to determine impairment for this segment of Sullivan Creek, TN concentrations close to the reservation boundary were reviewed and support the development of a protective TMDL for TN. Therefore, TMDLs will be written for TN and TP (**Table 6-11**).

Table 6-10. Nutrient Data Summary for Sullivan Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2012	5	< 0.01	< 0.01	< 0.01
TN, mg/L	2012	3	0.11	1.28	0.52
TP, mg/L	2004-2012	5	0.014	0.061	0.03
Chlorophyll-*a*, mg/m^2	2012	1	19	19	19
AFDM, g/m^2	2012	1	6	6	6
Periphyton, %	2004-2008	2	18	21	19
Macroinvertebrate HBI	2004, 2011	2	2.1	6.5	4.27

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient	Sample Size	Target Value (mg/l)	Target Exceed ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	5	0.1	0	n/a[2]	n/a[2]					NO
TN[1]	3	0.275	1	n/a[2]	n/a[2]	PASS[3]	PASS[3]	PASS[3]	FAIL[3]	YES
TP	5	0.025	2	n/a[2]	n/a[2]					YES

[1]There are insufficient data to include Sullivan Creek on the 303(d) List for TN, but based on the magnitude of exceedances, a TMDL was developed for TN.
[2]Not enough data to complete binomial test or T-test
[3]Minimum sample size not met

6.4.3.6 Swamp Creek (MT76N003_160)

Swamp Creek is on the 2012 303(d) List as impaired by TN, TP, and nitrate/nitrite. The impaired segment of Swamp Creek begins at West Fork Swamp Creek and flows 4.76 miles until its termination at the confluence with the Clark Fork River (**Figure 6-1**).

Summary nutrient data statistics and assessment method evaluation results for Swamp Creek are provided in **Tables 6-12 and 6-13**, respectively. Nutrient samples for Swamp Creek were collected from 2004 through 2011. Fourteen nitrate samples were collected and values ranged from < 0.01 to 0.01 mg/L with none of the samples exceeding the target of 0.1 mg/L. Thirteen TN samples were collected with values ranging from < 0.01 to 0.11 mg/L with none of the samples exceeding the target of 0.275 mg/L. Fourteen TP samples were collected and values ranged from <0.005 to 0.027 mg/L with one sample exceeding the target of 0.025 mg/L.

Twelve chlorophyll-*a* samples, three AFDM samples, six periphyton samples, and four macroinvertebrate samples were collected from Swamp Creek. Chlorophyll-*a* values ranged from 2 to 71 mg/m^2 and did not exceed the target of 125 mg/m^2. The AFDM samples ranged from 5 to 47 g/m^2 with one of the observations exceeding the target of 35 g/m^2. Two periphyton samples exceeded the 51% target. HBI values ranged from 3.39 to 6.05 with three exceedances of the 4.0 target. The exceedance of the targets for AFDM, periphyton, and HBI indicate nutrient impairment. According to DEQ's assessment methodology, failure of biological targets while meeting the nutrient targets indicates algae may be taking up excess nutrients in the water column and/or that water quality sampling missed the pulse of nutrients that is causing the biological response.

Based on the existing nutrient impairment listings and failure of multiple biological targets (**Table 6-13**), all nutrient listings (i.e., nitrate, TN and TP) will be retained. Therefore, TMDLs will be written for TN and TP. The TN TMDL will address the nitrate listing. However, because none of the water samples exceeded target values, additional water column and biological sampling is recommended to help refine the impairment cause(s) and sources.

Table 6-12. Nutrient Data Summary for Swamp Creek

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1]	Max	Mean
Nitrate, mg/L	2004-2011	14	< 0.01	0.01	0.006
TN, mg/L	2007-2011	13	< 0.01	0.11	0.074
TP, mg/L	2004-2011	14	< 0.005	0.027	0.010
Chlorophyll-*a*, mg/m^2	2007-2011	12	2	71	18
AFDM, g/m^2	2011	3	5	47	23
Periphyton, %	2004-2011	6	30	61	43
Macroinvertebrate HBI	2004, 2011	4	3.39	6.05	5.18

[1] Values preceded by a "<" symbol are detection limits for that parameter. The actual sample value was below the detection limit.

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

Nutrient	Sample Size	Target Value (mg/l)	Target Exceed ances	Binomial Test Result	T-test Result	Chl-*a* Test Result	AFDM Test Result	Peri-phyton Test	Macro Test Result	TMDL Required
Nitrate	14	0.1	0	PASS	PASS					YES
TN	13	0.275	0	PASS	PASS	PASS	FAIL	FAIL	FAIL	YES
TP	14	0.025	1	PASS	PASS					YES

6.5 Source Assessment

This section summarizes the source assessment approach and findings for each of the six stream segments of concern for nutrients.

6.5.1 Source Assessment Approach

Based on the review of water quality data, geographic information, and project reports and narratives, potential human caused sources of nutrient loading to the impaired waterbodies in the Thompson TMDL Project Area include agriculture, development, timber harvest, and failing septic systems. These are all nonpoint sources, meaning they are dispersed across the landscape and do not originate from a discrete source, such as a pipe (i.e., point source). The Thompson Project Area does not have any permitted point sources of nutrients. Nutrient sources therefore consist primarily of 1) natural sources derived from airborne deposition, vegetation, soils, and geologic weathering; and 2) human-caused nonpoint sources (i.e., grazing, septic, residential development, and timber harvest).

Because there are no point sources and nonpoint source categories are intermixed within each watershed, the source assessment approach focuses on using monitoring data collected between 2004 and 2012 to evaluate spatial patterns and identify the most probable nutrient sources. Since all water quality data were collected during the growing season (i.e., July 1 – September 30), the source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. To display this information, box plots are used. In descriptive statistics, box plots are a convenient way of graphically depicting groups of numerical data through their five number summaries. Box plots depict the smallest observation (sample minimum), 25th percentile, median, 75th percentile, and the largest observation (sample maximum). Box plots display differences between the data without making any assumptions of the underlying statistical distribution of the data. The spacing between the different parts of the box indicates the degree of dispersion and skewness in data and identifies outliers. When sample data used in boxplots were below detection limits, one half of the detection limit was used.

Synoptic sampling data (from multiple sites on the same day) as well as other sources such as DEQ assessment files, GIS land use data, and personal communication with land managers were also used for the source assessment. For streams where low nutrient concentrations limited the use of instream data for assessing source category contributions, these other data sources were the basis of the source assessment.

6.5.2 Source Categories

There are no permitted point sources of nutrients in the impaired waterbody segments; cattle grazing and timber harvest are the primary human source categories in the Thompson Project Area, but developed areas and septic systems are other potential human sources that were evaluated. **Section 6.5.2.1** through **Section 6.5.2.6** presents individual source assessment summaries for each impaired watershed in the Thompson Project Area. A brief summary of each potential source category is described below.

Agriculture

Although the majority of cattle are typically not grazing along the valley bottoms during the growing season, there are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of grazing on vegetative health and its ability to uptake nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989). Cattle grazing occurs in several of the impaired watersheds in the Thompson Project Area.

Pasture

Pasture is managed for hay production during the summer, and for grazing feed during the fall and spring. Hay pastures are fairly thickly vegetated in the summer, and less so in the fall through spring. During the winter grazing period (October – May), trampling and consumption reduces biomass at a time of the year when it is already low.

Rangeland

Rangeland has much less biomass than other land uses, and therefore contributes fewer nutrients from biomass decay. However, grazing impacts (manure deposition) do factor in. Rangeland is grazed during the summer months in the watershed. The rangeland grazing typically occurs from June through September in the Thompson Project Area.

Development

Developed areas can contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Although developed areas often have the highest nutrient loading rates, in the Thompson Project Area developed areas make up a very small percentage of the overall area (0.23%). The only town in the Thompson Project Area is Plains, which is located in the Lynch Creek subwatershed. The total population in Plains is 1,048 according to the 2010 U.S. Census.

Septics

Septic systems, even when operating as designed can contribute nutrients to surface water through subsurface pathways. The amount of nutrients that a given septic system contributes to a waterbody is dependent upon its discharge, soils, and distance from the waterbody. The number and location of septic systems in the watershed was estimated based on cadastral data.

Timber Harvest

The forested areas in the Thompson Project Area are heavily timbered. Timber harvest inevitably causes some measure of downstream effects that may or may not be significant over time. Changes in land cover will change the rate at which water evapotranspires and thus the water balance, in that the distribution of water between base flow and runoff will change. Disturbances of the ground surface will also disrupt the hydrological cycle. The combination of these changes can alter water yield, peak flows and water quality (Jacobson 2004). Changes in biomass uptake and soil conditions will affect the nutrient cycle. Nutrient uptake by biomass is greatly reduced after timber harvest, leaving more nutrients available for runoff. Elevated nitrate concentrations also result from increased leaching from the soil as mineralization is enhanced. This increase generally only lasts up to two or three years before returning to pre-harvest levels (Feller and Kimmins 1984; Likens et al. 1978; Martin and Harr 1989).

Therefore, the source assessment of timber harvest focuses on relatively recent harvest data. As part of the *Assessment of Upland Sediment Sources for TMDL Development* (**Appendix X**), timber harvest that occurred between 2006 and 2011 was identified by adjusting the 2006 NLCD layer. Adjustments on U.S. Forest Service lands were performed based on timber harvest polygons provided by the U.S. Forest Service.

Natural Background

The natural background component of nutrient loading was not explicitly evaluated, but a significant component of the forest category and portions of all other categories are associated with background loading.

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, wildlife were assumed to contribute a minimal nutrient load relative to livestock. Forest fires are also considered part of natural background. Fires occurring between 2006 and 2011 were quantified for private and public land using the process described above for timber harvest (and in **Appendix X**). Recently burned areas are indicated on the watershed map for each stream segment of concern within this section for informational purposes. The only recent fires occurred in the Little Bitterroot and Little Thompson drainages in 2007.

6.5.3 Lazier Creek (MT76N005_060)

The source assessment for Lazier Creek consists of an evaluation of nitrate, TN, and TP concentrations in the impaired segment of Lazier Creek. This is followed by a description of the potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Lazier Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.1**, **Table 6-2**). **Figures 6-2, 6-3, and 6-4** present summary statistics for TN, nitrate, and TP concentrations, respectively, at sampling sites in Lazier Creek. The stations are listed from upstream to downstream (left to right). All TN, nitrate, and TP values in this segment were below their respective targets of 0.275, 0.1, and 0.025 mg/L. The segment was listed for nutrient impairment due to exceedances of the HBI, periphyton, and AFDM targets. There does not appear to be a strong pattern for nutrient concentrations in the segment. Although all nutrient samples were below their targets, the highest observations occurred in the most downstream portion of the creek, below Whitney Creek. However, exceedances of the AFDM, HBI, and periphyton targets occurred both above and below Whitney Creek, indicating nutrient sources are likely dispersed throughout the watershed.

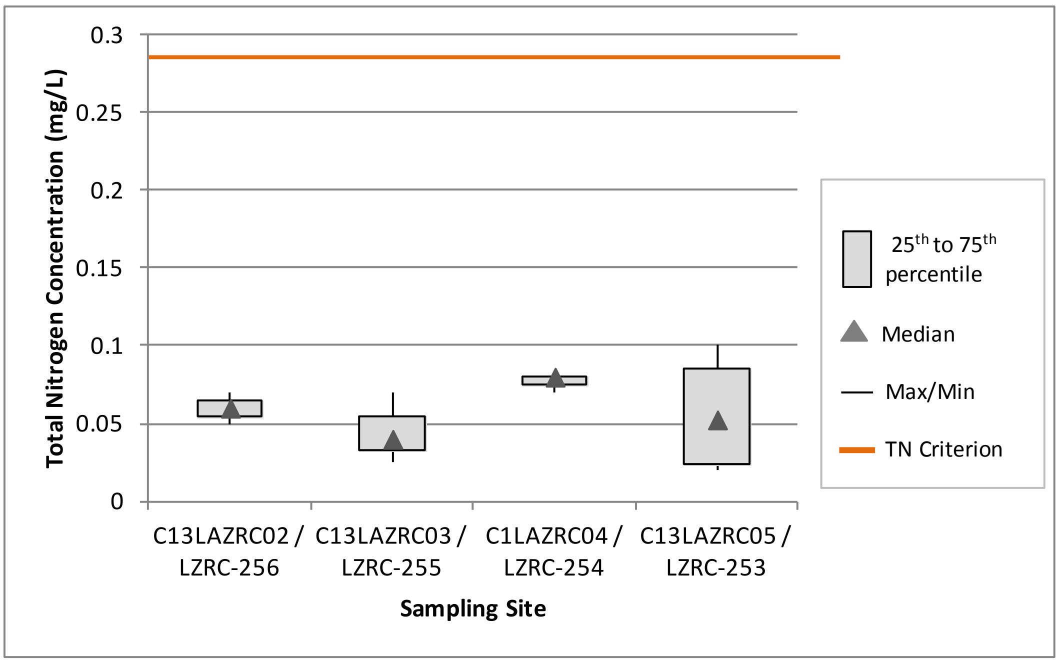

Figure 6-2: TN Box Plots for Lazier Creek.

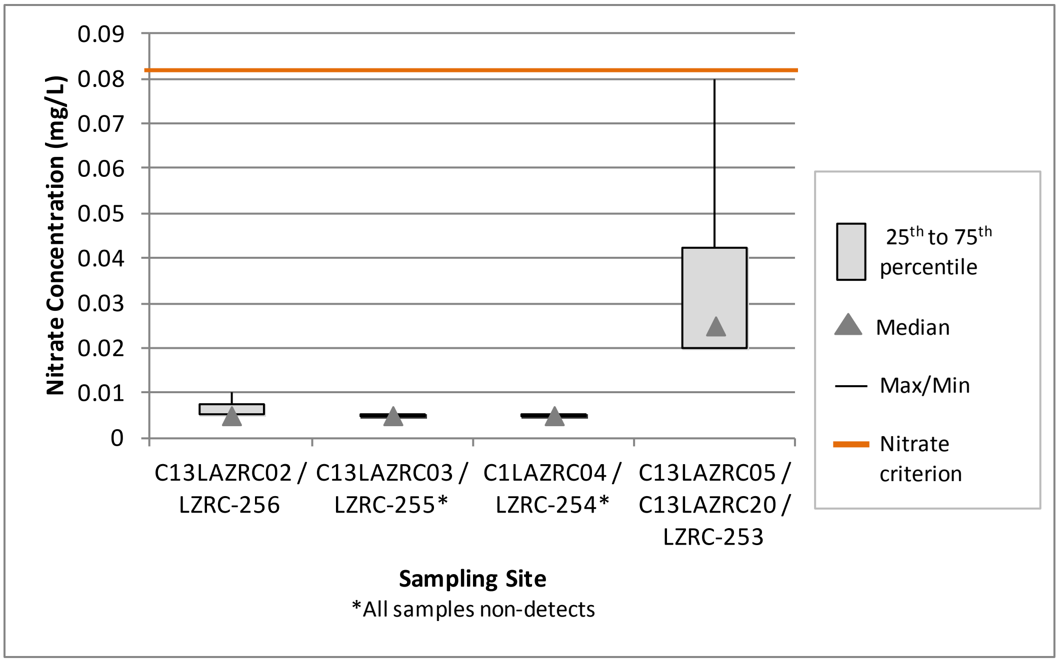

Figure 6-3: Nitrate Box Plots for Lazier Creek.

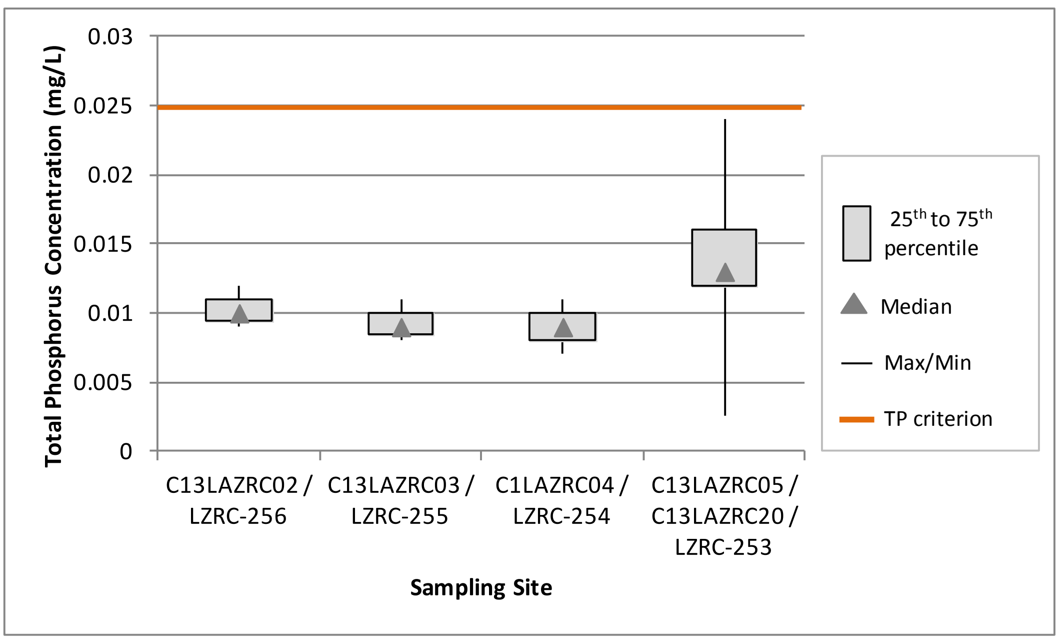

Figure 6-4: TP Box Plots for Lazier Creek.

Land Cover and Land Use

The dominant land cover in the Lazier Creek watershed is evergreen forest (81%) (NLCD 2006). Most of the evergreen forest (83%) is private timberland (Montana Cadastral 2013). DEQ's 2011 field notes (Atkins 2013) indicate timber harvest as the primary land use along Lazier Creek below the confluence with Whitney Creek. Above the confluence with Whitney Creek, timber harvest and grazing are the primary land uses. The field notes also indicate that extensive timber harvest has occurred throughout the watershed.

Plum Creek Timber Co., Inc. is a major landowner in the Thompson Project Area, including much of the Lazier Creek watershed. Most of the Plum Creek land in the Lazier Creek watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed while others are rested. These grazing pastures are rotated regularly. Portions of the U.S. Forest Service's (USFS's) Fishtrap grazing allotment are located in the headwaters of the Lazier Creek watershed (2,916 acres); however, the Fishtrap allotment is currently inactive (USFS 2009). The Fishtrap allotment was last used in 1993 and officially closed in May 2007 (USFS, personal communication 2013).

Montana Fish, Wildlife, and Parks (FWP) owns a conservation easement on 84,412 acres of land in the Thompson River watershed. Quite a bit of Plum Creek land in the lower portion of the Lazier Creek watershed is included in this easement. The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013).

According to the Montana cadastral, there are no septic systems in the Lazier Creek watershed (BMSC 2010).

Summary and Conclusions

Timber harvest and grazing appear to be the most probable sources of nutrients to Lazier Creek. The water quality data indicate some higher nutrient loading in the downstream portion of Lazier Creek; however, the biological data indicate sources throughout the impaired segment. Field observations also indicate timber harvest throughout the watershed and grazing upstream of Whitney Creek as potential sources. Development and septic systems are not expected to be nutrient sources in the watershed due to their absence. **Figure 6-5** shows the locations of all potential nutrient sources in the Lazier Creek watershed.

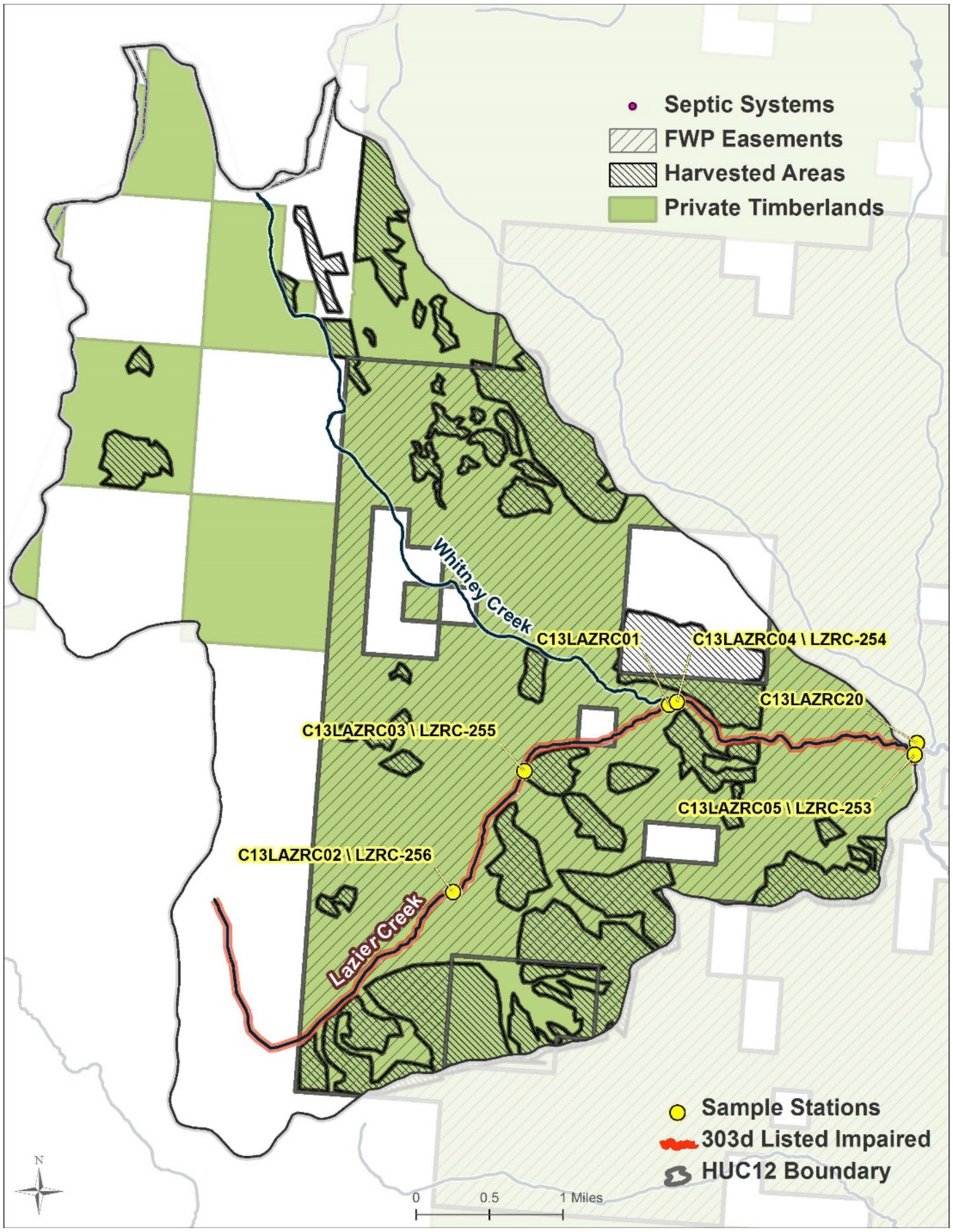

Figure 6-5: Location of potential nutrient sources in the Lazier Creek watershed.

6.5.4 Little Bitterroot River (MT76L002_060)

The source assessment for the Little Bitterroot River consists of an evaluation of nitrate, TN, and TP concentrations in the impaired segment of the Little Bitterroot River. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from the Little Bitterroot River during the growing season over the time period of 2004-2012 (**Section 6.4.3.2**, **Table 6-4**). **Figures 6-6** through **6-8** present summary statistics for TN, nitrate, and TP concentrations at sampling sites in the Little Bitterroot River. There are exceedances of the TN target of 0.275 mg/L at all 3 stations. The highest observation was at station

LBRR-299 below Clear Creek; however, there is no strong pattern of TN concentrations upstream to downstream (left to right). Nitrate values in this segment were typically below the target of 0.1 mg/L, except for one exceedance at the most upstream station (C12LTBTR02) just below Briggs Creek. There is no strong nitrate pattern along the stream gradient. TP values in this segment were often greater than the target of 0.025 mg/L at all sites, with the highest observation occurring in the upper part of the segment at station C12LTBTR02/LBRR-289 just below Briggs Creek, but there is no consistent spatial pattern.

Chlorophyll-*a* and AFDM observations were below their respective targets and HBI scores were exceeding their target throughout the entire reach. The periphyton target was exceeded in the upstream portion of the impaired segment just below Briggs Creek.

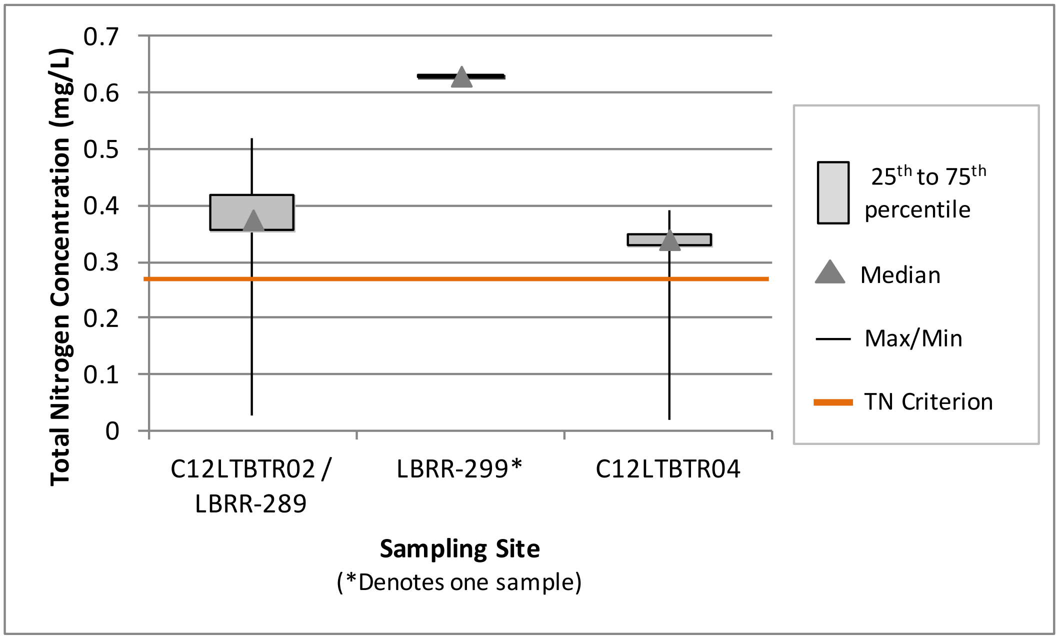

Figure 6-6: TN Box Plots for the Little Bitterroot River.

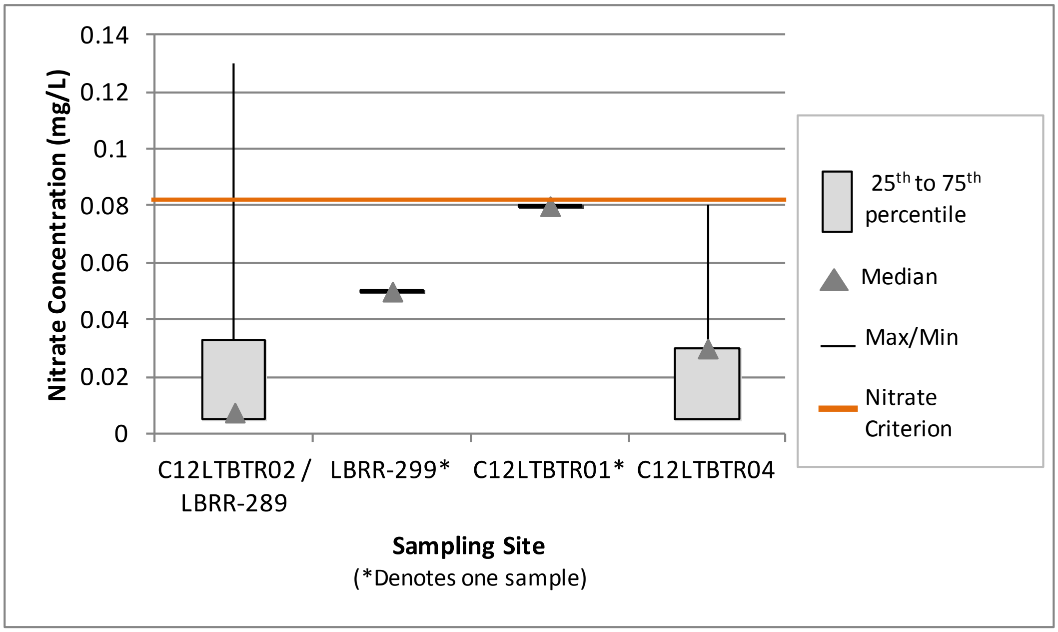

Figure 6-7: Nitrate Box Plots for the Little Bitterroot River.

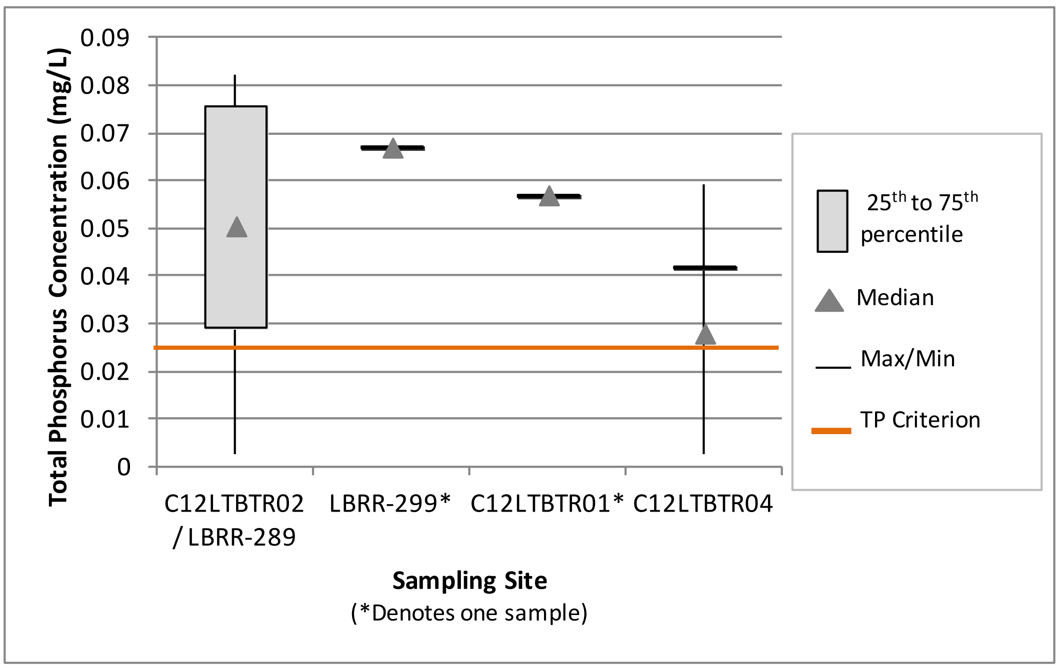

Figure 6-8: TP Box Plots for the Little Bitterroot River.

Land Use and Land Cover

The dominant land cover in the Little Bitterroot River watershed is evergreen forest (64%) and the predominant land use in this area is timber harvest (DEQ 2012b). Most of the land in the Little Bitterroot River watershed is owned by the Plum Creek Timber Company (Montana Cadastral 2013). There are no USFS or Bureau of Land Management (BLM) grazing allotments and no land is leased from Plum Creek for grazing in the Little Bitterroot River watershed, however, private lands are used for grazing.

There are 140 septic systems in the watershed (BMSC 2010), but they are concentrated around Little Bitterroot Lake, well upstream of the impaired portion of the river. There are two septic systems located along unnamed tributaries to the impaired portion of the Little Bitterroot River and there is one septic system located adjacent to the lower portion of the Little Bitterroot River. However, the water quality samples do not indicate that nutrient loading from septic systems is a particular issue in the Little Bitterroot River.

DEQ's 2011 field notes (Atkins 2013) indicate that the area near stations C12LTBR02/LBRR-289, just downstream of the confluence with Briggs Creek, is primarily used for grazing and timber harvest. Signs of heavy grazing were noticed near the mouth of Briggs Creek as well as extensive aquatic vegetation on the streambed. The field notes also noted severe streambank erosion near the lower end of the Little Bitterroot River, which is also used for cattle grazing. Woody vegetation was lacking along the streambanks and the wetland vegetation was heavily browsed.

Summary and Conclusions

In summary, grazing and timber harvests appear to be the most probable sources of nutrients to the Little Bitterroot River. The water quality data are exceeding the nutrient targets throughout the entire impaired portion of the Little Bitterroot River, indicating sources are located throughout the entire watershed. Recent site visits (2011) indicate grazing throughout the entire watershed and timber harvest in the upper watershed as potential sources. Timber harvests have occurred throughout the entire stream segment. The impaired portion of the Little Bitterroot River drains an area from the mouth of Little Bitterroot Lake (about 14 miles upstream of the northern portion of the impaired segment) and includes Hubbart Reservoir directly above the impaired segment; however, there are no data available for Hubbart Reservoir upstream of the impaired segment to analyze potential upstream sources. Data collection at the reservoir outlet and upstream of the impaired reach would be useful in determining additional potential sources. It is currently unknown if the development and septic systems located in the headwaters of the river near Little Bitterroot Lake could be contributing to the high nutrients in the lower portion of the waterbody. One observation in Little Bitterroot Lake in 2011 shows no exceedances of the TN or TP targets. No other data are available. Development and septic systems are not expected sources in the lower reach because nutrient concentrations below the unnamed tributaries, where septics are located, are no higher than any other area of the impaired reach. **Figure 6-9** shows the locations of all potential nutrient sources to the Little Bitterroot River.

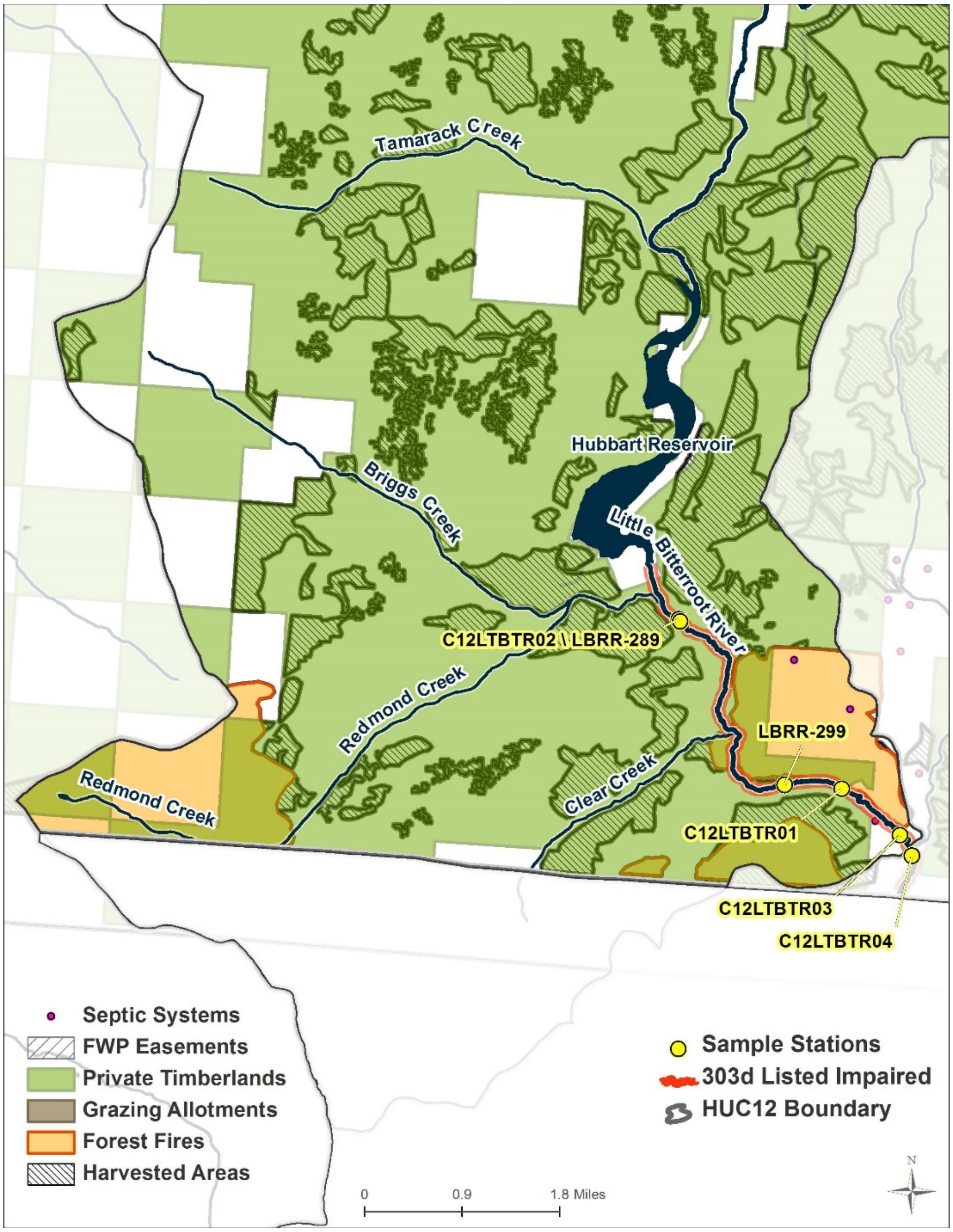

Figure 6-9: Location of potential nutrient sources in the Little Bitterroot River watershed.

6.5.5 Little Thompson River (MT76N005_040)

The source assessment for the Little Thompson River consists of an evaluation of TN and TP concentrations within the impaired segment of the Little Thompson River. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from the Little Thompson River during the growing season over the time period of 2004-2012 (**Section 6.4.3.3**, **Table 6-6**). **Figures 6-10** and **6-11** present summary statistics for TN and TP concentrations, respectively, at sampling sites in the Little Thompson River. All TN and TP values in this segment were below their respective targets of 0.275 and 0.025 mg/L. The segment was listed for nutrient impairment due to exceedances of the HBI, periphyton, and AFDM targets. Although none of the TN or TP observations exceed the criteria, the highest TN and TP concentrations were consistently observed in the upstream portion of the river below Alder Creek. During the four synoptic sampling events between 2004 and 2012, TN and TP concentrations were greatest at the upper most sample site and declined until downstream of the North Fork Little Thompson River (L13LTTPR03/LTLTR-244), where concentrations increased slightly until the mouth. Most exceedances of the biological data were observed in the upper portion of the watershed, above the confluence with McGinnis Creek, except for periphyton. Periphyton exceedances were observed at the mouth of the Little Thompson River. All three exceedances of the HBI target occurred just below the confluence with Tepee Creek and the AFDM exceedance was observed just above the confluence with McGinnis Creek.

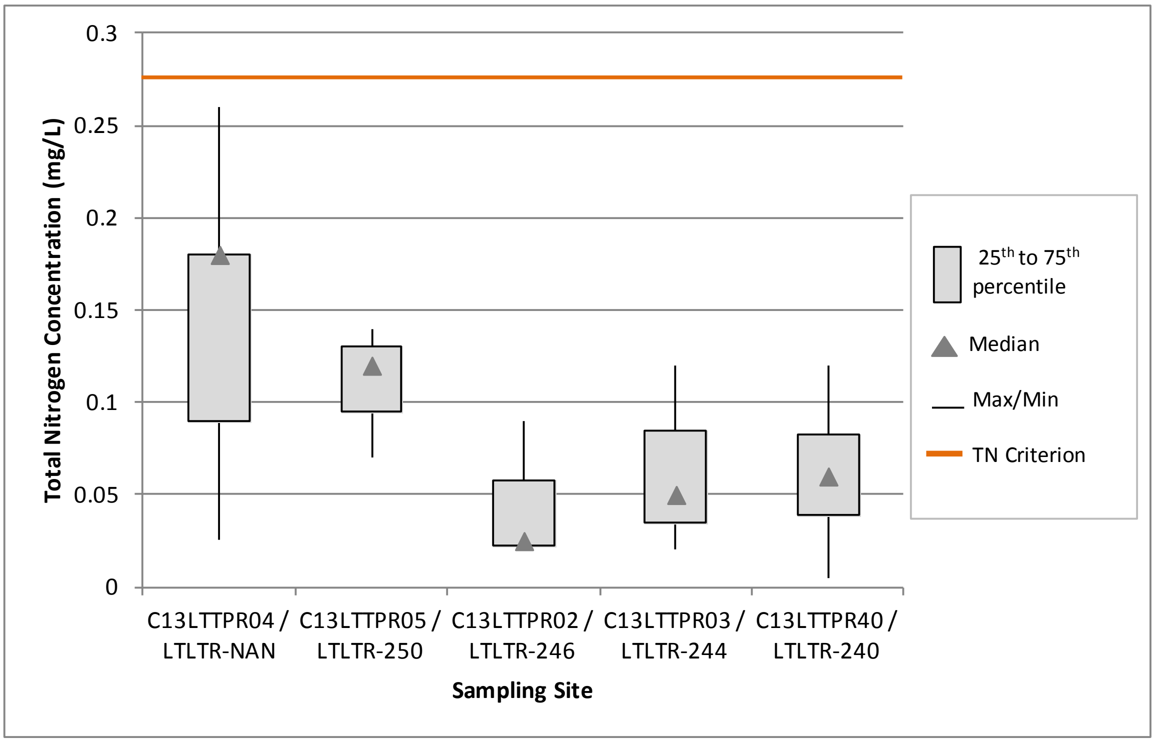

Figure 6-10: TN Box Plots for the Little Thompson River.

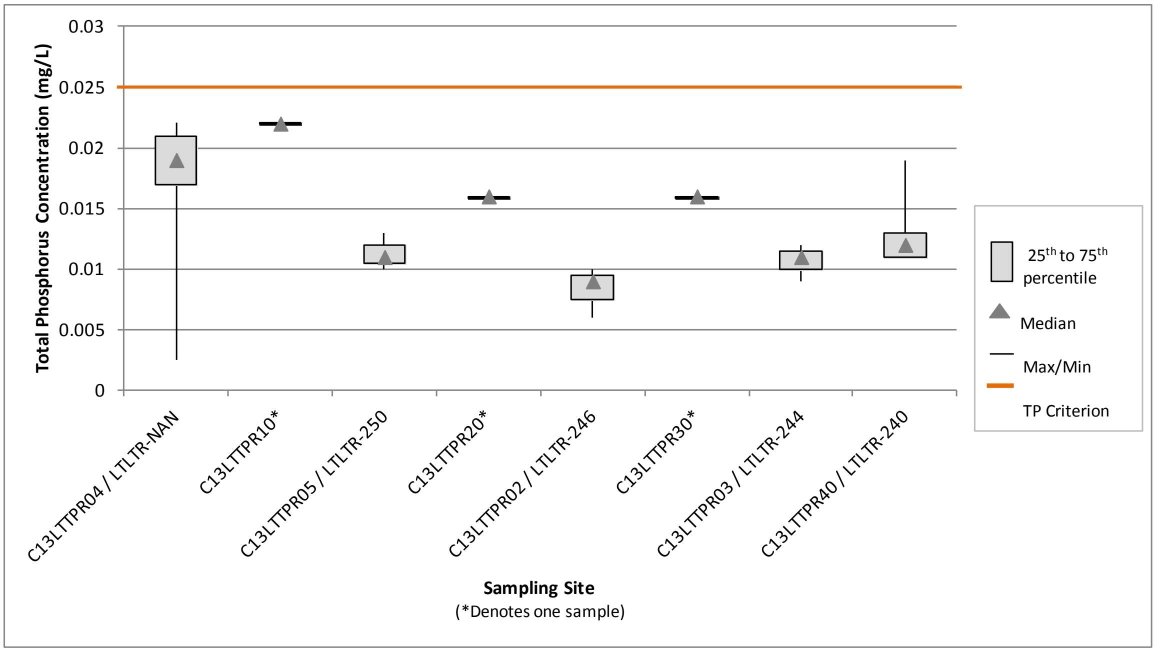

Figure 6-11: TP Box Plots for the Little Thompson River

Land Cover and Land Use

The dominant land cover in the Little Thompson River watershed is evergreen forest (87%) and 35% of that land is private timberland. DEQ's assessment record from 2004 (2012c) states that livestock use in the headwaters of the river is common. The USFS's Little Thompson and McGinnis grazing allotments are located in the headwaters of the watershed (USFS 2009). The Little Thompson grazing allotment is used in connection with approximately 1,280 acres of private land. The grazing occurs from June 15 through September 15 with 110 cattle permitted. The allotment is managed as three pastures under a rotation system. Each pasture is grazed two out of every three years: year 1 is grazed early, year 2 is grazed late, and year 3 is rested. The McGinnis allotment is active from June 1 through September 30 with 52 cattle permitted (USFS, personal communication 2013).

DEQ's 2011 field notes (Atkins 2013) indicate that the portion of the Little Thompson River above the confluence with the North Fork Little Thompson River is dominated by historic logging and grazing. Selective browsing of the wetland vegetation along the channel and hoof shear were observed along this area of the river (approximately 1 mile above the confluence with the North Fork Little Thompson River). Historic logging and ongoing grazing are also the primary land-use activities near the mouth of the Little Thompson River. Extensive logging occurs throughout the watershed.

Plum Creek Timber Co., Inc. is a major landowner in the Thompson Project Area. Montana Fish, Wildlife, and Parks (FWP) owns a conservation easement on 84,412 acres of land in the Thompson River watershed. Quite a bit of Plum Creek land in the Little Thompson River watershed is included in this easement. The state of Montana acquired the easement in several phases between 2001 and 2003. It precludes development, but allows traditional uses such as forestry, grazing, hunting, and fishing. Public access is secured through this easement (Plum Creek, personal communication 2013).

Most of the Plum Creek land in the Little Thompson River watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly (Plum Creek, personal communication 2013). Timber harvest is also common in the watershed and roads, pasture, and logging all cause a moderate amount of disturbance (DEQ 2012c).

The only septic system in the Little Thompson River watershed is located along Marten Creek, a tributary to the mouth of the river (BMSC 2010).

Summary and Conclusions

Grazing and timber harvest appear to be the most probable nutrient sources in the Little Thompson River. The water quality and biological data indicate some higher nutrient loading in the upper portion of watershed; however, exceedances were observed near the mouth of the watershed as well. This suggests that there is not a particular area of the watershed that has increased nutrient loading. Development and septic systems are not expected to be nutrient sources in the watershed due to their absence. **Figure 6-12** shows the locations of all potential nutrient sources in the Little Thompson River watershed.

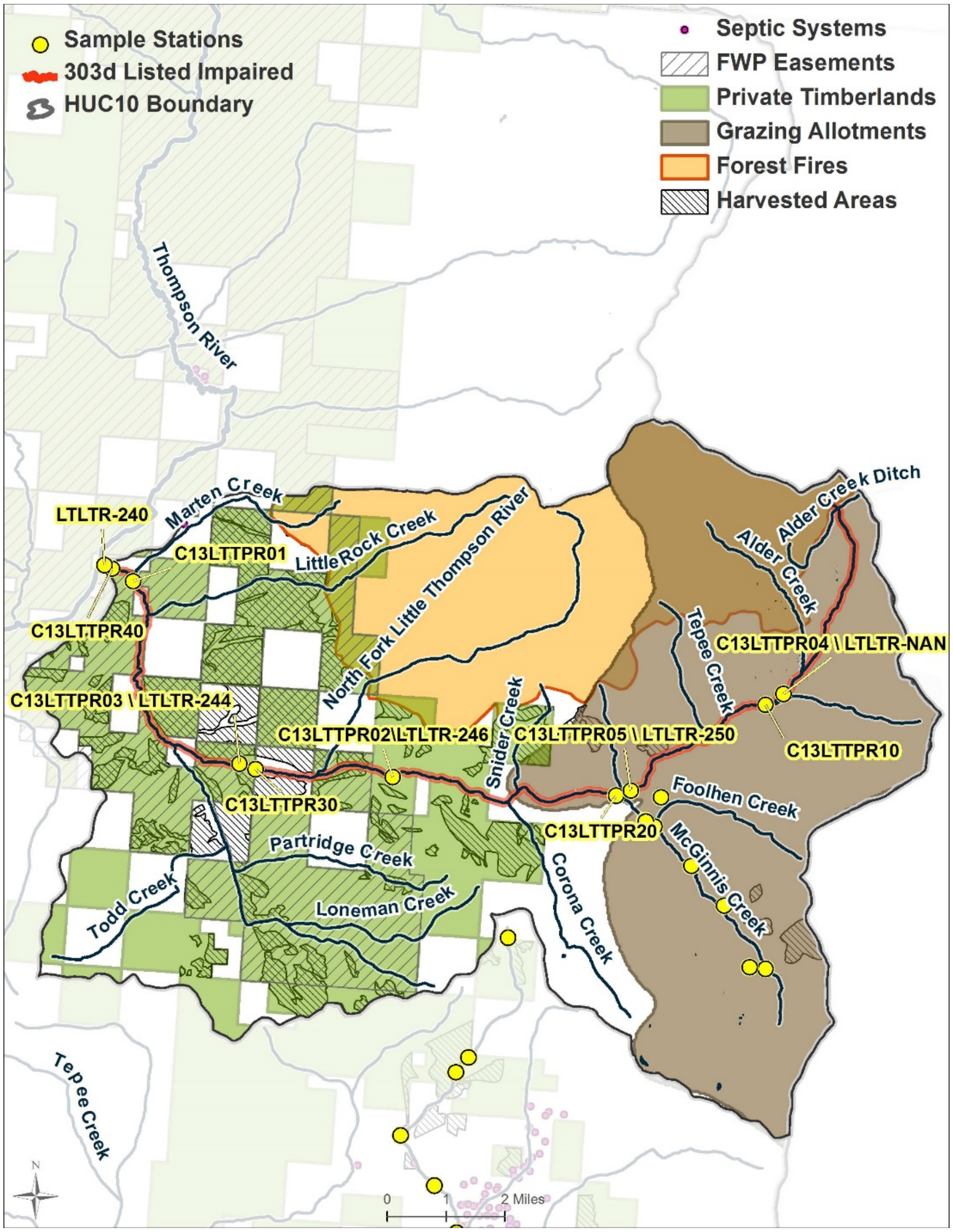

Figure 6-12: Location of potential nutrient sources in the Little Thompson River watershed.

6.5.6 Lynch Creek (MT76N003_010)

The source assessment for Lynch Creek consists of an evaluation of TN and TP concentrations in the impaired segment of Lynch Creek. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Lynch Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.4**, **Table 6-8**). **Figures 6-13 and 6-14** present summary statistics for TN and TP concentrations, respectively, at sampling sites in Lynch Creek. TN values in this segment were below the target of 0.275 mg/L at all stations except for the most upstream site and the two most downstream sites (**Figure 6-13**). **Figure 6-14** shows an increase in TP values in the downstream direction (left to right), with most exceedances of the 0.025 mg/L target occurring at the three most downstream sites. In addition to the TN and TP exceedances, one exceedance of the AFDM target occurred at the mouth of Lynch Creek as did the two HBI exceedances and one periphyton exceedance. The other three periphyton exceedances occurred in the upper portion of Lynch Creek above the confluence with Cedar Creek.

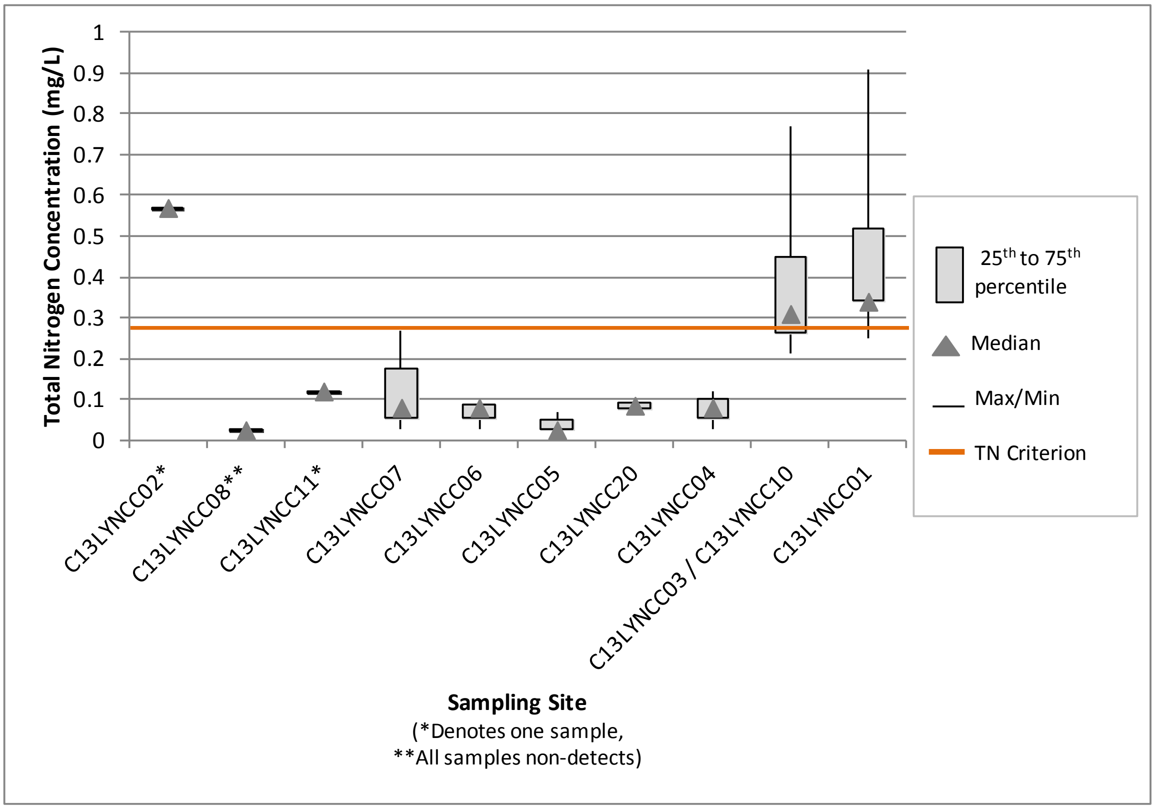

Figure 6-13: TN Box Plots for Lynch Creek.

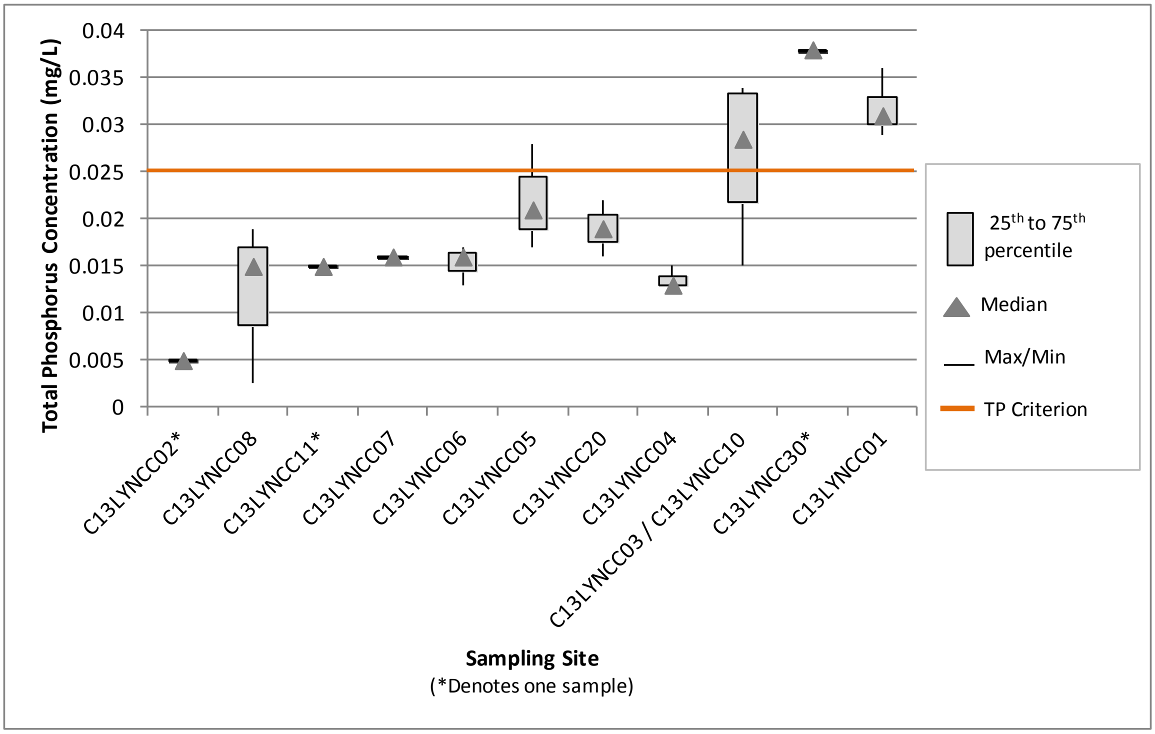

Figure 6-14: TP Box Plots for Lynch Creek.

Land Cover and Land Use

The dominant land cover in the Lynch Creek watershed is evergreen forest (66%) and 30% of the entire watershed is private timberland. Lynch Creek below Clark Creek is characterized by a lack of woody riparian vegetation and a straightened channel with a moderate amount of bank erosion. The dominant land uses in this lower portion of the creek are hay production and cattle grazing (DEQ 2012d). Hummocking, hoof trampling, and streambank erosion from cattle was noted during the 2011 site visit (Atkins 2013). There are 446 acres of pasture/hay in the watershed that appear to be concentrated near the mouth of the creek (NLCD 2006). The headwaters of Lynch Creek to the confluence with Clark Creek is mostly forest with some cattle grazing but less than below the confluence with Clark Creek (DEQ2012d). DEQ's 2011 field notes (Atkins 2013) indicate that the area of the watershed above Cedar Creek is forested and was harvested for timber at one time. Timber harvest has occurred throughout the Lynch Creek watershed and signs of grazing were observed in the upper watershed including hoof trampling resulting in streambank erosion.

There is more development in the Lynch Creek watershed than other nutrient impaired watersheds in the Thompson Project Area. The lower portion of Lynch Creek is just outside the town of Plains, MT, which has a population of 1,074 (U.S. Census 2010). There are 201 septic systems in the Lynch Creek watershed (BMSC 2010). Most are located on Cedar Creek, Hinchwood Creek, Clark Creek and along Lynch Creek downstream from Cedar Creek (**Figure 6-15**).

Summary and Conclusions

In summary, the water quality and biological data indicate some high TN concentrations and periphyton scores in the upper Lynch Creek watershed above Cedar Creek. The most probable sources of nutrients to this portion of the watershed appear to be timber harvest and cattle grazing. All TP, AFDM, and HBI exceedances occurred between Cedar Creek and the mouth of Lynch Creek. The most probable sources of nutrient loading to Lynch Creek below Cedar Creek appear to be development and timber harvest along Clark and Hinchwood Creeks as well as cattle grazing, hay production, and development along the mainstem of Lynch Creek below Cedar Creek. **Figure 6-15** shows the location of potential nutrient sources in the Lynch Creek watershed.

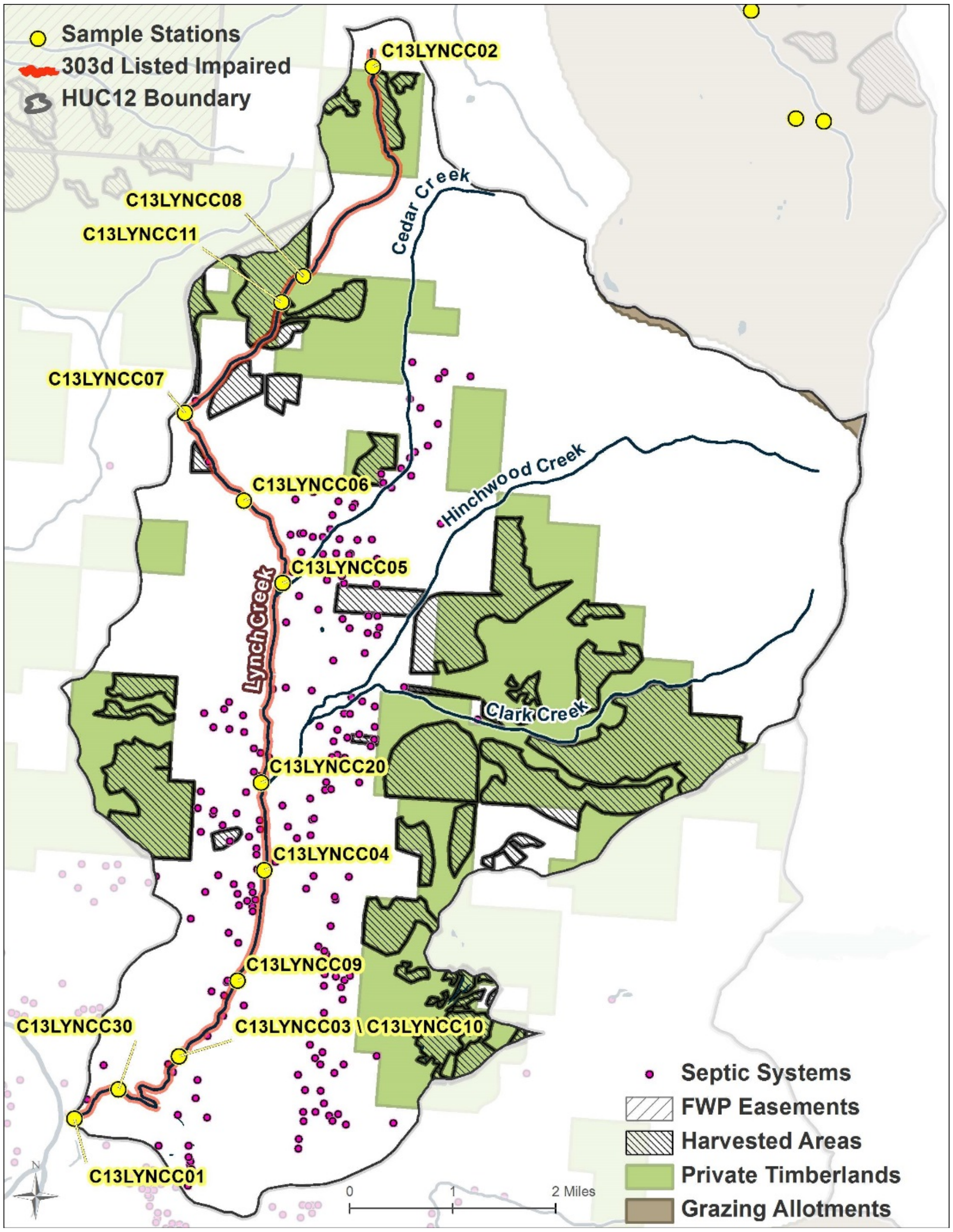

Figure 6-15: Locations of potential nutrient sources in the Lynch Creek watershed.

6.5.7 Sullivan Creek (MT76L002_070)

Data Analysis

Given the intermittent nature of Sullivan Creek, the water quality data are of limited use in assessing nutrient sources and loading. There are not enough stations with nutrient data on Sullivan Creek to make box plots meaningful. There are only two stations with a total of three TN observations and three stations with a total of six TP observations. There was one TN and one TP exceedance of their respective water quality targets. Both of the exceedances occurred at upstream station C12SLVNC02 (**Figure 6-16**) with the TN exceedance occurring in 2012 and the TP exceedance occurring in 2004. There was also one HBI score exceedance in 2012 at the most downstream station (C12SUllC02). There are not enough data to determine any seasonal or temporal trends or trends along the stream gradient.

Land Cover and Land Use

A site visit was performed at Sullivan Creek in 2011; however, no notes were included in the site assessment. The most recent site visit notes for Sullivan Creek are from the 2004 assessment. The upper section of the stream contains a swampy area that was disturbed by mining and the lower section is dry. Sub-surface flows predominate the segment. Cattle impacts are heavy throughout most of the watershed. Streambanks are trampled, riparian vegetation is degraded or missing, and the channel morphology has been altered by grazing (DEQ 2012e).

The dominant land covers in the Sullivan Creek watershed are evergreen forest (41%), shrub (25%), and grassland (34%) (NLCD 2006). Grazing and timber harvest appear to be the dominant land uses. There are a number of abandoned mines in the watershed, and one mine (Hog Heaven) that has an operating permit, but is not currently producing. These include both surface and underground mining (DEQ 2012e). These mines are not expected to be sources of nutrients to Sullivan Creek because they are currently inactive and they were not cyanide mines; therefore, there were no nitrates in the mining residuals. There are no other permitted point sources in the watershed, so any nutrient inputs are from nonpoint sources.

Plum Creek Timber Co., Inc. owns much of the land in the Sullivan Creek watershed. All of the Plum Creek land in the watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly.

Summary and Conclusions

There are only two septic systems in the watershed, both of which are located near the mouth of the stream (BMSC 2010) and are not expected to be a major source of nutrients to Sullivan Creek.
Water quality and biological data in Sullivan Creek indicate nutrient loading throughout the entire sampled portion of the creek. The most probable sources of nutrients to Sullivan Creek are timber harvesting and grazing in the upper portion of the watershed. Septic systems are not expected to be nutrient sources in the watershed due to their small numbers. **Figure 6-16** shows the locations of potential nutrient sources in the Sullivan Creek watershed.

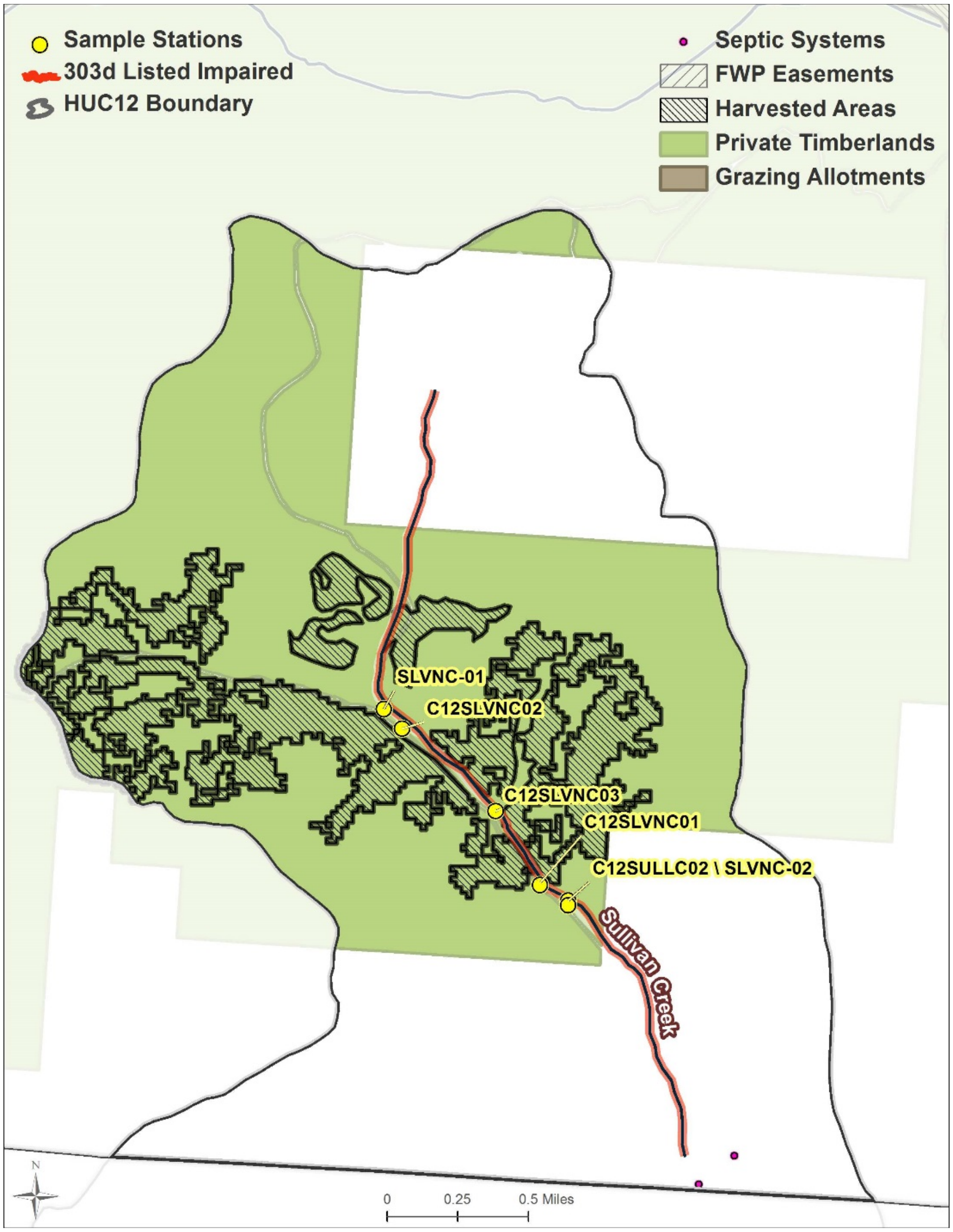

Figure 6-16: Location of potential nutrient sources in the Sullivan Creek watershed.

6.5.8 Swamp Creek (MT76N003_160)

The source assessment for Swamp Creek consists of an evaluation of nitrate, TN and TP concentrations in the impaired segment of Swamp Creek. This is followed by a description of potential human caused sources of nutrients as indicated by the source assessment for the Thompson Project Area.

Data Analysis

DEQ collected water quality samples from Swamp Creek during the growing season over the time period of 2004-2012 (**Section 6.4.3.6**, **Table 6-10**). **Figure 6-17** presents summary statistics for TN concentrations at sampling sites in Swamp Creek. TN values in this segment were always below the target of 0.275 mg/L and did not show any strong trends along the stream gradient.

Box plots for nitrate in Swamp Creek were not developed because almost all nitrate observations are non-detects or at the detection limit, therefore, box plots are of limited use in showing data trends. None of the observations were exceeding the 0.1 mg/L target. **Figure 6-18** presents summary statistics for TP concentrations at sampling sites in Swamp Creek. TP values in this segment were below the target of 0.025 mg/L at all sites except for one exceedance at the most downstream station (C13SWPCR20). Swamp Creek was listed for nutrients because of high AFDM, periphyton, and HBI scores rather than exceedances of the nitrate, TN, and TP targets. All exceedances of the AFDM, periphyton, and HBI targets occurred at the two most downstream stations: C13SWMPC02 (about 2.2 miles upstream of the mouth of Swamp Creek) and C13SWPCR20 (mouth of Swamp Creek).

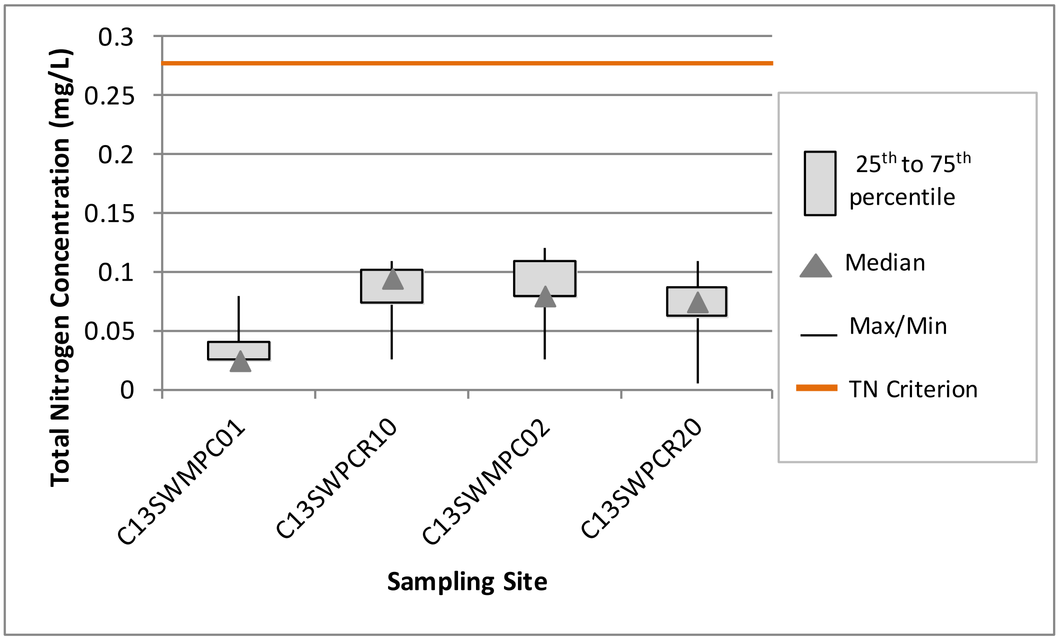

Figure 6-17: TN Box Plots for Swamp Creek.

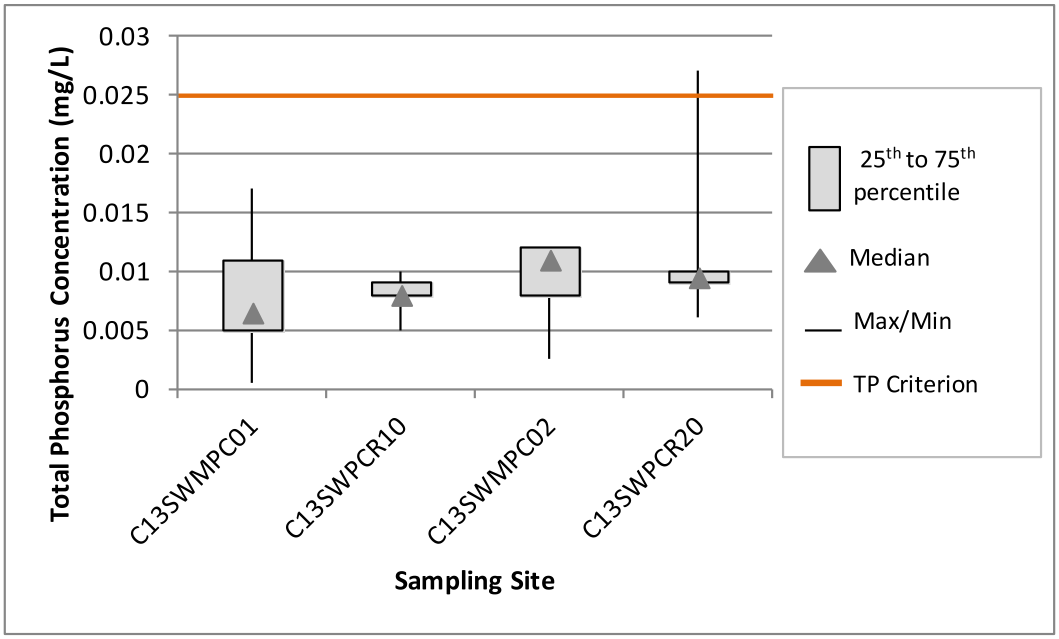

Figure 6-18: TP Box Plots for Swamp Creek.

Land Cover and Land Use

The dominant land cover in the Swamp Creek watershed is evergreen forest (86%) and 17 percent of the watershed is private timberland. Site visit notes from 2004 indicate that the upper and lower portions of Swamp Creek have distinct features. The lower portion is a meadow stream system, while the upper portion is a higher gradient gravel-bedded system (DEQ 2012f).

DEQ's 2011 field notes (Atkins 2013) confirm that the lower portion of Swamp Creek, below the confluence of the East and West Forks of Swamp Creek, are part of the meadow stream system, which may have been logged in the past and was likely grazed historically; however, there are no signs of recent grazing. The lower portion of the watershed, below station C13SWMPC02 was historically used for crop production and grazing but has been allowed to recover over the past 25 years (**Figure 6-19**).

The USFS has a grazing allotment in the headwaters of the Swamp Creek watershed. The Swamp Creek grazing allotment is active from June 1 through September 1 with 40 cattle permitted (USFS, personal communication 2013). Plum Creek Timber Co., Inc. also owns land in the watershed and timber harvest occurs in the headwaters. All of the Plum Creek land in the watershed is leased for grazing. The land is used for grazing from June through September and works on a rest-rotation system where some pastures are grazed whiles others are rested. These grazing pastures are rotated regularly.

There are 45 septic systems located along the lower portion of the creek, mostly below station C13SWMPC01 (BMSC 2010).

Summary and Conclusions

All monitoring stations in Swamp Creek are located below areas of grazing and timber harvest; however, no water quality or biological exceedances occurred at the upper two monitoring stations indicating that the nutrient sources may be downstream of station C13SWPCR10. Therefore, the most probable nutrient sources in Swamp Creek appear to be the ongoing grazing and timber harvesting occurring below station C13SWPCR10. Most of the septic systems in the watershed are located upstream of site C13SWPCR10, but there are no nutrient or biological exceedances seen until station C13SWMPC02, indicating that septic systems are not a significant source of nutrients to Swamp Creek. **Figure 6-19** shows the locations of all potential nutrient sources in the Swamp Creek watershed.

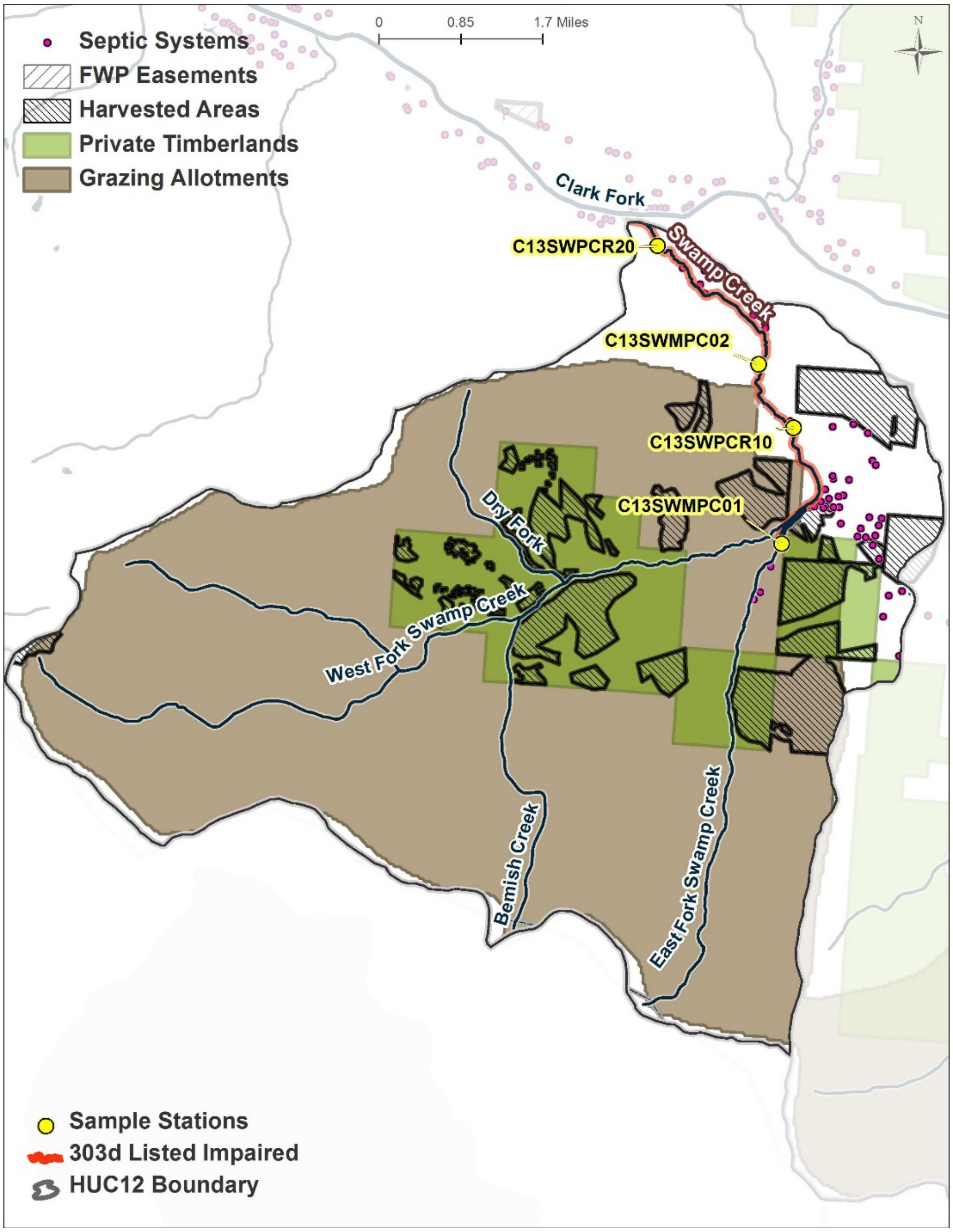

Figure 6-19: Locations of potential nutrient sources in the Swamp Creek watershed.

6.6 TMDL AND ALLOCATIONS FOR EACH STREAM

6.6.1 Nutrient TMDLs

DEQ presents nutrient TMDLs for impaired waterbodies in the Thompson TMDL Project Area, summarized in **Section 6.2**. The TMDL is based on the most stringent water quality criteria, or the water quality target, and the streamflow. All nutrient TMDLs are calculated using the most stringent target value, which ensures that the TMDLs are protective of all designated beneficial uses. A detailed discussion of target development is included in **Section 6.4.2**.

Because streamflow varies seasonally, the TMDL is not expressed as a static value, but as an equation of the appropriate target multiplied by flow. As flow increases, the allowable load (TMDL) increases as shown by the total phosphorus example in **Figure 6-20.** The TMDL calculations for TN and TP under a specific flow condition are calculated using the following formula:

Equation 1: TMDL = (X) (Y) (k)

TMDL= Total Maximum Daily Load in lbs/day
X = water quality target in mg/L (TN = 0.275 mg/L or TP = 0.025 mg/L)
Y = streamflow in cubic feet per second (cfs)
k = conversion factor of 5.4

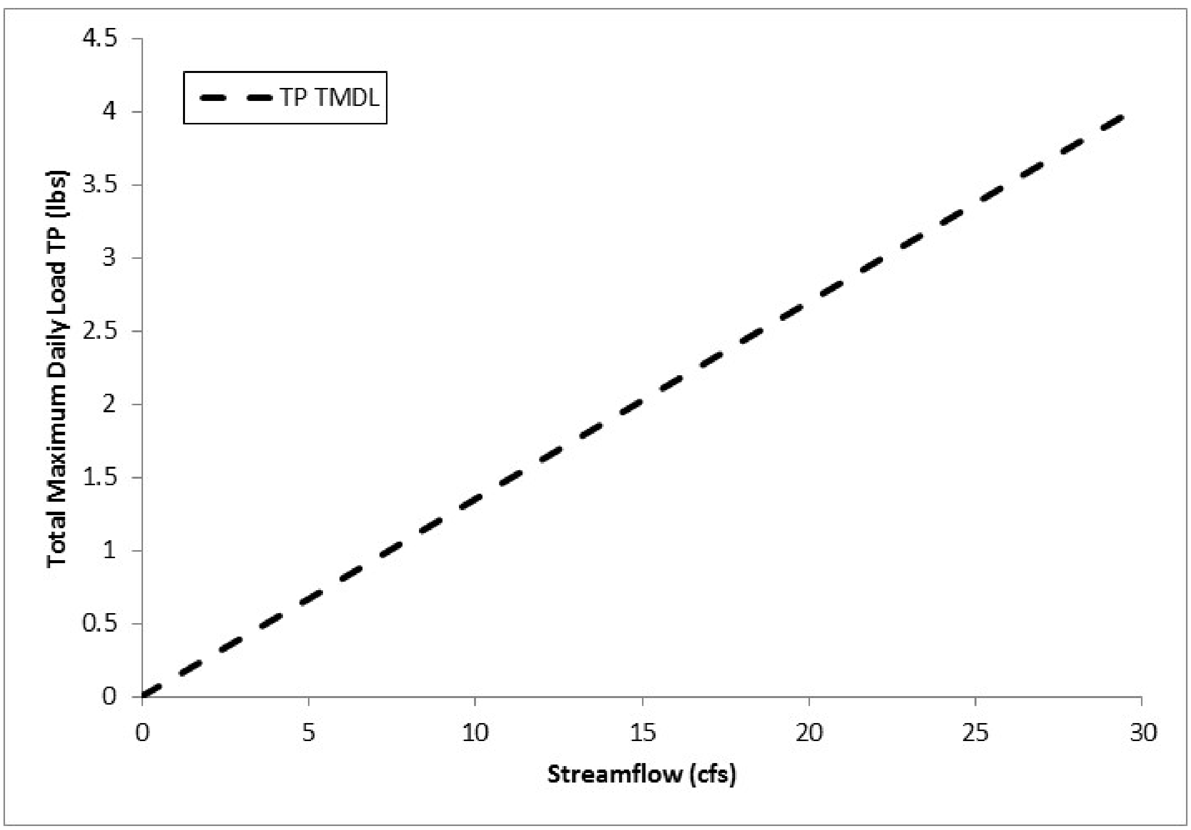

Figure 6-20: Example TMDL for total phosphorus from 0 to 30 cfs.

6.6.2 Approach to TMDL Allocations and Reductions

As discussed in **Section 4.0**, a TMDL equals the sum of all the wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS). WLAs are allowable pollutant loads that are assigned to permitted and non-permitted point sources. LAs are allowable pollutant loads assigned to nonpoint sources and may include the pollutant load from naturally occurring sources, as well as human-caused nonpoint loading. Where practical, LAs to human sources are provided separately from naturally occurring sources. In addition to nutrient load allocations, the TMDL must also take into account the seasonal variability of nutrient loads and adaptive management strategies in order to address uncertainties inherent in environmental analyses.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

> ***WLA*** *= Wasteload Allocation or the portion of the TMDL allocated to nutrient point sources.*
> ***LA*** *= Load Allocation or the portion of the TMDL allocated to nonpoint nutrient sources and naturally occurring background*
> ***MOS*** *= Margin of Safety or an accounting of uncertainty about the relationship between nutrient loads and receiving water quality.*

Because grazing and timber harvest are the most probable source categories and all sources are nonpoint, the TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources. Because there are no point sources, the wasteload allocation is zero. All nutrient TMDLs include an implicit margin of safety, which is based on conservative assumptions as described in **Section 6.7.2**. In the absence of point sources and an explicit MOS, the equation for all nutrient TMDLs is as follows:

Equation 2: TMDL = LA

> *LA = Load Allocation to all sources including natural background*

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

Equation 3: Total Existing Load = (X) (Y) (5.4)

> *X = measured concentration in mg/L (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)*
> *Y = streamflow in cubic feet per second (associated with the median reduction for measured loads that exceed the TMDL or with the median measured load if none exceed the TMDL)*
> *5.4 = conversion factor*

6.6.3 TMDLs and Allocations by Waterbody Segment

The following sections establish TMDLs, provide current nutrient loading estimates, and estimate reductions necessary to meet water quality targets for the following streams:

- Lazier Creek

- Little Bitterroot River
- Little Thompson River
- Lynch Creek
- Sullivan Creek
- Swamp Creek

The TMDL equations are shown for Lazier Creek as an example of how the TMDLs were calculated (**Section 6.6.3.1**). The calculations are not shown for the remaining impaired waterbodies, only the results.

The existing loads are used to estimate load reductions by comparing them to the allowable (TMDL) load and computing a required percent reduction to meet the TMDL. The actual reductions needed may be greater than the load reductions provided in this section because the reduction estimates are based on measured loads, which may differ from loading inputs because algae and other primary producers in streams regularly consume nutrients and alter instream concentrations.

6.6.3.1 Lazier Creek (MT76N005_060)

Total Nitrogen TMDL
The composite load allocation to all sources equals the TMDL, which is calculated from **Equation 1**. The value of the TN TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The flow used in the example below is associated with the median measured load from all sites during the 2011-2012 sampling (0.21 cfs):

TMDL = LA = (0.275 mg/L) (0.21 cfs) (5.4) = 0.3119 lbs/day

An example total existing load is calculated as follows using **Equation 3** and the flow and concentration associated with the median measured load for TN in Lazier Creek from 2011-2012:

Total Existing Load = (0.07 mg/L) (0.21 cfs) (5.4) = 0.0794 lb/day

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-14**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 9.0.**

Table 6-14. Lazier Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.3119	0.0794

[1] *Based on a flow of 0.21 cfs*

Nitrate TMDL Surrogate

Because nitrate is a component of TN, and because the loading sources and methods to reduce loading sources of nitrate and TN are essentially the same, the above TMDL for TN provides a surrogate TMDL for nitrate in Lazier Creek. None of the nitrate values measured in Lazier Creek were above the target of 0.1 mg/L (**Tables 6-2 and 6-3**), potentially due to nutrient uptake as discussed above.

Total Phosphorus TMDL

The composite load allocation to all sources equals the TMDL, which is calculated from **Equation 1**. The value of the TP TMDL is a function of the flow; an increase in flow results in an increase in the TMDL. The following example TP TMDL for Lazier Creek uses **Equation 1** and the flow associated with the median measured TP load from all sites during the 2011-2012 sampling (0.32 cfs):

TMDL = LA = (0.025 mg/L) (0.32 cfs) (5.4) = 0.0432 lb/day

An example total existing load is calculated as follows using **Equation 3** and the flow and concentration associated with the median measured TP load in Lazier Creek from 2004-2012:

Total Existing Load = (0.009 mg/L) (0.32 cfs) (5.4) = 0.0156 lbs/day

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-15**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of phosphorus warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 9.0.**

Table 6-15. Lazier Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0432	0.0156

[1] *Based on a flow of 0.32 cfs*

6.6.3.2 Little Bitterroot River (MT76L002_060)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-16**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Little Bitterroot River watershed indicates that timber harvest and grazing are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for the Little Bitterroot River may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-16. Little Bitterroot River TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	79.34	106.75

[1] Based on a flow of 53.43 cfs

Figure 6-23 shows the percent reductions for TN loads measured in the Little Bitterroot River from 2011-2012. TN reductions are required from the smallest to the largest measured flows. There were no measured loads less than or equal to the TMDL. Reductions ranged from 17% to 56% to meet the TMDL.

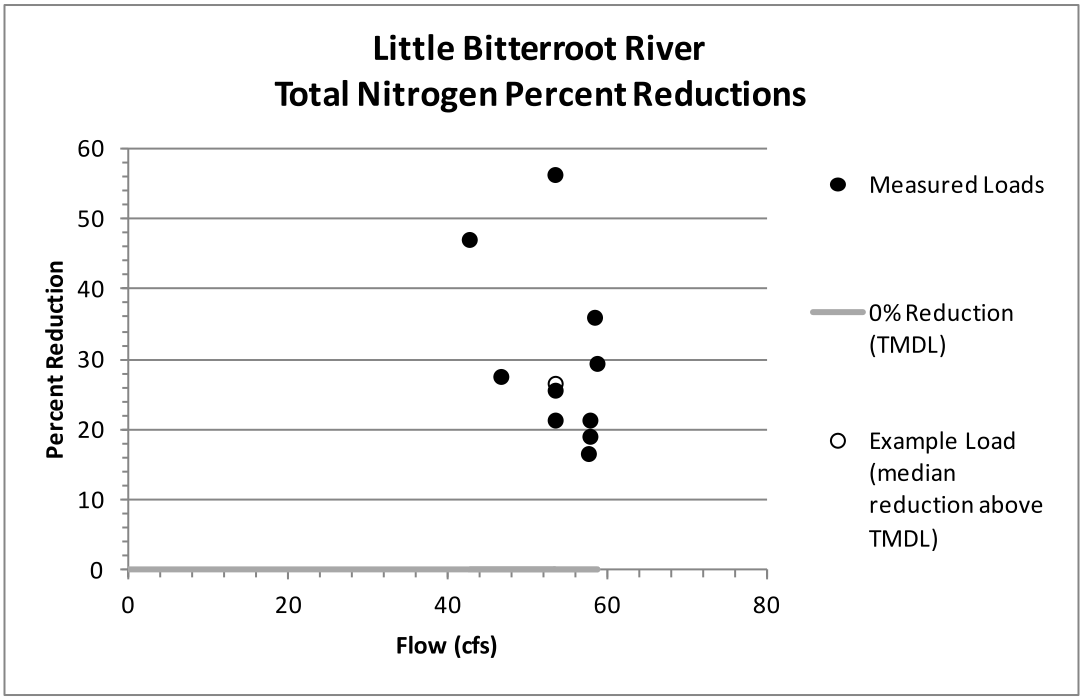

Figure 6-21: TN percent reductions for the Little Bitterroot River.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-16 is represented by the hollow circle.)

Nitrate TMDL Surrogate
Because nitrate is a component of TN, and because the loading sources and methods to reduce loading sources of nitrate and TN are essentially the same, the above TMDL for TN provides a surrogate TMDL for nitrate in the Little Bitterroot River. One of the nine nitrate values measured in the Little Bitterroot River was above the target of 0.1 mg/L (**Tables 6-4 and 6-5**). As a result, existing nitrate loading requires reductions consistent with the TN TMDL and the composite allocation for nitrate would apply to the same source categories as the TN composite allocation.

Total Phosphorus TMDL
The example TP TMDL, load allocations, and current loading are summarized in **Table 6-17**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Little Bitterroot River watershed indicates that timber harvest and grazing are the most likely sources of TP; load reductions should focus on limiting and controlling TP

loading from these sources. Meeting load allocations for the Little Bitterroot River may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 7.0**.

Table 6-17. Little Bitterroot River TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	7.78	18.35

[1] *Based on a flow of 57.6 cfs*

Figure 6-24 shows the percent reductions for TP loads measured in the Little Bitterroot River from 2004-2012. TP reductions are required from the smallest to the largest measured flows. There were no measured loads less than or equal to the TMDL. Reductions ranged from 7% to 70%.

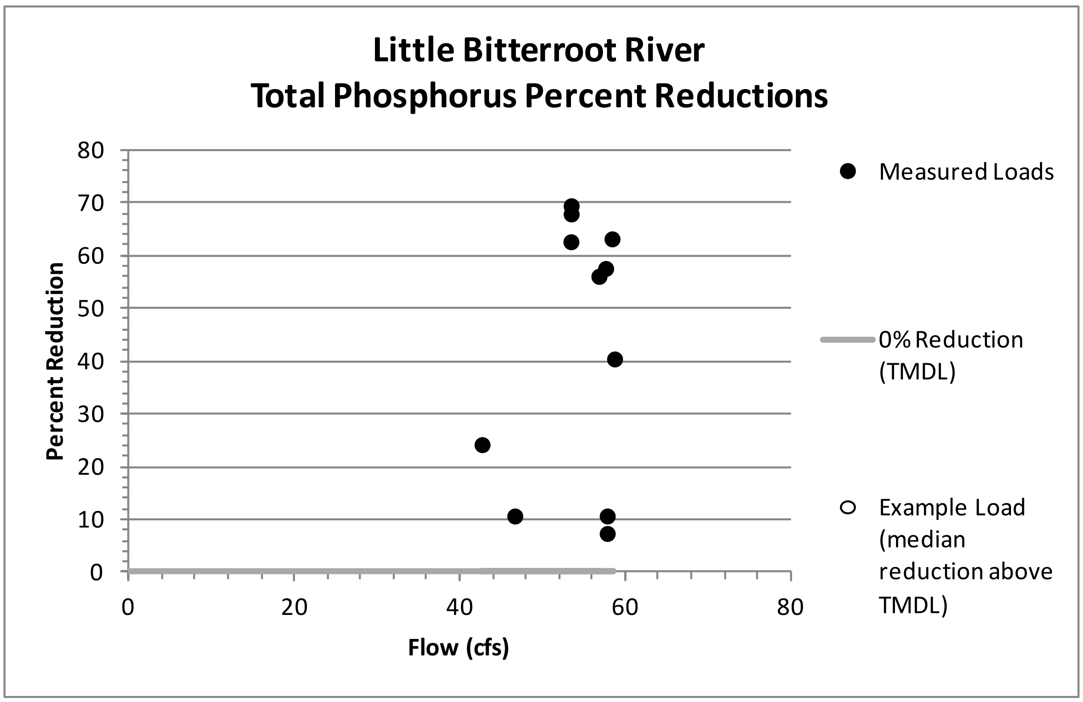

Figure 6-22: TP percent reductions for the Little Bitterroot River.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-17 is represented by the hollow circle.)

6.6.3.3 Little Thompson River (MT76N005_040)

Total Nitrogen TMDL

The example TN TMDL, composite load allocation, and current loading for the Little Thompson River are summarized in **Table 6-18**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 9.0.**

Table 6-18. Little Thompson River TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	12.1	1.1

[1] *Based on a flow of 8.15 cfs*

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-19**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of phosphorus warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 9.0.**

Table 6-19. Little Thompson River TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	1.06	0.4675

[1] *Based on a flow of 7.87 cfs*

6.6.3.4 Lynch Creek (MT76N003_010)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-20**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Lynch Creek watershed indicates that livestock grazing, timber harvest, and development are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Lynch Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-20. Lynch Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	7.63	9.44

[1] *Based on a flow of 5.14 cfs*

Figure **6-27** shows the percent reductions for TN loads measured in Lynch Creek from 2011-2012. TN reductions are required from the smallest to the largest measured flows. Most of the measured loads were meeting the TMDL. The remaining loads required reductions ranging from 19% to 47%.

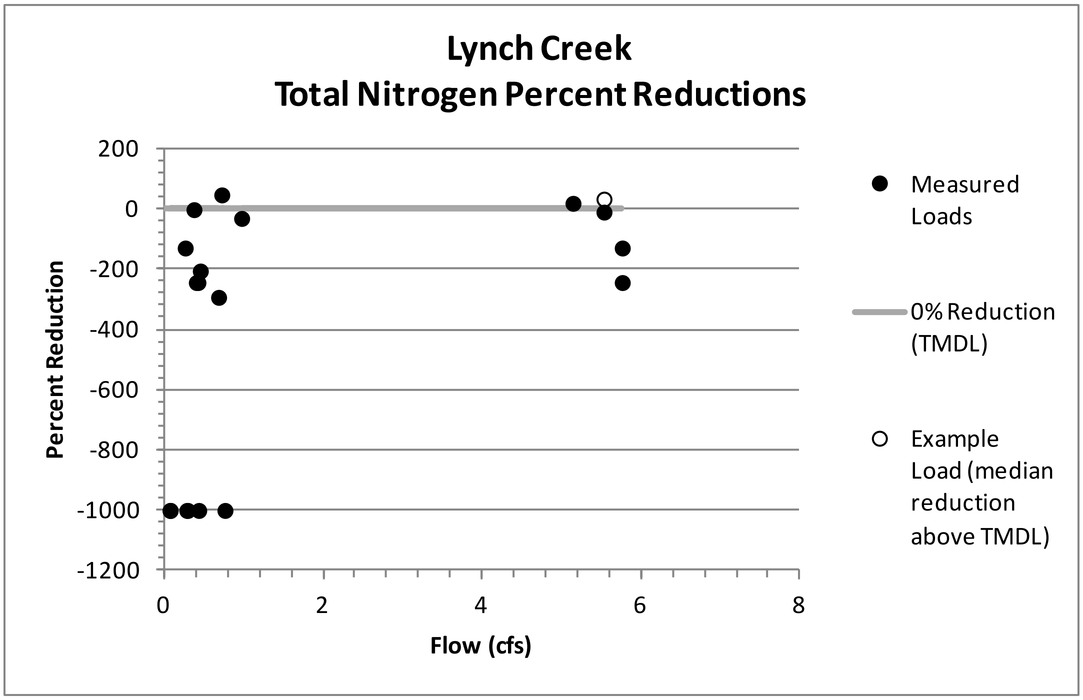

Figure 6-23: TN percent reductions for Lynch Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 5-20 is represented by the hollow circle.)

Total Phosphorus TMDL
The example TP TMDL, load allocations, and current loading are summarized in **Table 6-21**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Lynch Creek watershed indicates that livestock grazing, timber harvest, and development are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Lynch Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-21. Lynch Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0972	0.1205

[1] Based on a flow of 0.72 cfs

Figure 6-28 shows the percent reductions for TP loads measured in Lynch Creek from 2004-2012. TP reductions are required from the smallest to the largest measured flows. The reductions ranged from 11% to 34% to meet the TMDL.

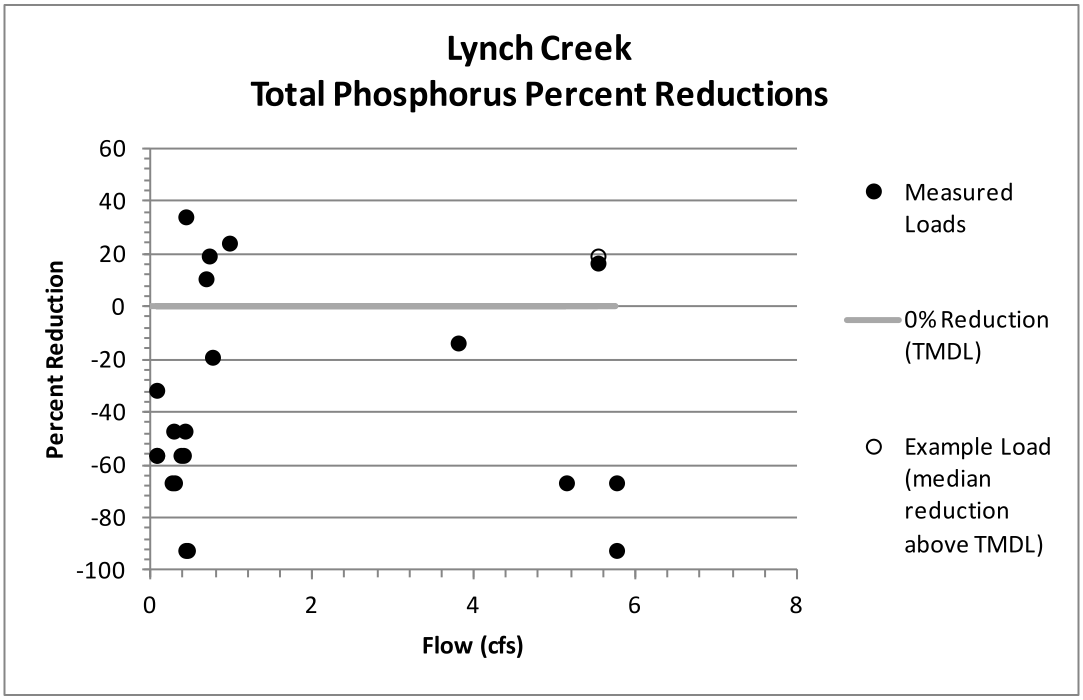

Figure 6-24: TP percent reductions for Lynch Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-21 is represented by the hollow circle.)

6.6.3.5 Sullivan Creek (MT76L002_070)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading are summarized in **Table 6-22**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TN. The source assessment for the Sullivan Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TN; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Sullivan Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-22. Sullivan Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Load Allocation (lbs/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0446	0.2074

[1] *Based on a flow of 0.03 cfs*

Figure 6-30 shows the percent reductions for TN loads measured in Sullivan Creek from 2012. TN reductions are required from the smallest to the largest measured flows. Only one of the measured loads was exceeding the TMDL. This load required a reduction of 79% to meet the TMDL.

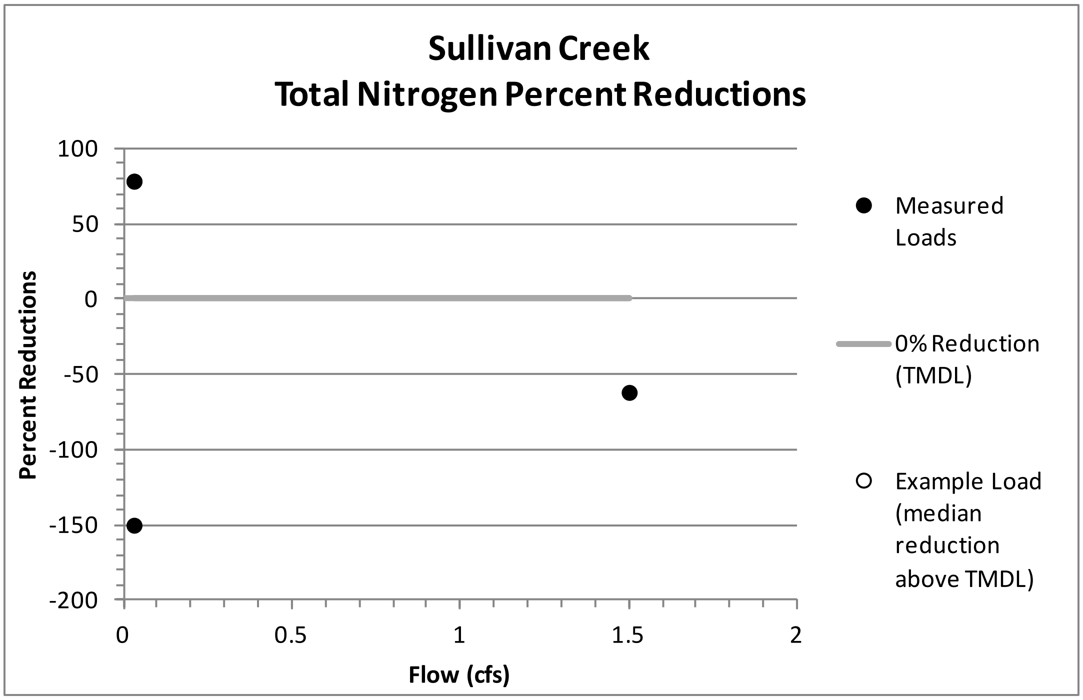

Figure 6-25: TN percent reductions for Sullivan Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-22 is represented by the hollow circle.)

Total Phosphorus TMDL
The example TP TMDL, load allocations, and current loading are summarized in **Table 6-23**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Sullivan Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Sullivan Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-23. Sullivan Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	0.0135	0.0329

[1] *Based on a flow of 0.1 cfs*

Figure 6-31 shows the percent reductions for TP loads measured in Sullivan Creek from 2004-2012. TP reductions are required from the smallest to the largest measured flows. Two of the measured loads were exceeding the TMDL. These loads required reductions of 42% and 59% to meet the TMDL.

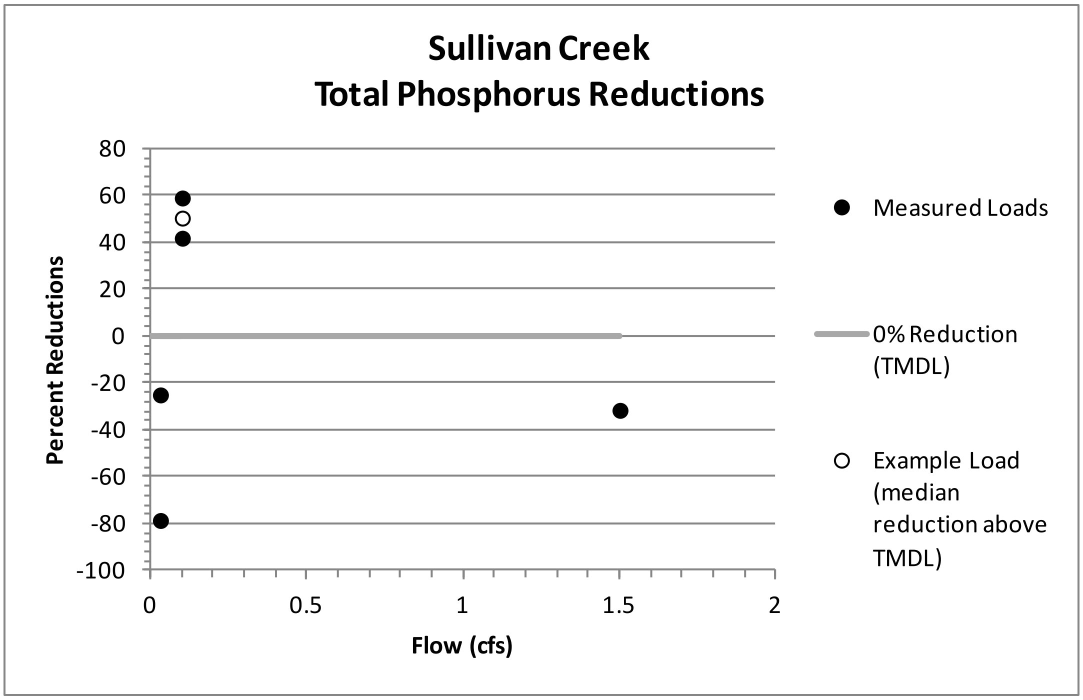

Figure 6-26: TP percent reductions for Sullivan Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-23 is represented by the hollow circle.)

6.6.3.6 Swamp Creek (MT76N003_160)

Total Nitrogen TMDL

The example TN TMDL and composite load allocation and current loading for Swamp Creek are summarized in **Table 6-24**. Because the measured existing load is less than the example TMDL, no reduction is provided to meet the water quality target. As discussed above, nutrient uptake by algae and other primary producers may decrease nutrient loads, which can make it appear as though there is not a nutrient problem when there actually is. The target exceedances of AFDM, which is a measure of excessive algal growth, along with periphyton and HBI scores all indicate excess nutrient loading to the stream. Determining the precise cause(s) of these target exceedances and the role of nitrogen warrants further study, but reducing nutrient loading to address excessive algal growth is still considered necessary to address the nutrient impairment. Reductions may be achieved through a variety of water quality planning and implementation actions as discussed in **Section 9.0.**

Table 6-24. Swamp Creek TN Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	22.19	2.02

[1] Based on a flow of 14.94 cfs

Nitrate TMDL Surrogate

Because nitrate is a component of TN, and because the loading sources and methods to reduce loading sources of nitrate and TN are essentially the same, the above TMDL for TN provides a surrogate TMDL for nitrate in Swamp Creek. None of the nitrate values measured in Swamp Creek were above the target of 0.1 mg/L (**Tables 6-12 and 6-13**), potentially due to nutrient uptake as discussed above.

Total Phosphorus TMDL

The example TP TMDL, load allocations, and current loading are summarized in **Table 6-25**. Because the existing load is greater than the TMDL, a reduction is necessary to meet the water quality target for TP. The source assessment for the Swamp Creek watershed indicates that livestock grazing and timber harvest are the most likely sources of TP; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Swamp Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 6-25. Swamp Creek TP Example TMDL, Composite Allocation, and Current Loading

Source Category	TMDL & Composite Allocation (lb/day)[1]	Existing Load (lbs/day)[1]
All Sources	2.2	2.38

[1] Based on a flow of 16.3 cfs

Figure 6-33 shows the percent reductions for TP loads measured in Swamp Creek from 2004-2011. TP reductions are required from the smallest to the largest measured flows. There was one measured load greater than the TMDL with a required reduction of 7%.

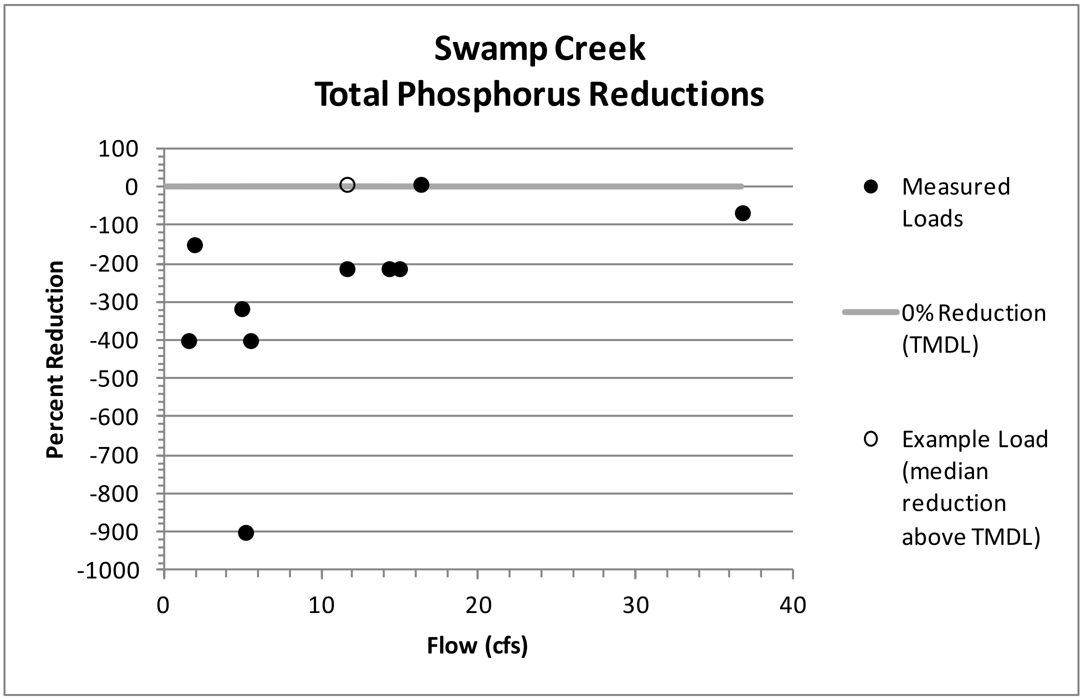

Figure 6-27: TP percent reductions for Swamp Creek.
(All points on or below the gray line are meeting the TMDL. The example existing load from Table 6-25 is represented by the hollow circle.)

6.7 Seasonality and Margin of Safety

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties 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 margin of safety in the Thompson Project Area nutrient TMDL development process.

6.7.1 Seasonality

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

- Water quality targets and subsequent allocations are applicable for the summer-time growing season (July 1st – Sept 30th), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads were collected during the summer-time period to coincide with applicable nutrient targets.

6.7.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan addresses MOS implicitly in a variety of ways:

- Static nutrient target values (e.g., 0.275 mg/L TN and 0.025 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- Seasonality (discussed above) and variability in nutrient loading were considered.
- An adaptive management approach is used to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

6.8 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through 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 both the water quality-based and model-based modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

Water Quality Conditions

It was assumed that sampling data for each waterbody segment is representative of conditions in each segment. Four of the segments have more than the desired 12 samples but 2 have fewer samples for at least 1 nutrient form. Additionally, there were situations where data for a specific nutrient indicated that values were below targets, but because of previous impairment determinations, exceedances of the chlorophyll-*a*, periphyton, or HBI targets, and the uncertainty in nutrient limitation and uptake within the streams the impairment determinations were retained. As a result, data for some waterbody segments with a nutrient TMDL indicate that targets are being attained. Future monitoring as discussed in **Section 9.0** should help reduce the uncertainty regarding data representativeness, clarify whether or not nutrient forms that have a TMDL but are meeting targets have a role in causing excess algal growth, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

It was assumed that background concentrations are less than the target values. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed. Future monitoring should help reduce uncertainty regarding background nutrients concentrations.

Based on the age of some septic systems within the watershed, there are probably some failing systems, and depending on their proximity or connectivity to surface water, they could be point sources of nutrient loading. However, a completely failing system has obvious symptoms and will be addressed quickly, and a partially failing system will likely result in similar loading as a functioning system, unless it is in close proximity to surface water. This source could be investigated further, particularly in segments with nearby septic systems and elevated nutrient concentrations that cannot be explained by other sources.

Despite the uncertainty associated with the loading contributions from the various nonpoint sources in the watershed, based on the literature and field observations there is a fairly high level of certainty that improvements in land management practices discussed in this document will reduce nutrient loading sufficiently to meet the TMDLs.

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APPENDIX A – NUTRIENT WATER QUALITY DATA

Table A-1. Recent Surface Water Nutrient Data for the Thompson TMDL Project Area

Waterbody Segment	Site ID	Sample Date	Organization	Flow (cfs)	TN (mg/L)	TP (mg/L)	NO2+3 (mg/L)	Chlorophyll-*a* (mg/m2)	AFDM (g/m2)	Macroinvertebrates (HBI)
Lazier Creek	C13LAZRC04	8/12/2012	DEQ	0.16	0.07	0.011	0.005	35.3	54.1	-
Lazier Creek	C13LAZRC04	9/21/2012	DEQ	0.12	0.08	0.007	0.005	-	-	-
Lazier Creek	C13LAZRC20	9/4/2004	DEQ	2.31	-	0.024	0.08	-	-	2.67
Lazier Creek	LZRC-254	8/21/2011	DEQ	0.32	0.08	0.009	0.005	68.6	30.9	-
Lazier Creek	C13LAZRC05	7/2/2012	DEQ	3.75	0.1	0.016	-	-	-	-
Lazier Creek	C13LAZRC05	8/12/2012	DEQ	2.2	0.025	0.012	0.02	< 50	-	-
Lazier Creek	C13LAZRC05	9/21/2012	DEQ	1.08	0.02	0.013	0.02	-	-	-
Lazier Creek	LZRC-253	8/22/2011	DEQ	3.93	0.08	0.0025	0.03	40	-	-
Lazier Creek	C13LAZRC02	8/12/2012	DEQ	0.21	0.07	0.01	0.005	21.7	36.2	-
Lazier Creek	C13LAZRC02	9/21/2012	DEQ	0.18	0.05	0.009	0.005	-	-	-
Lazier Creek	C13LAZRC03	8/12/2012	DEQ	0.21	0.07	0.009	0.005	19.7	17.83	-
Lazier Creek	C13LAZRC03	9/21/2012	DEQ	0.2	0.04	0.008	0.005	-	-	-
Lazier Creek	LZRC-256	8/21/2011	DEQ	0.21	0.06	0.012	0.01	40	-	-
Lazier Creek	LZRC-255	8/21/2011	DEQ	0.32	0.025	0.011	0.005	40	-	-
Lazier Creek	C13LAZRC01	8/23/2011	DEQ	-	-	-	-	-	-	5.37
Lazier Creek	C13LAZRC20	8/23/2011	DEQ	-	-	-	-	-	-	4.52
Little Bitterroot River	C12LTBTR02	7/5/2012	DEQ	42.65	0.52	0.033	0.13	-	-	-
Little Bitterroot River	C12LTBTR02	8/15/2012	DEQ	53.43	0.35	0.078	0.005	-	-	-
Little Bitterroot River	C12LTBTR02	9/22/2012	DEQ	46.61	0.38	0.028	0.01	-	-	-
Little Bitterroot River	C12LTBTR01	8/4/2004	DEQ	56.76	-	0.057	0.08	-	-	5.61
Little Bitterroot River	LBRR-299	8/25/2011	DEQ	53.4	0.63	0.067	0.05	-	-	-
Little Bitterroot River	LBRR-289	8/25/2011	DEQ	58.37	0.43	0.068	0.04	32	19.5	-
Little Bitterroot River	C12LTBTR04	7/5/2012	DEQ	58.68	0.39	0.042	0.08	-	-	-
Little Bitterroot River	C12LTBTR04	8/15/2012	DEQ	57.6	0.33	0.059	0.005	-	-	-
Little Bitterroot River	C12LTBTR04	9/22/2012	DEQ	57.79	0.34	0.027	0.03	-	-	-
Little Bitterroot River	C12LTBTR02	8/22/2011	DEQ	-	-	-	-	-	-	5.18
Little Bitterroot River	C12LTBTR03	8/22/2011	DEQ	-	-	-	-	-	-	4.72
Little Bitterroot River	472934114194301	6/17/2008	USGS	18	-	-	-	-	-	-
Little Thompson River	LTLTR-250	8/23/2011	DEQ	1.96	0.14	0.011	0.005	18.4	16.5	-
Little Thompson River	LTLTR-244	8/22/2011	DEQ	14.57	0.12	0.009	0.005	6.4	4.5	-
Little Thompson River	C13LTTPR03	8/13/2012	DEQ	13.35	0.05	0.012	0.005	-	-	-
Little Thompson River	C13LTTPR03	9/21/2012	DEQ	7.87	0.02	0.011	0.005	-	-	-
Little Thompson River	LTLTR-NAN	8/23/2011	DEQ	0.87	0.26	0.019	0.02	8.9	10.1	-

Waterbody Segment	Site ID	Sample Date	Organization	Flow (cfs)	TN (mg/L)	TP (mg/L)	NO2+3 (mg/L)	Chlorophyll-*a* (mg/m2)	AFDM (g/m2)	Macroinvertebrates (HBI)
Little Thompson River	LTLTR-246	8/22/2011	DEQ	11.36	0.09	0.006	0.005	25	-	-
Little Thompson River	C13LTTPR40	8/27/2004	DEQ	9.47	-	0.019	0.005	-	-	1.63
Little Thompson River	C13LTTPR40	8/10/2007	DEQ	-	0.005	0.011	0.0025	20.81	-	-
Little Thompson River	C13LTTPR40	8/13/2012	DEQ	17.21	0.07	0.013	0.005	-	-	-
Little Thompson River	C13LTTPR40	9/21/2012	DEQ	12.9	0.05	0.012	0.005	-	-	-
Little Thompson River	C13LTTPR30	8/27/2004	DEQ	13.83	-	0.016	0.005	-	-	3.02
Little Thompson River	LTLTR-240	8/22/2011	DEQ	23.78	0.12	0.011	0.005	14.4	6.04	-
Little Thompson River	C13LTTPR10	8/26/2004	DEQ	E 4.1	-	0.022	0.005	-	-	3.29
Little Thompson River	C13LTTPR20	8/26/2004	DEQ	E 12.8	-	0.016	0.005	-	-	3.94
Little Thompson River	C13LTTPR02	8/13/2012	DEQ	8.15	0.025	0.009	0.005	21.9	20.4	-
Little Thompson River	C13LTTPR02	9/21/2012	DEQ	5.55	0.02	0.01	0.005	-	-	-
Little Thompson River	C13LTTPR05	8/13/2012	DEQ	1.53	0.12	0.013	0.005	-	-	-
Little Thompson River	C13LTTPR05	9/22/2012	DEQ	0.96	0.07	0.01	0.005	-	-	-
Little Thompson River	C13LTTPR04	8/13/2012	DEQ	0.71	0.18	0.022	0.005	-	-	-
Little Thompson River	C13LTTPR04	9/22/2012	DEQ	0.42	0.09	0.017	0.005	-	-	-
Little Thompson River	C13LTTPR05	8/14/2012	DEQ	-	-	-	-	5.4	45.4	-
Little Thompson River	C13LTTPR01	8/24/2011	DEQ	-	-	-	-	-	-	2.69
Little Thompson River	C13LTTPR02	8/24/2011	DEQ	-	-	-	-	-	-	3.11
Little Thompson River	PIBO_139	7/25/2009	DEQ	-	-	-	-	-	-	3.36
Little Thompson River	PIBO_139	7/29/2008	DEQ	-	-	-	-	-	-	4.03
Little Thompson River	PIBO_139	7/30/2007	DEQ	-	-	-	-	-	-	3.78
Little Thompson River	PIBO_139	7/25/2006	DEQ	-	-	-	-	-	-	4.08
Little Thompson River	PIBO_139	7/28/2004	DEQ	-	-	-	-	-	-	4.23
Little Thompson River	PIBO_139	7/1/2003	DEQ	-	-	-	-	-	-	3.45
Lynch Creek	C13LYNCC04	7/26/2011	DEQ	5.76	0.08	0.013	0.005	-	-	-
Lynch Creek	C13LYNCC07	7/26/2011	DEQ	0.37	0.27	0.016	0.005	-	-	-
Lynch Creek	C13LYNCC04	9/4/2011	DEQ	0.43	0.025	0.013	0.01	0.7	3.77	2.08
Lynch Creek	C13LYNCC07	9/5/2011	DEQ	0.07	0.025	0.016	0.03	2.15	4.01	2.03
Lynch Creek	C13LYNCC07	7/3/2012	DEQ	0.4	0.08	0.016	0.005	-	-	-
Lynch Creek	C13LYNCC06	7/26/2011	DEQ	0.42	0.08	0.017	0.005	-	-	-
Lynch Creek	C13LYNCC06	9/4/2011	DEQ	0.07	0.025	0.016	0.005	-	-	-
Lynch Creek	C13LYNCC06	7/3/2012	DEQ	0.45	0.09	0.013	0.005	-	-	-
Lynch Creek	C13LYNCC03	7/26/2011	DEQ	5.14	0.34	0.015	0.005	-	-	-
Lynch Creek	C13LYNCC03	9/3/2011	DEQ	0.97	0.21	0.033	0.005	1.98	5.87	-

Waterbody Segment	Site ID	Sample Date	Organization	Flow (cfs)	TN (mg/L)	TP (mg/L)	NO2+3 (mg/L)	Chlorophyll-*a* (mg/m2)	AFDM (g/m2)	Macroinvertebrates (HBI)
Lynch Creek	C13LYNCC01	8/11/2009	DEQ	-	0.34	0.033	0.04	53	-	-
Lynch Creek	C13LYNCC01	9/9/2009	DEQ	-	0.91	0.036	0.07	13.6	-	-
Lynch Creek	C13LYNCC01	7/26/2011	DEQ	5.53	0.25	0.03	0.08	-	-	-
Lynch Creek	C13LYNCC01	9/3/2011	DEQ	0.72	0.52	0.031	0.32	6.47	37.1	7.17
Lynch Creek	C13LYNCC08	7/27/2011	DEQ	0.29	0.025	0.015	0.005	-	-	-
Lynch Creek	C13LYNCC08	9/5/2011	DEQ	0.07	0.025	0.019	0.005	1.1	3.68	-
Lynch Creek	C13LYNCC05	7/26/2011	DEQ	0.76	0.025	0.021	0.01	-	-	-
Lynch Creek	C13LYNCC05	9/4/2011	DEQ	0.28	0.025	0.017	0.05	7.23	3.82	-
Lynch Creek	C13LYNCC05	7/3/2012	DEQ	0.68	0.07	0.028	0.08	-	-	-
Lynch Creek	C13LYNCC30	9/7/2004	DEQ	E 0.43	-	0.038	0.005	-	-	5.93
Lynch Creek	C13LYNCC20	9/7/2004	DEQ	E 3.8	-	0.022	0.005	-	-	3.58
Lynch Creek	C13LYNCC20	8/12/2009	DEQ	-	0.1	0.016	0.005	17	-	-
Lynch Creek	C13LYNCC20	9/10/2009	DEQ	-	0.07	0.019	0.02	16.6	-	-
Lynch Creek	C13LYNCC11	7/3/2012	DEQ	0.26	0.12	0.015	0.005	-	-	-
Lynch Creek	C13LYNCC10	8/11/2009	DEQ	-	0.28	0.024	0.01	10.5	-	-
Lynch Creek	C13LYNCC10	9/9/2009	DEQ	-	0.77	0.034	0.005	11.6	-	-
Lynch Creek	C13LYNCC05	8/25/2011	DEQ	-	-	-	-	-	-	2.99
Lynch Creek	C13LYNCC09	8/25/2011	DEQ	-	-	-	-	-	-	2.14
Sullivan Creek	C12SLVNC02	8/4/2004	DEQ	E 0.1	-	0.061	0.005	-	-	-
Sullivan Creek	C12SLVNC02	7/4/2012	DEQ	-	1.28	0.02	0.005	-	-	-
Sullivan Creek	C12SLVNC01	8/4/2004	DEQ	E 0.1	-	0.043	0.005	-	-	2.08
Sullivan Creek	C12SULLC02	7/4/2012	DEQ	0.03	0.11	0.014	0.005	19.3	5.85	6.46
Sullivan Creek	C12SULLC02	8/15/2012	DEQ	E 1.5	0.17	0.019	0.005	-	-	-
Sullivan Creek	C12SLVNC02	7/23/2011	DEQ	0.05	-	-	-	-	-	-
Sullivan Creek	C12SLVNC02	7/24/2011	DEQ	0.05	-	-	-	-	-	-
Sullivan Creek	C12SLVNC02	5/31/2012	DEQ	E 40	-	-	-	-	-	-
Sullivan Creek	C12SLVNC02	8/15/2012	DEQ	E 0	-	-	-	-	-	-
Sullivan Creek	C12SLVNC02	9/22/2012	DEQ	E 0	-	-	-	-	-	-
Sullivan Creek	C12SLVNC03	7/23/2011	DEQ	0.03	-	-	-	-	-	-
Sullivan Creek	C12SLVNC03	7/24/2011	DEQ	0.02	-	-	-	-	-	-
Sullivan Creek	C12SULLC02	7/23/2011	DEQ	0.04	-	-	-	-	-	-
Sullivan Creek	C12SULLC02	7/24/2011	DEQ	0.03	-	-	-	-	-	-
Sullivan Creek	C12SULLC02	5/31/2012	DEQ	0.17	-	-	-	-	-	-
Sullivan Creek	C12SULLC02	9/22/2012	DEQ	E 0	-	-	-	-	-	-

Waterbody Segment	Site ID	Sample Date	Organization	Flow (cfs)	TN (mg/L)	TP (mg/L)	NO2+3 (mg/L)	Chlorophyll-*a* (mg/m2)	AFDM (g/m2)	Macroinvertebrates (HBI)
Sullivan Creek	SLVNC-01	8/25/2011	DEQ	E 0	-	-	-	-	-	-
Sullivan Creek	SLVNC-02	8/25/2011	DEQ	E 0	-	-	-	-	-	-
Swamp Creek	C13SWPCR20	8/9/2007	DEQ	-	0.005	0.009	0.01	70.948	-	-
Swamp Creek	C13SWPCR20	8/16/2009	DEQ	-	0.11	0.01	0.005	14.4	-	-
Swamp Creek	C13SWPCR20	9/15/2009	DEQ	-	0.08	0.009	0.005	7.3	-	-
Swamp Creek	C13SWPCR20	7/28/2011	DEQ	16.3	0.06	0.027	0.005	-	-	-
Swamp Creek	C13SWPCR20	8/26/2011	DEQ	4.91	0.09	0.006	0.005	-	-	-
Swamp Creek	C13SWPCR10	9/8/2004	DEQ	E 1.92	-	0.01	0.005	-	-	-
Swamp Creek	C13SWPCR10	8/17/2009	DEQ	-	0.11	0.009	0.01	15.7	-	-
Swamp Creek	C13SWPCR10	9/15/2009	DEQ	-	0.09	0.008	0.005	14.5	-	-
Swamp Creek	C13SWPCR10	7/28/2011	DEQ	14.94	0.025	0.008	0.005	-	-	-
Swamp Creek	C13SWPCR10	8/27/2011	DEQ	5.47	0.1	0.005	0.005	7.13	4.65	-
Swamp Creek	C13SWMPC02	8/16/2009	DEQ	-	0.11	0.012	0.005	35	-	-
Swamp Creek	C13SWMPC02	9/15/2009	DEQ	-	0.08	0.011	0.005	10.5	-	-
Swamp Creek	C13SWMPC02	7/28/2011	DEQ	14.28	0.025	0.008	0.005	-	-	-
Swamp Creek	C13SWMPC02	8/27/2011	DEQ	5.15	0.08	0.0025	0.005	15.44	46.7	4.58
Swamp Creek	C13SWMPC01	8/17/2009	DEQ	-	-	-	-	6.28	-	-
Swamp Creek	C13SWMPC01	9/15/2009	DEQ	-	-	-	-	2.33	-	-
Swamp Creek	C13SWMPC01	8/28/2011	DEQ	1.53	-	-	-	19.11	16.7	-
Swamp Creek	C13SWMPC03	9/12/2011	DEQ	-	-	-	-	-	-	3.39
Swamp Creek	C13SWMPC02	8/25/2011	DEQ	-	-	-	-	-	-	6.05
Swamp Creek	C13SWPCR20	9/8/2004	DEQ	E 1.9	-	-	-	-	-	4.91
Swamp Creek	C13SWMPC01	7/28/2011	DEQ	11.6	-	-	-	-	-	-
Swamp Creek	C13SWMPC10	9/21/2004	DEQ	36.75	-	-	-	-	-	-

Waterbody Segment	**Site ID**	**Sample Date**	**Organization**	**Flow (cfs)**	**TN (mg/L)**	**TP (mg/L)**	**NO2+3 (mg/L)**	**Chlorophyll-*a* (mg/m2)**	**AFDM (g/m2)**	**Macroinvertebrates (HBI)**