E. Coli Bacteria TMDL for Little Missouri River in Billings, Golden Valley and Slope Counties, North Dakota

Draft: July 2020

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ABBREVIATIONS AND ACRONYMS

BMP	Best Management Practices
cfs	Cubic Feet Per Second
cfu	Colony Forming Units
EPA	U.S. Environmental Protection Agency
FDC	Flow Duration Curve
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
mL	Milliliter
MOS	Margin of Safety
NRCS	Natural Resource Conservation Service
NDDEQ	North Dakota Department of Environmental Quality
NWIS	National Water Information System
NDPDES	North Dakota Pollutant Discharge Elimination System
NDAWN	North Dakota Agriculture Weather Network
POTW	Publicly Owned Treatment Works
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WLA	Waste Load Allocation

1.0 INTRODUCTION AND DESCRIPTON OF THE WATERSHED

The Little Missouri River watershed associated with this Total Maximum Daily Load (TMDL) is a 434,494-acre watershed in Billings and portions of Slope and Golden Valley counties in southwest North Dakota (Figure 1 & 2). For the purposes of this TMDL, the impaired segments are located solely in Billings and Slope counties.

Table 1. Table of General Characteristics of the Contributing 12-Digit Watersheds that Drain to the Listed TMDL Segment.

Legal Name	Little Missouri River
Stream Classification	Class II
Major Drainage Basin	Little Missouri
8-Digit Hydrologic Unit	Within 10110203 (Middle Little Missouri River)
Counties	Billings, Golden Valley and Slope Counties
Level IV Ecoregions	Missouri Plateau (43a) and Little Missouri Badlands (43b)
Watershed Area (acres)	434,494

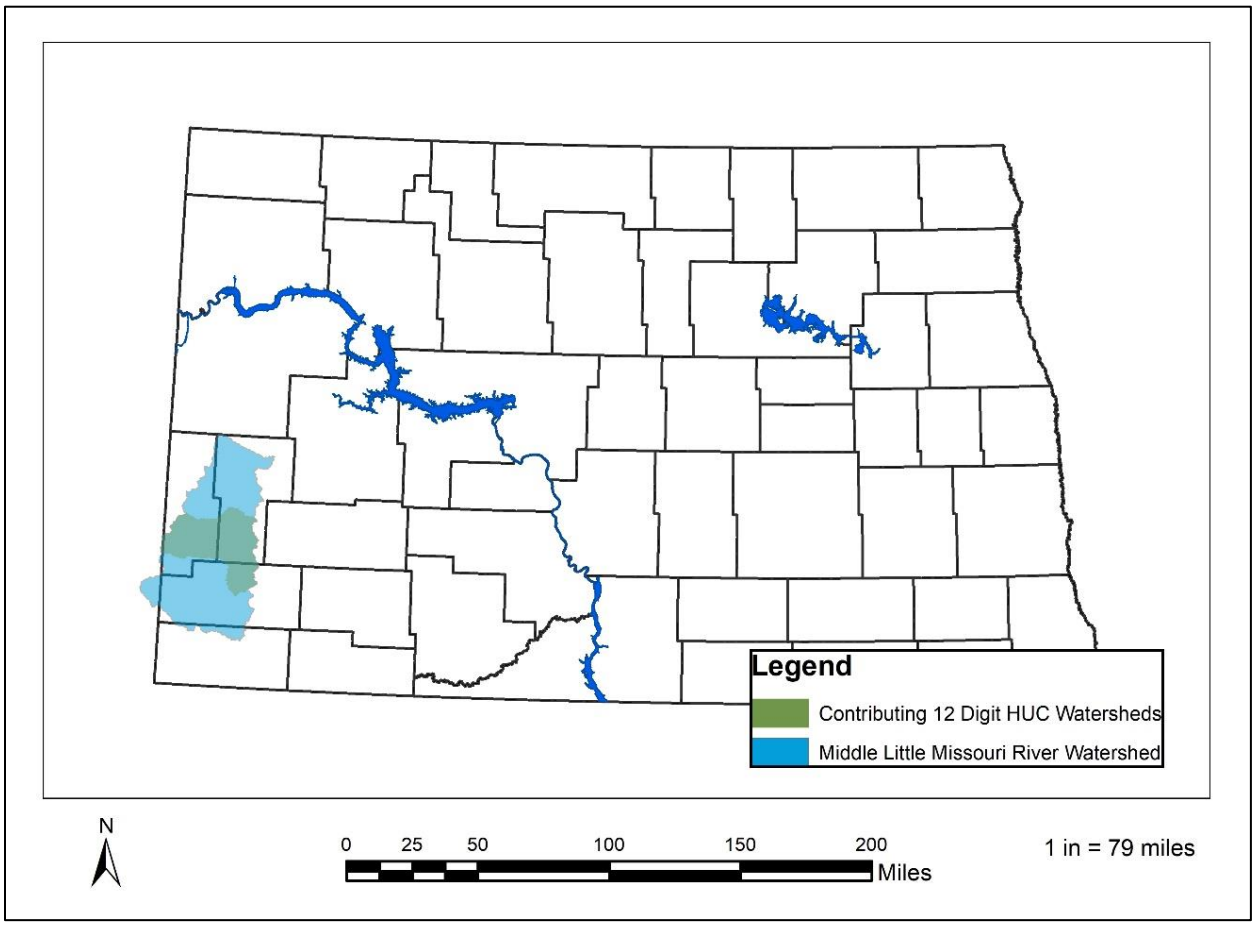

Figure 1. Map of Middle Little Missouri River Watershed and Contributing 12-Digit Watersheds that Drain to the Listed TMDL Segment.

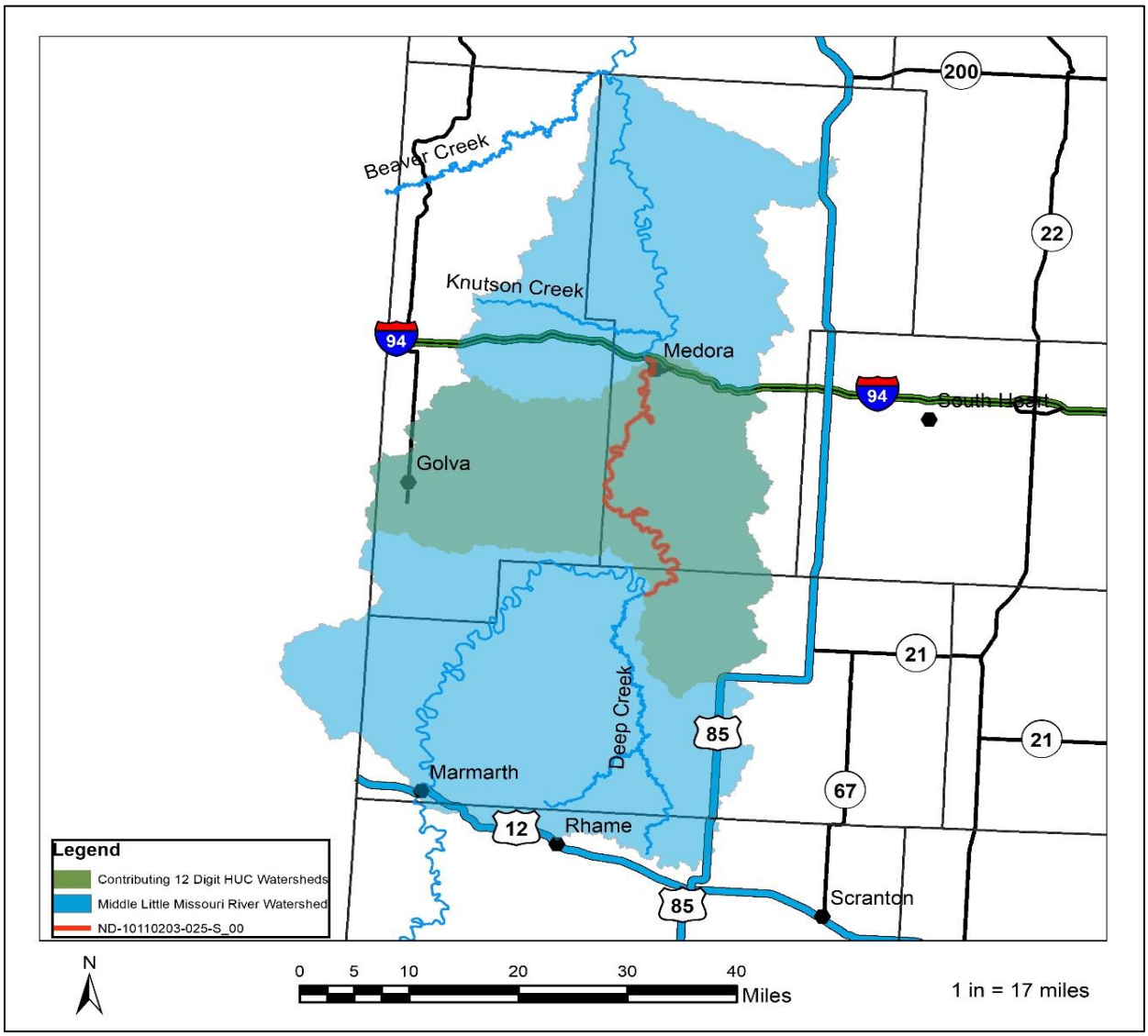

Figure 2. Map of Middle Little Missouri River Watershed and Contributing 12-Digit Watersheds that Drain to the Listed TMDL Segment.

1.1 Clean Water Act Section 303(d) Listing Information

Based on the North Dakota 2018 Section 303(d) List of Waters Needing Total Maximum Daily Loads (NDDEQ, 2019), the North Dakota Department of Environmental Quality, has identified the following segment of the Little Missouri River for TMDL development (Figure 3).

A 48.85-mile segment (ND-10110203-025-S_00) of the Little Missouri River from its confluence with Deep Creek downstream to its confluence with Andrews Creek is listed as not supporting for recreational uses due to Escherichia Coli (E. Coli) Bacteria.

Table 2. Table of Little Missouri River Section 303(d) Listing Information for Assessment Unit ID ND-10110203-025-S_00 (NDDEQ, 2019).

Assessment Unit ID	ND-10110203-025-S_00
Waterbody Description	Little Missouri River from its confluence with Deep Creek downstream to its confluence with Andrews Creek. Located in Billings and Slope Counties.
Size	48.85 miles
Designated Use	Recreation
Use Support	Not Supporting
Impairment	E. Coli Bacteria
TMDL Priority	High

There is currently, only one other completed TMDL located up-stream to the Impaired Segments. That TMDL addresses the Deep Creek for Fecal Coliform bacteria, and can be found on the NDDEQ website: www.deq.nd.gov

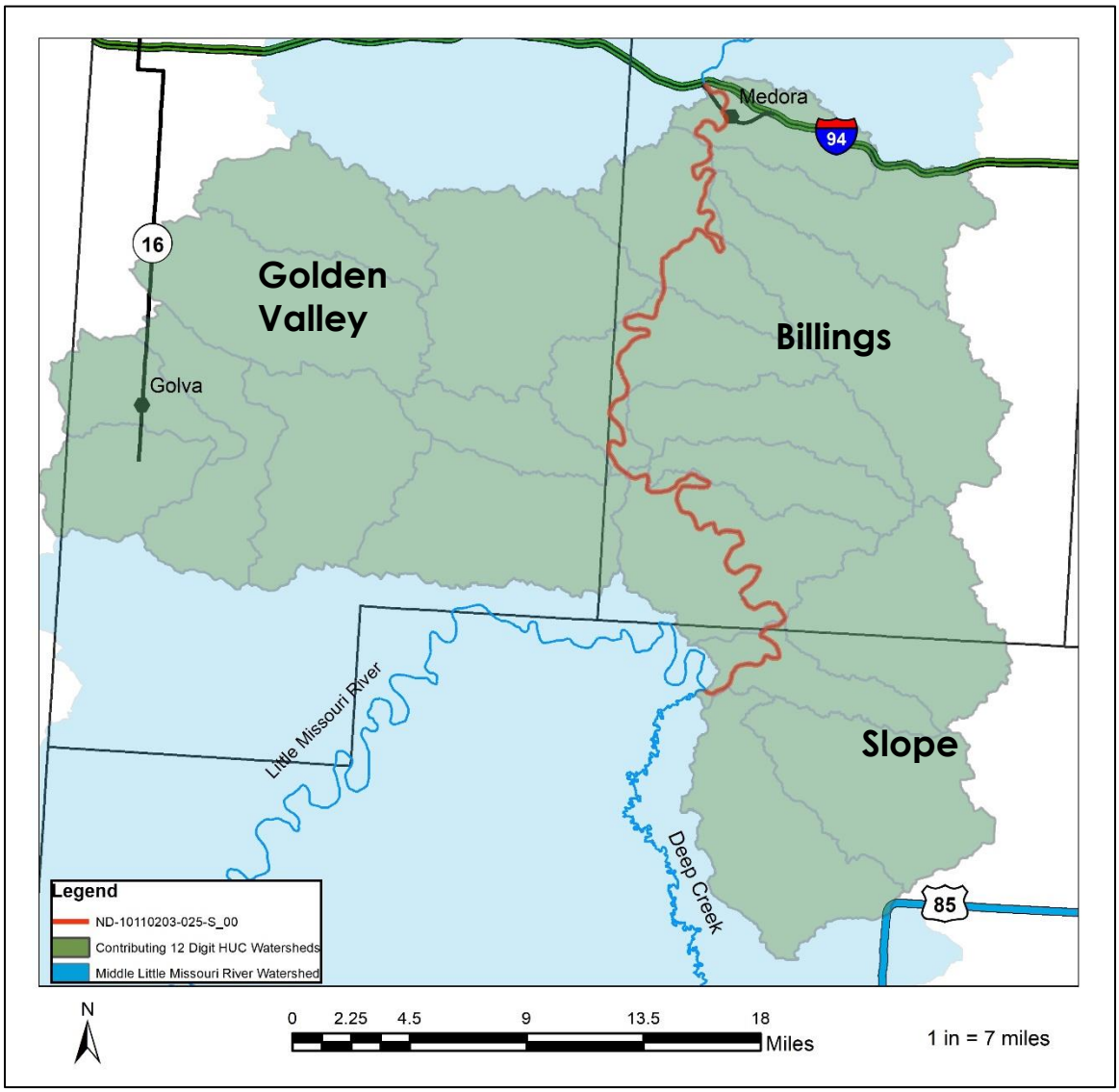

Figure 3. Map of Little Missouri River TMDL Listed Segment in Slope and Billings County.

1.2 Ecoregions

The impaired reaches of the Little Missouri River watershed lie within the Missouri Plateau (43a) and Little Missouri Badlands (43b) level IV ecoregions (Figure 4).

The Missouri Plateau (43a) ecoregion is characterized by moderately dissected level to rolling plains with isolated sandstone buttes. Elevation ranges from 1,750 – 3,300 ft. Precipitation for this region is 15-17 inch per year. Soil orders include Mollisols and Entisols, with soil series including Vebar, Chama, Amor, Williams, Golva and Zahl (EPA, 2006).

The Little Missouri Badlands (43b) ecoregion is characterized as highly dissected erosional landscape of conical hills, with widespread mass wasting and slumping. Most streams are ephemeral and flowing streams carry heavy sediment loads. Elevation ranges from 1,850 – 3,000 ft. Precipitation for this region is 14-16 inches per year. Soil orders include Entisols and Mollisols, with soil series including Cabbart, Fleak, Zeona, Boxwell, Patent and Wolfpont (EPA, 2006).

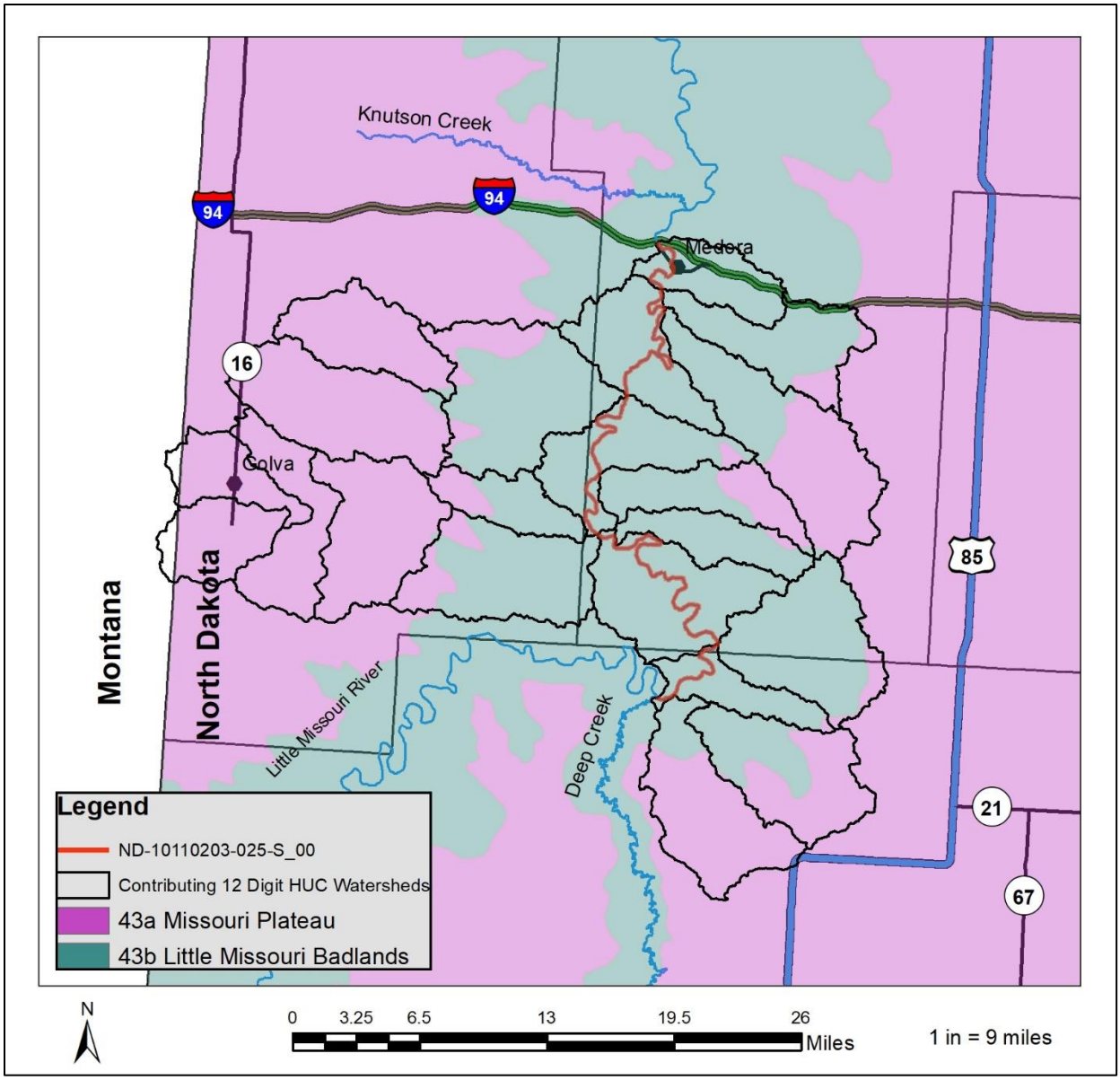

Figure 4. Map of Level IV Ecoregions in the Little Missouri River and TMDL Listed Segments.

1.3 Land Use

The dominant land use in the contributing watersheds for the listed segment of the Little Missouri River is grasslands. According to the 2018 National Agricultural Statistical Service (NASS, 2018) Cropland Data Layer, approximately 80 percent of the land is native and non-native grasslands, 17 percent is cropland including alfalfa or tilled acres, and two percent includes wetlands, water, woods, and urban development. The majority of the crops grown consists of wheat, lentils and hay other than alfalfa (Figure 5).

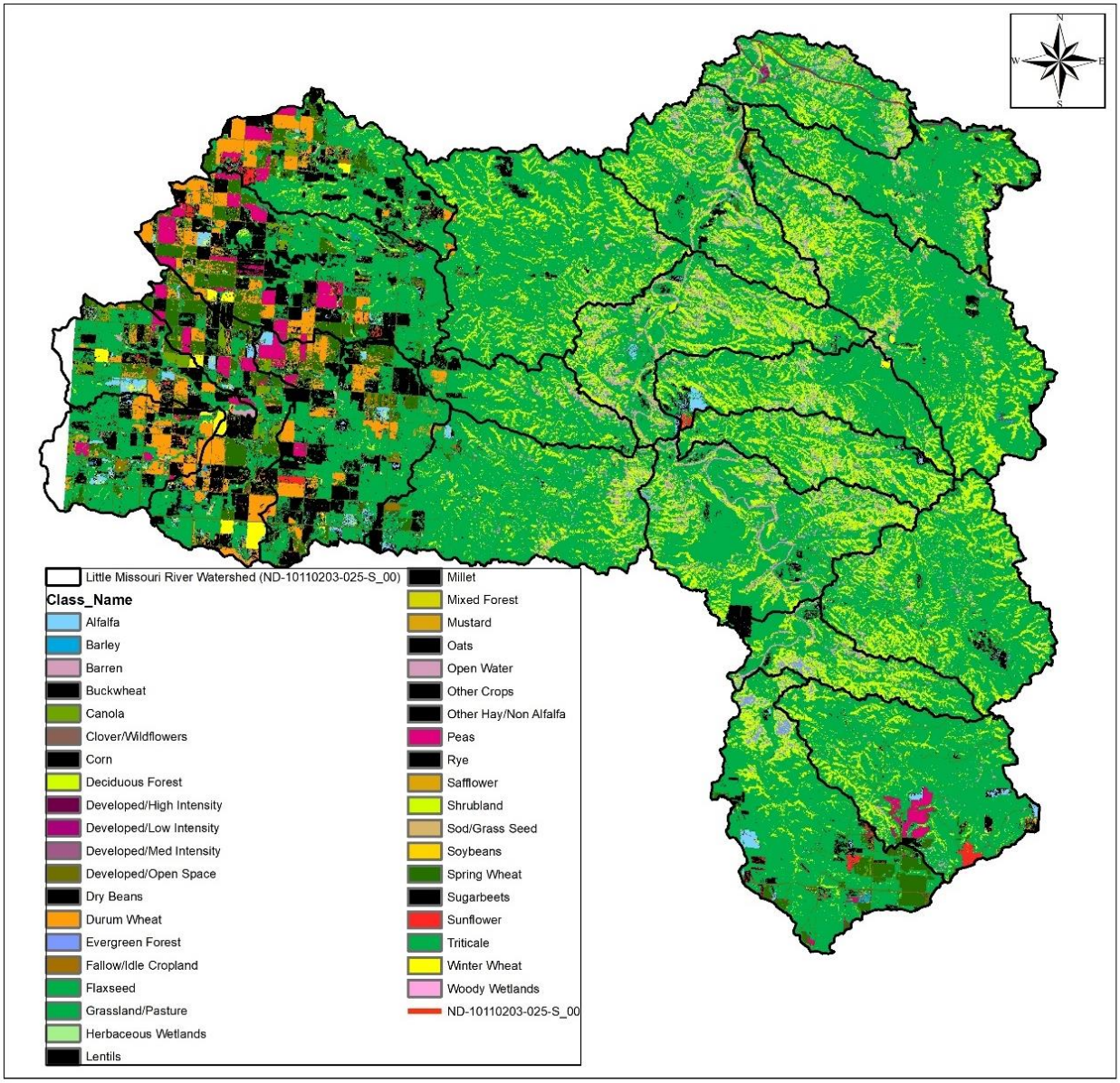

Figure 5. Map of Land Use in the Little Missouri River Watershed (NASS, 2018).

1.4 Land Ownership

A considerable amount of land ownership is held by the U.S. Forest Service, specifically, adjacent to the Little Missouri River (Figure 6). Other ownerships include; private land, N.D. Land Department and U.S. National Park Service. The Theodore Roosevelt Nation Park – South Unit, borders the northeastern boundary of the watershed.

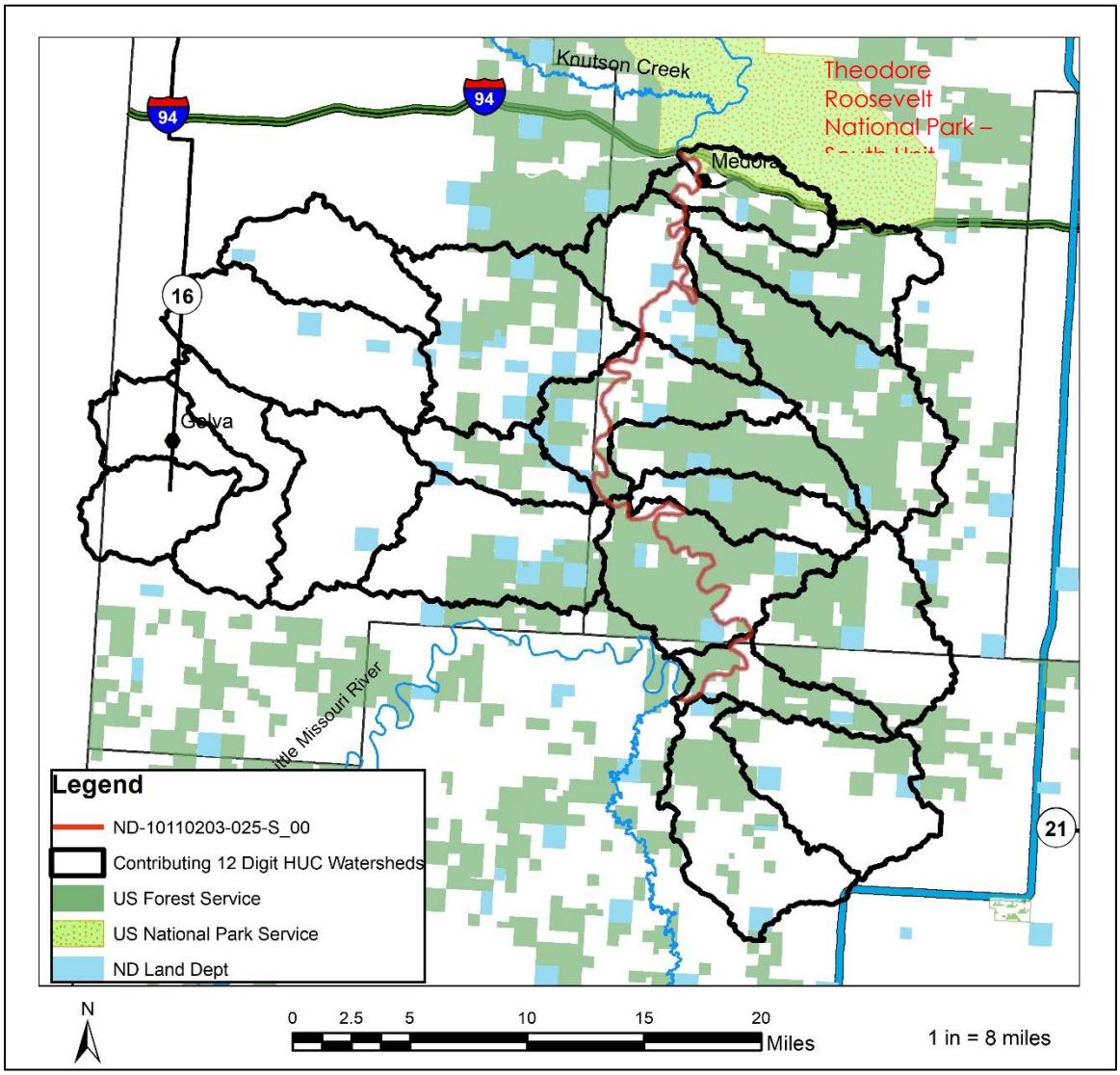

Figure 6. Map of Land Ownership Adjacent to the Listed Segment of the Little Missouri River.

1.5 Climate and Precipitation

Figures 7 and 8 show the average monthly precipitation and temperature for the Dickinson, ND, (Stark County), North Dakota Agriculture Weather Network (NDAWN) station from 1991-2017 for precipitation and 2001-2018 for temperature. The Dickinson station was chosen because it is the closest station available to the listed TMDL segment – located roughly 30 miles east of the City of Medora. Source data can be found at the NDAWN website: https://www.ndawn.ndsu.nodak.edu/

Stark County has a sub-humid climate characterized by warm summers with frequent hot days and occasional cool days. Average temperatures range from 15º F in winter to about 70º F in summer. Precipitation occurs primarily during the warm period and is normally heavy in later spring and early summer. Total annual precipitation is about 12 inches.

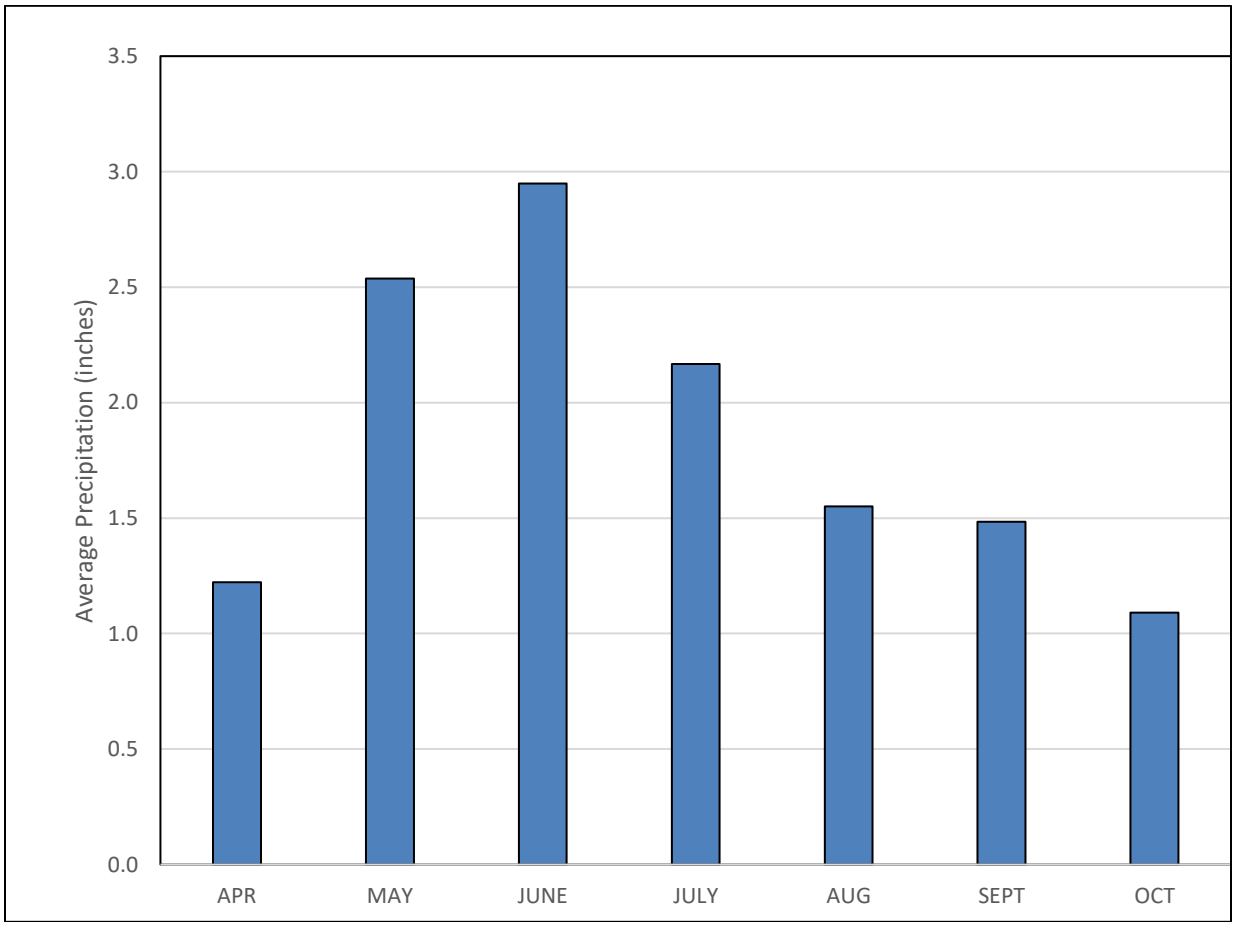

Figure 7. Graph of Average Monthly Precipitation at Dickinson, North Dakota from 1991-2017. Data Provided by North Dakota Agricultural Weather Network (NDAWN).

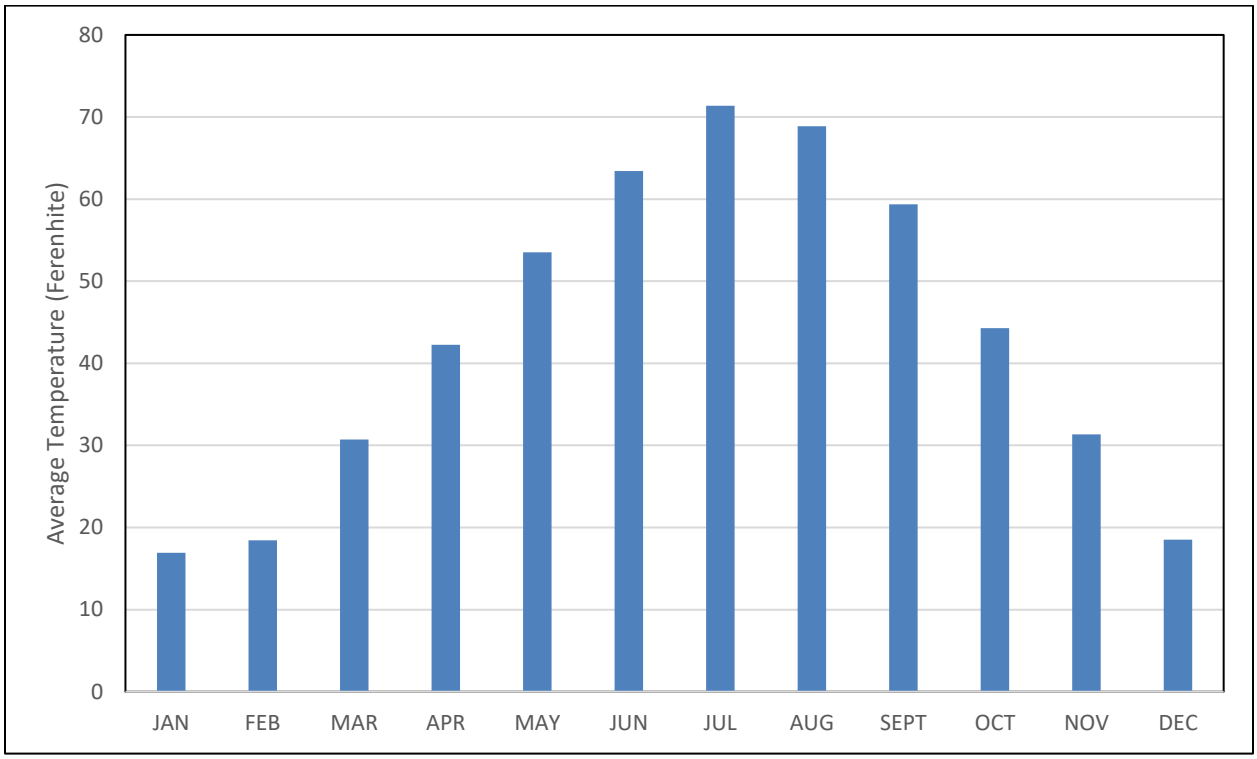

Figure 8. Monthly Average Air Temperature at Dickinson, North Dakota from 2001-2018. Data Provided by North Dakota Agricultural Weather Network (NDAWN).

1.6 Available Data

1.6.1 E. Coli Bacteria Data

NDDEQ Monitoring Site 380022 (Figure 9) was monitored for E. Coli Bacteria monthly, or when flow conditions were present during the recreational season (May 1-September 30) between the years of 2001 and 2018. This monitoring site was sampled by the NDDEQ as part of its on-going Ambient Monitoring Program.

Samples were taken and then analyzed by the NDDEQ, Chemistry Division Laboratory located in Bismarck, North Dakota. E. Coli Bacteria samples are typically measured as Colony Forming Units (CFU) per 100 mL of solution. After sample data is processed, it is measured against the current NDDEQ's Water Quality Standard (section 2.0) to determine if it falls above or below statutory limits.

Table 3 provides a summary of a) E. Coli Bacteria geometric mean concentrations, b) percentage of samples exceeding 409 CFU/100mL for each month and c) the recreational use assessment by month. These metrics will be defined in section 2.0 of this report. Source data for E. Coli. can be found in Appendix A and at https://deq.nd.gov/.

Table 3. Summary of E. Coli Bacteria Data for Site 380022 from 2001 – 2018.

Month	N	Geometric Mean Concentration (CFU/100mL)	Percentage of Samples Exceeding 409 (CFU/100mL)	Recreational Use Assessment
May	18	77	11%	Fully Supporting but Threatened
June	16	155	25%	Not Supporting
July	10	96	30%	Fully Supporting but Threatened
August	15	218	40%	Not Supporting
September	9	66	22%	Fully Supporting but Threatened

1.6.2 Hydraulic Discharge

Daily stream discharge, measured as average Cubic Feet per Second (CFS) per day, data for the listed TMDL segment was obtained from the United States Geological Survey (USGS) gauging station 06336000 which is co-located with the NDDEQ monitoring site 380022 (Figure 9). Source data can be found at USGS website: https://waterdata.usgs.gov/nwis/rt. Daily Stream discharge data was collected for the time periods between 2001-2018 (a total of 6,000+ days), to correlate with the available E. Coli Bacteria data.

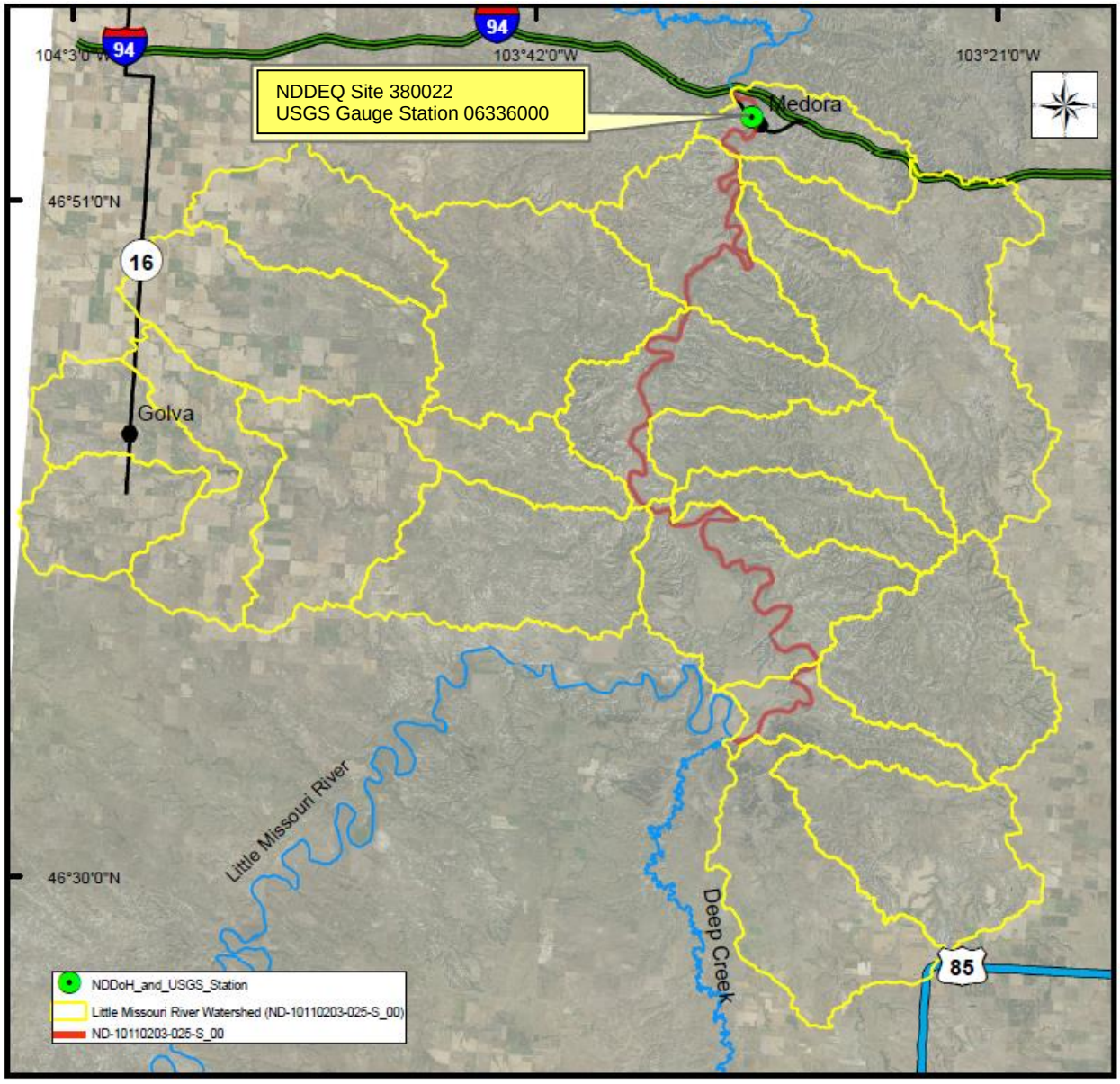

Figure 9. E. Coli Bacteria NDDEQ Monitoring Site 380022 and USGS Gaging Station 06336000 on the TMDL Listed Segment of the Little Missouri River.

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as “the sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background” such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain state water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis.

2.1 Narrative Water Quality Standards

The North Dakota Department of Environmental Quality has set narrative water quality standards that apply to all surface waters in the State. The narrative general water quality standards are listed below (NDAC, 2019).

- All waters of the State shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations that are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances shall:
    a. Cause a public health hazard or injury to environmental resources;
    b. Impair existing or reasonable beneficial uses of the receiving water; or
    c. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDEQ has set a biological goal for all surface waters in the state. The goal states “the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites” (NDAC, 2019).

2.2 Numeric Water Quality Standards

The Little Missouri River is a Class II stream. The NDDEQ definition of a Class II stream is shown below.

Class II- The quality of the waters in this class shall be the same as the quality of class I streams, except that additional treatment may be required to meet the drinking water requirements of the Department. Streams in this classification may be intermittent in nature which would make these waters of limited value for beneficial uses such as municipal water, fish life, irrigation, bathing, or swimming.

Table 4 provides a summary of the current numeric E. Coli Bacteria criteria which applies to all streams. It should be noted that the E. Coli Bacteria standard applies only during the recreation season of May 1st through September 30th.

Water Quality Standards for the State of North Dakota can be found at:
https://deq.nd.gov/

Table 4. Table of NDDEQ E. Coli Bacteria Water Quality Standards for all Streams.

Parameter	Standard	
	Geometric Mean[1]	Maximum[2]
E. Coli Bacteria	126 CFU*/100 mL*	409 CFU/100 mL

[1] Expressed as a geometric mean of representative samples collected during any consecutive 30-day period.

[2] No more than 10 percent of samples collected during any consecutive 30-day period shall individually exceed the standard.

*Colony Forming Units/milliliters

The NDDEQ has established a Recreational Use Assessment for E. Coli Bacteria, which can be determined by following the guidance in *Chapter 33.1-16-02.1 of the North Dakota Administrative Code*, *Standards of Quality for Waters of the State*, 2019, which is summarized as BOTH:

1. A 30-day geometric mean concentration of 126 CFU/100 mL or less, based on samples collected during the recreation season of May 1st through September 30th.

2. No more than 10 percent of samples collected during any consecutive 30-day period being above 409 CFU/100 ml.

The two Criteria are then applied using the following Recreational Use support decision criteria;

- Fully Supporting: Both criteria 1 and 2 are met.
- Fully Supporting but Threatened: Criterion 1 is met, but 2 is not.
- Not Supporting: Criterion 1 is not met. Criterion 2 may or may-not be met.

3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets must be based on State water quality standards but can also include site specific values when no numeric criteria are specified in a State's water quality standards. The following TMDL targets for the Little Missouri River, are based on the State water quality standard for E. Coli Bacteria.

3.1 Little Missouri River Target Reductions in E. Coli Bacteria Concentrations

Reach ND-10110203-025-S_00 listed in this TMDL is impaired because of E. Coli Bacteria and listed as Not Supporting for Recreational beneficial uses, due to E. Coli Bacteria counts exceeding the NDDEQ state water quality standard.

The North Dakota water quality standard for E. Coli Bacteria is summarized in Table 4 as being both:

1. a 30-day geometric mean concentration of 126 CFU/100 mL or less, based on samples collected during the recreation season of May 1st through September 30$^{th.}$

2. no more than 10 percent of samples collected during any consecutive 30-day period being above 409 CFU/100 mL.

Therefore, the TMDL target for this report is the NDDEQ water quality standard, or better.

4.0 SIGNIFICANT POLLUTION SOURCES

4.1 Point-Source Pollution

Within the watershed of the TMDL listed reach of the Little Missouri River there are two wastewater treatment systems permitted through the NDDEQ's North Dakota Pollutant Discharge Elimination System (NDPDES) Program. The first is the City of Medora, located within city limits and the second is The Burning Hills Amphitheater, Waste Water Treatment Plant (WWTP), located 1 mile west of the City of Medora.

Both point sources are located 1000 feet upstream from NDDEQ sampling site 380022.

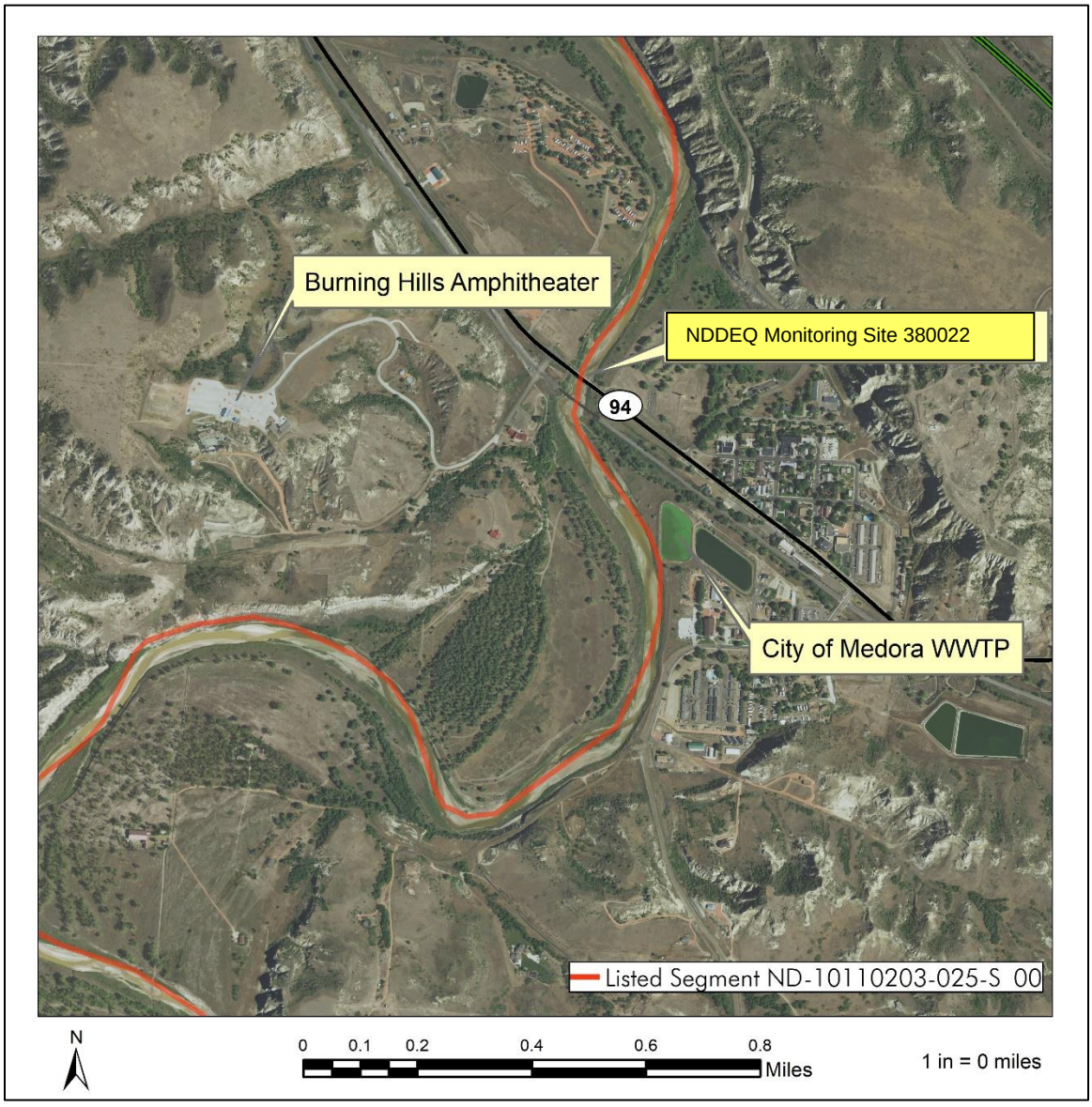

Figure 10. Point-Source Pollution Sources near the City of Medora.

The City of Medora has a brief record of E. Coli Bacteria discharge data between the years 2013 and 2018. Of the 7 samples submitted during this time period, none were above the 126 CFU/100 mL NDDEQ limit. Discharge sample data can be found in Appendix C.

The Burning Hills Amphitheater WWTP was constructed in the spring of 2018, therefore only a single E. Coli Bacteria sample was taken in July of 2018. Discharge sample data can be found in Appendix D. This single sample revealed an E. Coli Bacteria level of 2,420 CFU/100 mL. According to the Discharge Monitoring Report (DMR) there were several issues with the new system not operating correctly that could have caused the exceptionally high reading. According to the NDPDES, a UV lighting system is being utilized to disinfect E. Coli bacteria but has had issues with the light source not penetrating deeply enough into the treatment pond. A second UV light was added in 2019 to address this deficiency.

Four permitted Concentrated Animal Feeding Operations/Animal Feeding Operations (CAFO/AFO) operations are located within the TMDL watershed. Three of them are classified as Large (1,000+ Animal Units (AU)) and one as Medium (300-999 AU). All four operations are prohibited from discharging into any part of the watershed as specified by their NDPDES permits.

4.2 Nonpoint Source Pollution

The TMDL listed segment which is the focus of this report is experiencing high levels of E. Coli Bacteria pollution from nonpoint sources in the watershed. Through the analysis of land use data, water quality sample results, recreational use assessment and through the development of a load duration curve, potential nonpoint pollution sources in the contributing watershed of the listed segment in the Little Missouri River were determined and are discussed below.

4.2.1 Livestock Grazing

Land use data indicates roughly 80 percent of the watershed is pasture/grassland acres. This would indicate cattle production to be a dominant economic activity within the Little Missouri River watershed.

As indicated by Figure 6, the majority of land directly adjacent to the listed segment of the Little Missouri River is owned by the U.S. Forest Service (USFS). According to the 2006, *Livestock Grazing Record of Decision*, (USFS, 2006), the USFS authorized grazing management leases on the Little Missouri Dakota Prairie Grasslands. These leases allow private cattle and livestock owners to graze lands in the Dakota Prairie Grassland as governed by set rules and regulations of the USFS. Herd size and grazing duration are administered in each lease based on land condition, vegetative types and soils. Stock persons are held to a high standard of ecological stewardship through the use of education, outreach and enforcement capacities.

According to the USFS, City of Medora Field Office, the total leased allotment in the TMDL section of the Little Missouri River may contain up-to a maximum of 2,454 Animal Units (AU) per month between the date of May 1st and December 31st.

A large amount of livestock grazing also takes place on lands owned by private entities. To give the reader an idea of a typical private cattle grazing rotation for the southwestern portion of North Dakota, the following narratives have been provided.

Spring and summer are the prime grazing seasons, beginning sometime in late April when complete snowmelt has taken place and vegetation starts growing again. It is during this time period that riparian and their upland areas are heavily utilized. Riparian areas provide cattle with prolific vegetative growth and easy access for daily water consumption. Due to the lack of other available water sources, a large majority of North Dakota ranchers use these areas for the entire spring and summer grazing season.

During the fall, cattle are rotated off open land and into post-harvested cropland fields for grazing. Grazing from these highly vegetative-rich fields allows for the cattle herd to utilize a valuable energy source to assist with the brutally cold winters in North Dakota.

As temperatures drop and cropland fields have been fully grazed, cattle are relocated to a confined feeding area typically close to a ranchers' home or operation. This allows the rancher to keep a close watch on their livestock and to provide adequate feeding during the winter months. Winter feeding is commonly done with hay-bales and nutrient rich silage.

During fall and winter-feeding, manure is either left in place or collected in a pile to be spread on cropland or hay land the following spring or summer. If manure is not incorporated into the ground or managed poorly, the potential for surface water contamination due to spring runoff or heavy precipitation will drastically increase.

During all the seasons, contamination of surface waters by pollutants, such as E. Coli Bacteria, remain high. The NDDEQ water quality sample data and recreational use assessment indicated that the primary months that E. Coli Bacteria levels were exceeding state water quality standards for the listed TMDL segment, were between the months of June through August. It is the intensive and often over-utilization of riparian and upland areas that contribute to high E. Coli levels during these times.

Intensive grazing can significantly reduce upland vegetative biomass and fecal matter can build up in these areas. When a rain event occurs, the reduced biomass of the riparian and upland areas cannot function properly to filter out fecal matter running off the landscape, ultimately entering the stream. This type of grazing system also contaminates surface waters by allowing pollutants such as sediment, fertilizers and pesticides to pass into the stream. Fecal matter is also directly deposited in the stream channel while cattle are drinking and wallowing in the water.

Fall and winter feeding can also contribute to E. Coli Bacteria concentrations in surface water during the spring and summer seasons. In a study by the University of Regina, *Survival and Overland Transport of Fecal Coliform under Canadian Prairie Conditions* (Baker-Ismail, et al., 2016), the authors looked at winter grazing and fall manure application and their impact on water quality. The study found that fecal bacteria found within cow dung can, in fact, survive harsh winters. This is accomplished by fecal bacteria entering a stationary phase once deposited outside of the host body until conditions or environments become favorable for growth and propagation.

4.2.1.1 Livestock Grazing in Cropland

The majority and concentration of cropland is located in the western most part of the contributing watersheds (Figure 5).

Spring and fall are the prime grazing seasons in this cropland dominated area. In the spring, farmers will graze their animals on their fields before spring cultivation and planting to lessen residue burdens and to increase soil warming. During this rotation, livestock deposit manure indirectly and directly into small water ways that contribute to E. Coli Bacteria loading to the listed segment of the Little Missouri River. E. Coli Bacteria is also directly deposited in the stream channel by cattle drinking and wallowing in the water, if these croplands are immediately adjacent to waterbodies.

Although there is a relatively large area of cropland within the contributing watershed, grazing on cropland is considered lower risk due to it large distance from the listed segment, compared to grassland grazing adjacent to the segment.

4.2.2 Septic Systems

Septic system failure might contribute to the E. Coli Bacteria impairment. Failures can occur for several reasons, although the most common reason is improper maintenance (e.g., age, inadequate pumping). Other reasons for failure include improper installation, location, and choice of system. Harmful household chemicals can also cause failure by killing the bacteria that digest the waste. While the number of systems that are not functioning properly is unknown, it is estimated that 28 percent of the systems in North Dakota are failing likely due to backup and surfacing (EPA, 2002).

There are less than 20 septic systems located within a ¼ mile buffer of the Little Missouri River for the listed segment. Septic systems locations are assumed to be associated with homes and were identified and quantified by scanning over aerial imagery in Google Earth™ (USGS. 2014. Landsat Imagery).

4.2.3 Recreation

Not generally considered a significant source of E. Coli Bacteria, recreational use along the Little Missouri River for the listed segment is relatively high. Recreational use in this area include; fishing, hunting, horseback riding, back country camping, canoeing, kayaking, biking and hiking. The northern border of the watershed is the South Unit of the Theodore Roosevelt National Park, which attracts thousands of visitors yearly (Figure 6).

The famous Maah Daah Hey Trail stretches 96 miles across the N.D. Little Missouri National Grassland connecting all three units of the Theodore Roosevelt National Park. The southern portion of the trail, south of the City of Medora, meanders along portions of the Little Missouri River for the listed segment. Additionally, there are nine developed US Forest Service campgrounds along the trail and trail users can also camp in undeveloped areas on US Forest Service and National Park Service managed lands.

Another major recreational area is Sully Creek State Park, located on the banks of the Little Missouri River. In the early spring, canoeing and kayaking on the Little Missouri River is a popular activity. The facility has accommodations for 35 primitive campsites and 6 group primitive campsites. Vault toilets are located throughout the State Park. Due to the proximity of the river, these toilets may occasionally be subject to flooding or seasonal high-water tables, which could be a localized source of E. Coli Bacteria, if not maintained.

4.2.4 Ranch Facilities

There are fourteen small to medium ranch operations located directly adjacent to the listed segment. Most ranches in this area cater to the recreational tourist industry by providing over-night accommodations, food and tours. These ranches typically maintain a horse herd for tourists' activities. Since these small operations are not required to obtain a formal NDDEQ permit, improperly designed and/or managed holding facilities could contribute to high levels of E. Coli Bacteria being directly deposited into the listed segment.

These operations typically have not had formal or non-formal pollution control training and are not exposed to BMP literature. Permitted operations are, at a minimum, given literature on BMPs and the risks involved with poor management practices.

4.2.5 Other Minor Sources

Other potential nonpoint source pollution may include wildlife. Wildlife may contribute to the E. Coli Bacteria found in the water quality samples, but most likely in a lower concentration. Wildlife are nomadic with fewer numbers concentrating in a specific area, thus decreasing the probability of their contribution of fecal matter in significant quantities.

5.0 TECHNICAL ANALYSIS

The loading capacity or Total Maximum Daily Load (TMDL) is the amount of a pollutant (e.g. E. Coli Bacteria) a waterbody can receive and still meet and maintain water quality standards and beneficial uses. In TMDL development, the goal is to define the linkage between the water quality target and the identified source or sources of the pollutant (i.e., E. Coli Bacteria) and to determine the load reduction needed to meet the TMDL target.

To determine the cause and effect relationship between the water quality target and the identified source, the Load Duration Curve (LDC) methodology was applied. The following technical analysis addresses the reductions necessary to achieve the TMDL target for E. Coli Bacteria of 126 CFU/100 mL with a margin of safety.

5.1 Mean Daily Stream Flow

In southwestern North Dakota, rain events are variable, generally occurring during the months of April through September. Rain events can be sporadic and heavy or light, occurring over a short duration. Precipitation events of large magnitude, occurring at a faster rate than absorption, contribute to high runoff events.

Mean daily discharge for TMDL segment ND-10110203-025-S_00 were developed using stage and discharge data obtained from USGS gauge station site 06336000 for the years of 2001 to 2018. Over 6,000+ days of data was available for use.

Source data for all USGS Gauging Stations can be found at the USGS National Water Information System (NWIS) website: https://waterdata.usgs.gov/nwis/rt

5.2 Flow Duration Curve Analysis

The Flow Duration Curve (FDC) serves as the foundation for the Load Duration Curve used in the TMDL. FDC analysis looks at the cumulative frequency of historic flow data over a specified time period. A FDC relates flow (expressed as mean daily discharge) to the percent of time those mean daily flow values have been met or exceeded. The use of *"percent of time exceeded"* (i.e., duration) provides a uniform scale ranging from 0 to 100 percent, thus accounting for the full range of stream flows for the period of record. Low flows are exceeded most of the time, while flood flows are exceeded infrequently (EPA, 2007).

A basic Flow Duration Curve runs from high to low (0 to 100 percent) along the x-axis with the corresponding flow value on the y-axis (Figure 11). Using this approach, flow duration intervals are expressed as a percentage, with zero corresponding to the highest flows in the record (i.e., flood conditions) and one-hundred (100) to the lowest flows in the record (i.e., drought). Once the FDC is developed for the stream site, flow duration intervals can be defined which can be used as a general indicator of hydrologic condition (i.e. wet vs dry conditions and to what degree). These intervals (or zones) provide additional insight about conditions and patterns associated with the impairment (E. Coli Bacteria in this case) (EPA, 2007).

As depicted in Figure 11, the FDC for NDDEQ Monitoring Site 380022 (co-located with USGS gauging station 06336000), representing TMDL segment ND-10110203-025-S_00, was divided into four zones; high flows (0-15 percent), moist conditions (15-40 percent), dry conditions (40-75 percent) and low flows (75-99 percent). Based on the FDC analysis, no flow occurred 1 percent of the time (99-100 percent).

These flow intervals were defined by examining the range of flows for the period of record and then looking for natural breaks in the flow record based on the FDC data analysis (Appendix B). When possible, breaks were adjusted to try and include E. Coli Bacteria observations above the criterion in every flow regime.

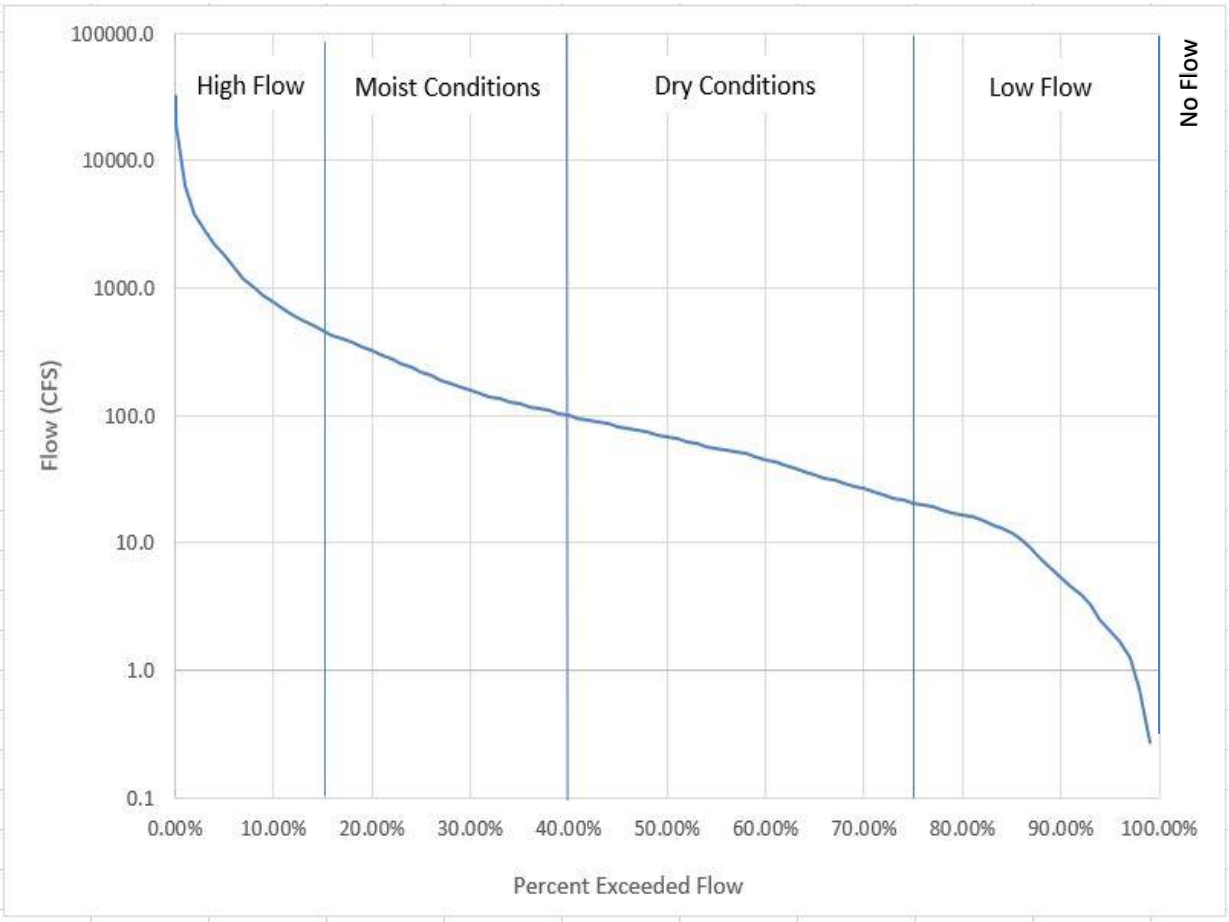

Figure 11. Graph of Flow Duration Curve for the Little Missouri River NDDEQ Monitoring Site 380022 (co-located with USGS gauge station 06336000), near the City of Medora, North Dakota.

5.3 Load Duration Analysis

An important factor in determining nonpoint source pollution loads is the variability in stream flows and loads associated with these flows. To better correlate the relationship between the pollutant of concern and the hydrology of the Section 303(d) TMDL listed segment(s), a Load Duration Curve (LDC) was developed. The LDC was derived using the E. Coli Bacteria TMDL target of 126 CFU/100 mL and the flows generated as described in Sections 5.1 and 5.2.

Observed in-stream E. Coli Bacteria data obtained from NDDEQ monitoring site 380022 in 2001 to 2018 (Appendix A) were converted to a pollutant load by multiplying E. Coli Bacteria concentrations by the mean daily flow and a conversion factor. These loads are plotted against the percent of flow exceeded on the day of sample collection (Figure 12). Points plotted above the 126 CFU/100 mL target curve exceed the state water quality standards. Points plotted below the curve are meeting the State water quality target of 126 CFU/100 mL.

For each flow interval or zone, a regression relationship was developed between the samples which occur above the TMDL target (126 CFU/100 mL) curve and a corresponding 50% percent exceeded flow was identified. The regression lines for the high, moist, dry and low zone for site 380022 were then used with the midpoint of 50% exceeded for that interval to calculate the existing E. Coli Bacteria load.

In the example provided in Figure 12, the regression relationship between observed E. Coli Bacteria loading and percent exceeded flow for the High Flow, Moist Conditions, Dry Conditions and Low Flow interval is expanded below:

High Flow

E. Coli Bacteria load (expressed as 10^7 CFUs/day) = antilog (Intercept + (Slope*Percent Exceeded Flow))

Where the midpoint of the High flow interval from, 0 to 15 percent, is 7.5 percent, the Intercept is 6.49 and the Slope is -4.51; the existing E. Coli Bacteria load is:

E. Coli Bacteria load (10^7 CFUs/day) = antilog (6.49 + (-4.51*0.075))
= 1,406,382, x 10^7 CFUs/day

Moist Conditions

E. Coli Bacteria load (expressed as 10^7 CFUs/day) = antilog (Intercept + (Slope*Percent Exceeded Flow))

Where the midpoint of the Dry flow interval from, 15 to 40 percent, is 27.5 percent, the Intercept is 6.18 and the Slope is -2.49 the existing E. Coli Bacteria load is:

E. Coli Bacteria load (10^7 CFUs/day) = antilog (6.18 + (-2.49*0.275))
= 310,553 x 10^7 CFUs/day

Dry Conditions

E. Coli Bacteria load (expressed as 10^7 CFUs/day) = antilog (Intercept + (Slope*Percent Exceeded Flow))

Where the midpoint of the Dry flow interval from, 40 to 75 percent, is 57.5 percent, the Intercept is 6.60 and the Slope is -3.33; the existing E. Coli Bacteria load is:

E. Coli Bacteria load (10^7 CFUs/day) = antilog (6.60 + (-3.33*0.575))
= 48,006 x 10^7 CFUs/day

Low Flow

E. Coli Bacteria load (expressed as 10^7 CFUs/day) = antilog (Intercept + (Slope*Percent Exceeded Flow))

Where the midpoint of the Dry flow interval from, 75 to 99 percent, is 87 percent, the Intercept is 5.29 and the Slope is -1.64; the existing E. Coli Bacteria load is:

E. Coli Bacteria load (10^7 CFUs/day) = antilog (5.29 + (-1.64*0.87))
= 7,391 x 10^7 CFUs/day

As stated above, the midpoint for the 50% flow intervals are used to estimate the TMDL target load. In the case of the previous example, the TMDL target load for the midpoint of each flow regime is displayed in Table 5.

Table 5. Load Duration Curve Result Table.

	Load (CFU x 10^7 /Day)		
	Median Percentile	**Existing**	**TMDL**
High	7.50%	1,406,382	336,442
Moist	27.50%	310,553	56,420
Dry	57.50%	48,006	15,477
Low	87.00%	7,391	2,772

The Load Duration Curve analysis of the listed reach indicates that there had been exceedances of the state water quality standard for E. Coli Bacteria in all four of the flow and condition regimes.

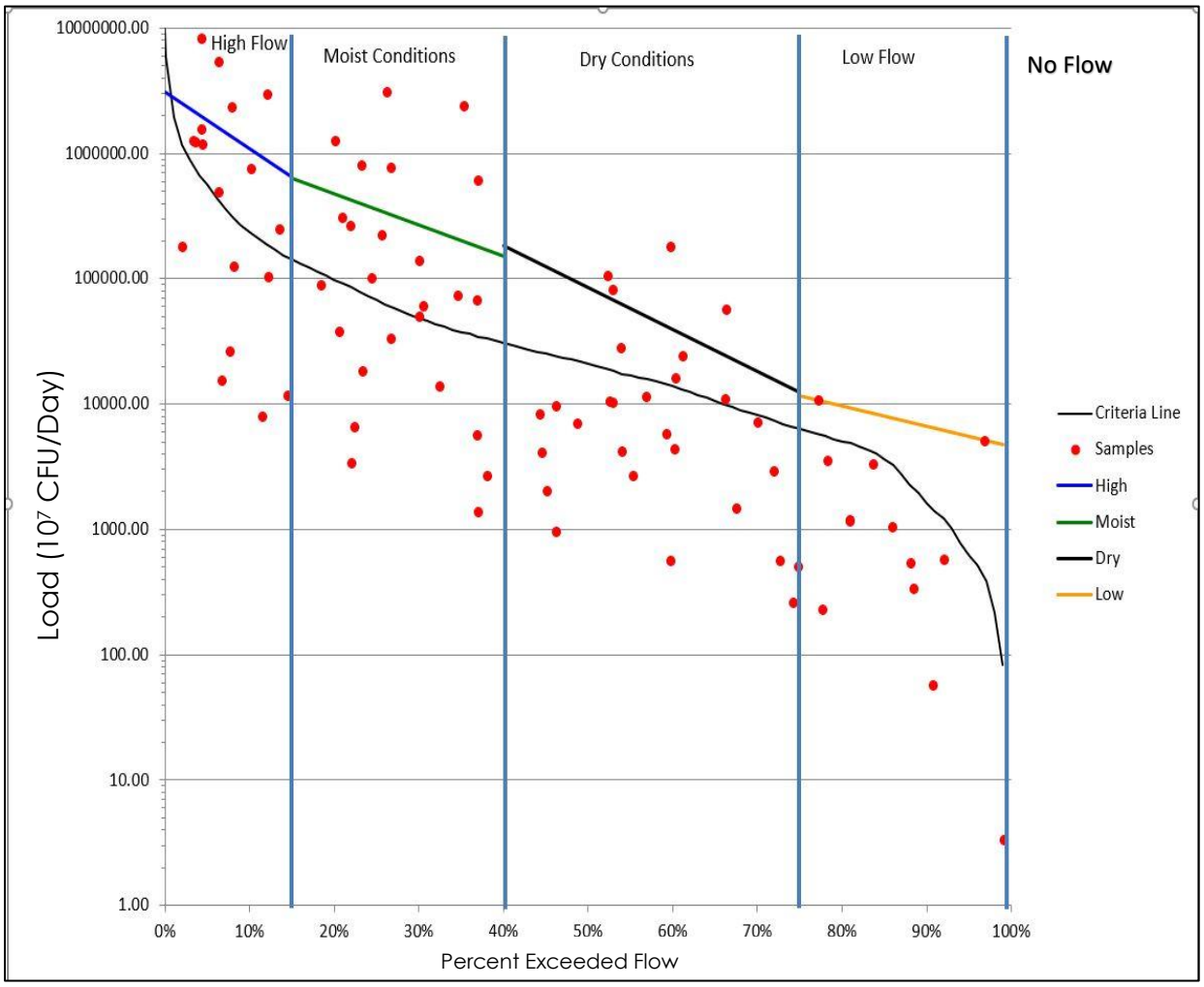

Figure 12. Graph of E. Coli Bacteria Load Duration Curve for the Little Missouri River NDDEQ Monitoring Station 380022. The Curve Reflects Flows Collected from 2001-2018.

5.4 Waste Load Allocation (WLA) Analysis

Waste load allocation calculations for the City of Medora and The Burning Hills Amphitheater, WWTP will be calculated based on the following criteria:

1) The computed average daily discharge - during the Recreational period - will be used in waste load allocation calculations. This value was chosen because it represents the average discharge volume during the Recreational period, and will allow for flexibility, due to the variability of the facilities discharge volumes and durations.

2) Although E. Coli Bacteria data has been collected for both point sources, the systems are assigned the water quality standards value of 126 CFU/100mL for this TMDL. This value was chosen because it is the NDDEQ water quality standard, and because dischargers throughout the state are required by their permit to sample for bacteria at this same value.

5.4.1 City of Medora, ND Wastewater Treatment Plant

According to NDPDES permit 'ND0022799', the City of Medora, N.D., has two wastewater discharge points which are fed from the same storage cells. Discharges are typically in the time periods of the recreation season (May 1-September 30). Records of available discharge are between the years 2001 and 2018.

Because both discharge points are fed from the same group of storage cells, both points will be considered from the same source. Only one discharge point will be designated for the City of Medora.

Discharge amounts* between the months of May through September – for all years on record - were grouped and averaged (Appendix D). The calculated average is 0.38 MGAL

> *The Discharge Monitoring Report (DMR), summarizes discharge amounts by the **Number** of days and the total **MGAL (Million Gallons)** for all the days of discharge. To convert the loading data into a daily discharge amount, the total MGAL is divided by the number of days in the discharge event.

The waste load allocation for the City of Medora was determined by taking the calculated average daily discharge volume – during the Recreational period -- of 0.38 Million Gallons per Day (MGD) multiplied by an E. Coli Bacteria concentration of 126 CFUs/100 mL, times appropriate conversion factors. Calculations follow:

City of Medora

= 0.38 million gallons/day * 3.7854 L/gal*1000mL/L* 126 CFU/100mL

= 181.2 x 10^7 CFUs/day

5.4.2 The Burning Hills Amphitheater, N.D. Waste Water Treatment Plant

According to NDPDES permit 'NDG426905', The Burning Hills Amphitheater has one wastewater discharge point. The facility was permitted in 2018 and only has a single record available for discharge and E. Coli Bacteria for the year 2018.

Due to a misunderstanding in the required reporting procedures, The Burning Hills Amphitheater WWTP did not report their discharge amount for July of 2018 in their DMR (Appendix E). To obtain an estimated discharge amount for the purpose of WLA, The Burning Hills Amphitheater WWTP operator, was contacted in January of 2019, and asked what their maximum possible daily discharge amount was, which was reported as 12,000 gallons per day.

The Waste Load Allocation for The Burning Hills Amphitheater WWTP was determined by using the maximum daily discharge volume of 12,000 gallon per day and then multiplied by an E. Coli Bacteria concentration of 126 CFUs/100 mL, times an appropriate conversion factor;

The Burning Hills Amphitheater

= 12,000 gallons/day * 3.7854 L/gal*1000mL/L* 126 CFU/100mL

= 5.723×10^7 CFUs/day

5.5 Loading Reduction Analysis

The majority of load reductions can generally be allotted to nonpoint sources. However, to account for uncertainty due to periodic discharges from permitted municipal facilities, (e.g., City of Medora) WLAs for all point-sources are included for the calculation this TMDL.

As previously described, exceedances of the E. Coli Bacteria standard were observed in all flow regimes (i.e., High Flow, Moist Conditions, Dry Conditions, Low Flow) at NDDEQ monitoring site 380022.

Based on best professional judgment, the general focus for the establishment of Best Management Practices (BMPs) and load reductions for the listed impaired segment should be on riparian grazing adjacent to, or in close proximity to, the Little Missouri River.

One of the more important concerns regarding nonpoint sources is variability in stream flows. Variable stream flows often cause different source areas and loading mechanisms to dominate (Cleland, 2003).

By relating runoff characteristics to each flow regime, one can infer which sources are most likely to contribute to E. Coli Bacteria loading (Table 6). Animals grazing in the riparian area contribute E. Coli Bacteria by depositing manure where it has an immediate impact on water quality. Due to the proximity of manure to the stream, or by direct deposition in the stream, riparian grazing impacts water quality at high flow or under moist and dry conditions.

In contrast, intensive grazing of livestock in the upland and not in the riparian area has a high potential to impact water quality at high flows and under moist conditions. Intensive grazing in the upland creates the potential for manure accumulation and availability for runoff at high flows and a high potential for total E. Coli Bacteria contamination. Exclusion of livestock from the riparian area eliminates the potential of direct manure deposit and therefore is considered to be of high importance at all flows.

Table 6. Table of Nonpoint Sources of Pollution and Their Potential to Pollute at a Given Flow Regime.

Nonpoint Sources	Flow Regime		
	High Flow	Moist Conditions	Dry Conditions
Riparian Area Grazing (Livestock)	H	H	H
Animal Feeding Operations	H	M	L
Manure Application to Crop and Range Land	H	M	L
Intensive Upland Grazing (Livestock)	H	M	L

(H: High M: Medium; L: Low)

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency (EPA) regulations require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The Margin of Safety (MOS) can be either incorporated into conservative assumptions used to develop the TMDL (implicit) or added to a separate component of the TMDL (explicit).

To account for the uncertainty associated with known sources and the load reductions necessary to reach the TMDL target of 126 CFU/100 mL, a ten percent (10%) explicit margin of safety was used. The MOS was calculated as ten percent (10%) of the total TMDL.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and associated regulations require that a TMDL be established with seasonal variations. The TMDLs which are included in this report address seasonality because the Flow Duration Curve for the Little Missouri River (ND-10110203-025-S_00) were developed using 17 years of data, between 2001 and 2018, and encompassing all 12 months of the year. Additionally, the water quality standard is seasonally based on the recreation season from May 1 to September 30 and controls will be designed to reduce E. Coli Bacteria loads during the seasons covered by the standard.

7.0 TMDL

Table 7 provides an outline of the critical elements of the E. Coli Bacteria TMDL for the listed segment. The TMDL for the Little Missouri River section (ND-10110203-025-S_00) is summarized in Table 8. It provides an estimate of the existing daily load and target average daily load, by flow regime, necessary to meet North Dakota water quality standards. The TMDL also includes a load allocation from known point-sources and a ten percent (10%) Margin of Safety.

It should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring.

Table 7. Table of Critical Elements for the Listed Segment of the Little Missouri River**.**

Category	Description	Explanation
Beneficial Use Impaired	Recreation	Contact Recreation (i.e. swimming, fishing)
Pollutants	E. Coli Bacteria	See Section 2.0
E. Coli Bacteria TMDL Target	126 CFU/100 mL	Based on the current state water quality standard for E. Coli Bacteria. Monitoring will be conducted to determine compliance with the current water quality standard of 126 CFU/100 mL.
Significant Sources	Nonpoint and Point Sources	Includes nonpoint sources (e.g. unpermitted AFOs and riparian grazing),and point sources for the City of Medora and The Burning Hills Amphitheater WWTP.
Margin of Safety	Explicit	Ten percent (10%)

TMDL = LC = WLA + LA + MOS, where:

LC = loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;
WLA = waste load allocation, or the portion of the TMDL allocated to existing or future point sources;
LA = load allocation, or the portion of the TMDL allocated to existing or future non-point sources;
MOS = margin of safety, or an accounting of the uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity.

Table 8. E. Coli Bacteria TMDL (CFU x 10^7 day) for the Little Missouri River Listed Segment ND-10110203-025-S_00 as represented by NDDEQ Monitoring Site 380022.

	Flow Regime			
	High Flow	Moist Conditions	Dry Conditions	Low Flow
Existing Load	1,406,382	310,553	48,006	7,391
TMDL	336,442	56,420	15,477	2,772
WLA-City of Medora	181.2	181.2	181.2	181.2
WLA-Burning Hills Amphitheater	5.723	5.723	5.723	5.723
LA	302,612	50,593	13,744	2,309
MOS	33,644.2	5,642.0	1,547.7	277.2

7.1 Allocation

The City of Medora and the Burning Hills Amphitheater produce only short duration discharges into an extremely small portion of the TMDL watershed. Their contribution and overall emphasis on the total watershed load are at best, minimum to none.

The permitted facility in the City of Medora with discharge points into segment ND-10110203-025-S_00, will have a portion of the TMDL, 181.2 x 10^7 CFUs/day. The Burning Hills Amphitheater WWTP will be set at 5.723 x 10^7 CFUs/day.

All four flow regimes are set at the same amount. The remaining load for all four flow regimes has been allocated to nonpoint sources (LA) in the watershed and the MOS.

8.0 MITIGATION

Nonpoint source pollution maybe the sole contributor to elevated E. Coli Bacteria levels in the listed segment of the Little Missouri River watershed. To achieve the TMDL targets identified in the report, it will require the widespread support and voluntary participation of landowners and residents in the watershed. The TMDLs described in this report are a plan to improve water quality by implementing best management practices (BMPs) through non-regulatory approaches. BMPs are methods, measures, or practices that are determined to be a reasonable and cost-effective means for a landowner to meet nonpoint source pollution control needs (EPA, 2001).

USDA-NRCS is a leading agency in the development and implementation of BMPs. The agency has cataloged and described in detail over 100 BMPs to protect water quality. NRCS's BMPs are recommended for mitigation for this TMDL report, due to their creditability and through designs produced from their department. It should be noted, that this does not exclude the use of other recognized BMPs as a means for mitigation.

To reduce nonpoint source pollution for all the flow regimes, specific BMPs are described in Sections 8.1 and 8.2 that will mitigate the effects of E. Coli Bacteria loading to the impaired reaches.

Controlling nonpoint sources is an immense undertaking requiring extensive financial and technical support. Provided that technical/financial assistance is available to stakeholders, these BMPs have the potential to significantly reduce total E. Coli Bacteria loading to the Little Missouri River. Water quality monitoring should continue in order to measure BMP effectiveness and determine through adaptive management if loading allocation recommendations need to be adjusted.

Table 9. Table of Management Practices, Flow Regimes and Expected Reduction of E. Coli Bacteria by the Implementation of BMPs (Cleland, 2003).

Management Practice	Flow Regime and Expected Reduction		
	High Flow-70%	Moderate Flow-80%	Low Flow-74%
Livestock Exclusion from Riparian Area	X	X	X
Water Well and Tank Development	X	X	X
Prescribed Grazing	X	X	X
Waste Management System	X	X	
Vegetative Filter Strip		X	
Septic System Repair		X	X

8.1 Livestock Management Recommendations

Livestock management BMPs are designed to promote healthy riparian areas and improve water quality through management of livestock and associated grazing land.

Fecal matter from livestock, erosion from poorly managed riparian areas and grazing lands can be a significant source of E. Coli Bacteria loading to surface water.

Precipitation, plant cover, number of animals, and soils are factors that affect the amount of bacteria delivered to a waterbody because of livestock. These specific BMPs are known to reduce nonpoint source pollution from livestock. These BMPs include:

Livestock Exclusion from Riparian Areas- (NRCS Practice Specification 382 & 472)
This practice is established to remove livestock from grazing riparian areas and watering in the stream. Livestock exclusion is accomplished through fencing. A reduction in stream bank erosion can be expected by minimizing or eliminating hoof trampling. A stable stream bank will support vegetation that will hold banks in place and serve a secondary function as a filter from nonpoint source runoff. Added vegetation will create aquatic habitat and shading for macroinvertebrates and fish. Direct deposit of fecal matter into the stream and stream banks will be eliminated as a result of livestock exclusion by fencing.

Fencing, Water well and Tank Development- (NRCS Practice Specification 587)
Fencing animals from stream access requires an alternative water source. Installing water wells and tanks satisfies this need. Installing water tanks provides a quality water source and keeps animals from wading and defecating in streams. This will reduce the probability of pathogenic infections to livestock and the public.

Prescribed Grazing- (NRCS Practice Specification 528)
This practice is used to increase ground cover and ground stability by rotating livestock throughout multiple fields. Grazing with a specified rotation minimizes overgrazing and resulting erosion. The Natural Resource Conservation Service recommends grazing systems to improve and maintain water quality and quantity. Duration, intensity, frequency, and season of grazing can be managed to enhance vegetation cover and litter, resulting in reduced runoff, improved infiltration, increased quantity of soil water for plant growth, and better manure distribution and increased rate of decomposition.

Waste Management System- (NRCS Practice Specification 313)
Waste management systems can be effective in controlling up to 90 percent of E. Coli Bacteria loading originating from confined animal feeding areas. A waste management system is made up of various components designed to control nonpoint source pollution from Concentrated Animal Feeding Operations (CAFOs) and Animal Feeding Operations (AFOs). Diverting clean water from the feeding area and containing dirty water from the feeding area in a pond are typical practices of a waste management system. Manure handling and application of manure is designed to be adaptive to environmental, soil, and plant conditions to minimize the probability of contamination of surface water.

Vegetative Filter Strip- (NRCS Practice Specification 393)
Vegetated filter strips are used to reduce the amount of sediment, particulate organics, dissolved contaminants, nutrients, and in the case of this TMDL, E. Coli Bacteria to streams. The effectiveness of filter strips and other BMPs in removing E. Coli Bacteria is quite successful. Results from a study by Pennsylvania State University (1992a) as presented by USEPA (1993), suggest that vegetative filter strips are capable of removing up to 55 percent of E. Coli Bacteria loading to rivers and streams. The ability of the filter strip to remove contaminants is dependent on field slope, filter strip slope, erosion rate, amount and particulate size distribution of sediment delivered to the filter strip, density and height of vegetation, and runoff volume associated with erosion producing events.

8.2 Cropland Management Recommendations

Vegetative Barrier – (NRCS Practice Specification 601)
Vegetative barriers are used to reduce sheet and rill erosion, reduce ephemeral gully erosion, manage water flow, stabilize steep slopes, and trap sediment. This practice applies to all eroding areas, including cropland, grazing land, forest land, farmsteads, mined land, and construction sites. By reducing erosion any accumulated amount of fecal matter will less likely be moved off site and into an adjacent waterway.

Cover Crop – (NRCS Practice Specification 380)
Cover crops are crops which are not usually grown for harvest, but which serve multiple functions in crop rotation systems. Cover crops are typically grown to prevent soil erosion or for improvement of soil quality, however, other important roles include the enhancement of soil structure, improvement of soil fertility, enhancement or preservation of environmental quality, and in the management of weeds, insect pests, and plant pathogens.

8.3 Area Wide Septic System Analysis

In the absence of an existing analysis, an area wide septic system analysis is recommended to identify possible E. Coli Bacteria discharges from failing or improperly functioning septic systems.

8.4 E. Coli Bacteria Source Tracking Analysis

Source tracking analysis provides a clear understanding of sources and their points of entry into a watershed. Over the last decade, technology and widespread use, has decreased the cost of Source Tracking Analysis and made it more available for local watershed agency partners to incorporate into their water quality monitoring programs.

8.5 Other Recommendations

Promote and encourage the attendance of informational and educational opportunities and venues for landowners and watershed users. Programs such as these create a community of watershed actors to network and share ideas and technologies that work in a local setting. The state of North Dakota hosts a wide variety of these opportunities and venues, some include;

a) The state funded Water Education Foundation – Water Tours – is an exceptional opportunity for all interested parties to learn more about local water usage, water quality and sustainability. https://ndwater.org/nd-water-education-foundation/

b) Soil Conservation District sponsored multi-day workshops/summits that bring in speakers on a wide range of ecological topics and include participant involved learning.

c) Soil Conservation District sponsored field day demonstrations.

d) North Dakota State University and NDDEQ sponsored “Leadership Academy”, which focuses on watershed restoration and resource conservation activities.

e) NDDEQ annually sponsored “Water Quality Certification” workshop. Participants use a hands-on approach to better understand water quality sampling procedures and techniques.

f) River Keepers annually sponsored river educational activities. Activities include canoeing, excursions and fishing. All events are designed with an educational theme and include participant involvement. https://www.riverkeepers.org/

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for the listed segments of the Little Missouri River and a request for comment will be mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy are as follows:

- Golden Valley County Soil Conservation District;
- Slope-Hettinger County Soil Conservation District;
- Bowman-Slope County Soil Conservation District;
- Maah Daah Hey Trail Association;
- U.S. Forest Service; Dakota Prairie National Grasslands;
- Natural Resource Conservation Service (State Office);
- U.S. Environmental Protection Agency, Region VIII

In addition to mailing copies of this TMDL report to interested parties, the TMDL will be posted on the North Dakota Department of Environmental Quality web site at https://deq.nd.gov/WQ/3_Watershed_Mgmt/2_TMDLS/TMDLs_Comments.aspx.

A 30-day public notice soliciting comment and participation will also be published in the Bismarck Tribune Newspaper.

10.0 FUTURE MONITORING

As stated previously, it should be noted that the TMDL loads, load allocations, and the MOS are estimated based on available data and reasonable assumptions and are to be used as a guide for implementation. The actual reduction needed to meet the applicable water quality standards may be higher or lower depending on the results of future monitoring.

Monitoring of the listed segment will continue through the means of the NDDEQ Ambient Stream Monitoring Network. The network includes over 30 designated sampling sites located throughout the state of North Dakota. Surface water samples are taken 8 times per year for the following variables: total suspended solids, dissolved oxygen, nitrates, phosphorus and E. Coli Bacteria. E. Coli Bacteria data will continue to be collected at NDDEQ monitoring site 380022 for the indefinite future. Future data will be compared to current TMDL levels to determine progress towards E. Coli Bacteria reduction and TMDL compliance.

With the assistance of Soil Conservation Districts and local partners, Watershed Restoration Plans (e.g. Section 319 Project) for the Little Missouri River watershed will be sought after in the future. Section 319 Projects typically provide funding for additional sampling sites within the watershed and listed segment. With additional sampling sites, comes better monitoring and data collection.

Currently, there are no Section 319 Projects directly addressing the Little Missouri River; however, there is an approved TMDL for Deep Creek, which confluences with the Little Missouri River downstream of this TMDL section. This TMDL report can be used in conjunction with future monitoring to gain better insights in E. Coli Bacteria loading amounts and sources.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA EQIP), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a Project Implementation Plan (PIP) is developed in accordance with the TMDL and submitted to the North Dakota Nonpoint Source Pollution Task Force and EPA for approval. The implementation of the BMPs contained in the NPS PIP is voluntary. Therefore, success of any TMDL implementation project is ultimately dependent on the ability of the local project sponsor to find cooperating producers.

Monitoring is important and a required component of any PIP. As a part of the PIP, data is collected to monitor and track the effects of BMP implementation as well as to judge overall project success. Quality Assurance Project Plans (QAPPs) detail the strategy of how, when and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data is gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

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Practice Specification 528 (Prescribed Grazing)
Practice Specification 393 (Filter Strip)
Practice Specification 313 (Waste Storage Facility)
Practice Specification 362 (Diversion)
Practice Specification 587 (Structure for Water Control)
Practice Specification 382 (Fence)
Practice Specification 472 (Access Control)
Practice Specification 380 (Cover Crop)
Practice Specification 601 (Vegetative Barrier)

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Appendix A
E. Coli Bacteria Data Collected for
NDDEQ monitoring site 380022 from 2001-2018

NDDEQ Monitoring site 380022 on Little Missouri River near the City of Medora, ND

	MAY		JUNE		JULY		AUGUST		SEPTEMBER	
	08-May-01	20	19-Jun-01	240	19-Jul-04	200	04-Aug-03	1600	11-Sep-01	50
	21-May-02	10	25-Jun-03	240	17-Jul-07	20	08-Aug-05	40	04-Sep-02	30
	15-May-03	5	14-Jun-04	230	14-Jul-09	420	08-Aug-06	60	15-Sep-03	1600
	03-May-04	20	27-Jun-05	240	06-Jul-11	5	20-Aug-07	560	19-Sep-05	5
	16-May-05	200	26-Jun-06	40	09-Jul-13	390	11-Aug-08	70	18-Sep-06	230
	17-May-06	30	12-Jun-07	200	07-Jul-14	920	24-Aug-09	50	22-Sep-08	40
	08-May-07	2000	30-Jun-08	10	21-Jul-15	10	03-Aug-10	160	13-Sep-10	2200
	19-May-08	10	03-Jun-09	10	25-Jul-16	80	16-Aug-11	50	28-Sep-11	5
	12-May-10	310	22-Jun-10	1600	19-Jul-17	720	08-Aug-12	10	18-Sep-12	20
	16-May-12	70	26-Jun-12	140	17-Jul-18	41	13-Aug-13	1300		
	07-May-13	90	11-Jun-13	150			12-Aug-14	1600		
	21-May-13	1600	10-Jun-14	410			25-Aug-15	8000		
	13-May-14	70	09-Jun-15	100			22-Aug-16	50		
	12-May-15	40	08-Jun-16	700			14-Aug-17	1600		
	17-May-16	130	14-Jun-17	110			21-Aug-18	150		
	15-May-17	360	05-Jun-18	430						
	01-May-18	52								
	22-May-18	180								
N		18		16		10		15		9
GeoMean		77		155		97		218		66
% > 409		11		25		30		40		22
Recreation Use Assemesment		FSbT		NS		FSbT		NS		FSbT

Legend

FSbt = Fully Supporting but Threatened
NS = Non-Supporting
FS = Fully Supporting

Results are reported in Colony Forming Units (CFU) per 100 milliliters

Cells highlighted in Green is the threshold value of the lower detection limit (i.e., non-detect)
These results get assigned a value of 5
Cells highlighted in Yellow is the threshold value of the upper detection limit (i.e., detection is too high to count)
These results get assigned a value of 1600

Appendix B
Flow Interval for FDC and LDC Analysis
For NDDEQ Sampling Site 380022

All E. Coli Samples above the 126 cfu / 100 mL standard

High Flow

	PercentRank	PercentRank				**Slope**	-4.51			
High	>0	<0.15				**Intercept**	6.49			
	PercentRank	PercentRank				**X**	**Y**			
Moist	>0.15	<0.4				0.00%	3062892			
	PercentRank	PercentRank				15.00%	645765			
Dry	>0.4	<0.75				**Median**	**Existing Load/day**	**TMDL Load/day**	**Days**	
	PercentRank	PercentRank				7.50%	1406382	336442	55	
Low	>0.75	<0.99								

Date	C	Q	PercentRank	Load(CFUx10^7/Day)
19-Jun-01	240	2000	4.5%	1174511
25-Jun-03	240	114	36.9%	66947
04-Aug-03	1600	1.3	96.9%	5090
15-Sep-03	1600	318	20.1%	1244982
14-Jun-04	230	42.4	61.2%	23862
19-Jul-04	200	56.7	53.9%	27748
16-May-05	200	2580	3.4%	1262600
27-Jun-05	240	125	34.6%	73407
18-Sep-06	230	19	77.2%	10693
04-Apr-07	190	527	13.6%	245008
08-May-07	2000	601	12.1%	2941172
12-Jun-07	200	2490	3.6%	1218556
20-Aug-07	560	59.6	53.0%	81668
14-Jul-09	420	297	21.0%	305226
07-Oct-09	6200	202	26.2%	3064496
12-May-10	310	2070	4.4%	1570175
22-Jun-10	1600	1360	6.4%	5324452
03-Aug-10	160	154	30.6%	60292
13-Sep-10	2200	113	37.0%	608299
26-Jun-12	140	32.1	66.2%	10996
21-May-13	1600	2080	4.4%	8143279
11-Jun-13	150	1350	6.4%	495497
09-Jul-13	390	278	22.0%	265293
13-Aug-13	1300	250	23.3%	795242
10-Jun-14	410	745	10.2%	747405
07-Jul-14	920	1030	7.9%	2318681
12-Aug-14	1600	195	26.7%	763432
25-Aug-15	8000	122	35.3%	2388173
17-May-16	130	157	30.1%	49941
08-Jun-16	700	61.3	52.4%	104996
15-May-17	360	157	30.1%	138299
19-Jul-17	720	31.9	66.4%	56200
14-Aug-17	1600	45.6	59.8%	178526
22-May-18	180	230	24.4%	101302
05-Jun-18	430	211	25.6%	222007
21-Aug-18	150	44.2	60.4%	16223

Date	C	Q	PercentRank	Load(CFUx10^7/Day)
19-Jun-01	240	2000	4.5%	1174511
16-May-05	200	2580	3.4%	1262600
04-Apr-07	190	527	13.6%	245008
08-May-07	2000	601	12.1%	2941172
12-Jun-07	200	2490	3.6%	1218556
12-May-10	310	2070	4.4%	1570175
22-Jun-10	1600	1360	6.4%	5324452
21-May-13	1600	2080	4.4%	8143279
11-Jun-13	150	1350	6.4%	495497
10-Jun-14	410	745	10.2%	747405
07-Jul-14	920	1030	7.9%	2318681

Moist Conditions

Slope	-2.49			
Intercept	6.18			
X	**Y**			
15.00%	635702			
40.00%	151712			
Median	**Existing Load/day**	**TMDL Load/day**	**Days**	
27.50%	310554	56421	91	

Date	C	Q	PercentRank	Load(CFUx10^7/Day)
25-Jun-03	240	114	36.9%	66947
15-Sep-03	1600	318	20.1%	1244982
27-Jun-05	240	125	34.6%	73407
14-Jul-09	420	297	21.0%	305226
07-Oct-09	6200	202	26.2%	3064496
03-Aug-10	160	154	30.6%	60292
13-Sep-10	2200	113	37.0%	608299
09-Jul-13	390	278	22.0%	265293
13-Aug-13	1300	250	23.3%	795242
12-Aug-14	1600	195	26.7%	763432
25-Aug-15	8000	122	35.3%	2388173
17-May-16	130	157	30.1%	49941
15-May-17	360	157	30.1%	138299
22-May-18	180	230	24.4%	101302
05-Jun-18	430	211	25.6%	222007

Dry Conditions

Slope	-3.33			
Intercept	6.60			
X	**Y**			
40.00%	183965			
75.00%	12527			
Median	**Existing Load/day**	**TMDL Load/day**	**Days**	
57.50%	48006	15477	128	

Date	C	Q	PercentRank	Load(CFUx10^7/Day)
14-Jun-04	230	42.4	61.2%	23862
19-Jul-04	200	56.7	53.9%	27748
20-Aug-07	560	59.6	53.0%	81668
26-Jun-12	140	32.1	66.2%	10996
08-Jun-16	700	61.3	52.4%	104996
19-Jul-17	720	31.9	66.4%	56200
14-Aug-17	1600	45.6	59.8%	178526
21-Aug-18	150	44.2	60.4%	16223

Low Flow

Slope	-1.64			
Intercept	5.29			
X	**Y**			
75.00%	11617			
99.00%	4702			
Median	**Existing Load/day**	**TMDL Load/day**	**Days**	
87.00%	7391	2772	88	

Date	C	Q	PercentRank	Load(CFUx10^7/Day)
04-Aug-03	1600	1.3	96.9%	5090
18-Sep-06	230	19	77.2%	10693

Appendix C
North Dakota Department of Environmental Quality, Division of Water Quality, NDPDES DMR Data for the City of Medora, North Dakota

Date Printed: 12/13/2018

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '1/13/2001' AND '12/12/2018' AND Discharge End BETWEEN '1/13/2001' AND '12/12/2018'

Environmental Interest: Medora City Of Permit: ND0022799
Discharge Point: 001 A Parameter: Drain MG

Disch	Discharge Dates		Treat		Concentration Data				Loading Data				No Di	
Type	Start	End	Struct	Duration	Min	Avg	Max	Units	Avg	Max	Units	No. Exc.	Code	Freq/Type
Effluent	5/1/2001	5/4/2001	Cell 2	4						1.764	MGAL	0		Monthly/Calculated
Effluent	7/24/2001	7/28/2001	Cell 4	5						0.98	MGAL	0		Monthly/Calculated
Effluent	7/24/2001	7/28/2001	Cell 5	5						0.718	MGAL	0		Monthly/Calculated
Effluent	4/10/2002	4/15/2002	Cell 1	6						3.593	MGAL	0		Monthly/Calculated
Effluent	4/10/2002	4/15/2002	Cell 3	6						2.156	MGAL	0		Monthly/Calculated
Effluent	4/10/2002	4/15/2002	Cell 4	6						0.98	MGAL	0		Monthly/Calculated
Effluent	4/10/2002	4/15/2002	Cell 5	6						0.718	MGAL	0		Monthly/Calculated
Effluent	9/12/2003	9/14/2003	Cell 4	2						0.735	MGAL	0		Monthly/Calculated
Effluent	9/12/2003	9/14/2003	Cell 5	2						0.539	MGAL	0		Monthly/Calculated
Effluent	3/18/2004	3/24/2004	Cell 1	6						3.593	MGAL	0		Monthly/Calculated
Effluent	3/18/2004	3/25/2004	Cell 3	7						2.156	MGAL	0		Monthly/Calculated
Effluent	3/18/2004	3/25/2004	Cell 4	7						2.45	MGAL	0		Monthly/Calculated
Effluent	3/18/2004	3/25/2004	Cell 5	7						1.796	MGAL	0		Monthly/Calculated
Effluent	4/11/2005	4/18/2005	Cell 1	8						0.449	MGAL	0		Monthly/Calculated
Effluent	4/20/2005	4/25/2005	Cell 4A	6						0.294	MGAL	0		Monthly/Calculated
Effluent	7/19/2005	7/26/2005	Cell 4A	8						0.196	MGAL	0		Monthly/Calculated
Effluent	10/13/2005	10/19/2005	Cell 4A	7						2.94	MGAL	0		Monthly/Calculated
Effluent	5/29/2009	6/3/2009	Cell 1	6						2.69	MGAL	0		Monthly/Calculated
Effluent	4/8/2010	4/15/2010	Cell 1	8						4.04	MGAL	0		Monthly/Calculated
Effluent	4/9/2010	4/16/2010	Cell 4A	8						2.45	MGAL	0		Monthly/Calculated
Effluent	10/4/2011	10/10/2011	Cell 1	7						5.39	MGAL	0		Monthly/Calculated
Effluent	10/10/2011	10/16/2011	Cell 1	7						2.94	MGAL	0		Monthly/Calculated
Effluent	3/21/2012	3/27/2012	Cell 1	7						6.288	MGAL	0		Monthly/Calculated
Effluent	3/30/2012	4/4/2012	Cell 4A	6						3.43	MGAL	0		Monthly/Calculated
Effluent	9/5/2012	9/11/2012	Cell 1	7						6.288	Mgal	0		Monthly/Calculated
Effluent	9/5/2012	9/11/2012	Cell 2	7						2.058	Mgal	0		Monthly/Calculated
Effluent	5/8/2013	5/14/2013	Cell 4A	7						2.94	Mgal	0		Monthly/Calculated

Date Printed: 12/13/2018

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '1/13/2001' AND '12/12/2018' AND Discharge End BETWEEN '1/13/2001' AND '12/12/2018'

Disch	Discharge Dates		Treat		Concentration Data				Loading Data				No Di	
Type	Start	End	Struct	Duration	Min	Avg	Max	Units	Avg	Max	Units	No. Exc.	Code	Freq/Type
Effluent	9/19/2013	9/23/2013	Cell 3	5						4.312	Mgal	0		Monthly/Calculated
Effluent	5/8/2014	5/14/2014	Cell 1	7						8.984	Mgal	0		Monthly/Calculated
Effluent	10/14/2014	10/20/2014	Cell 3	7						3.8	Mgal	0		Monthly/Calculated
Effluent	9/5/2015	9/10/2015	Cell 1	6						6.3	Mgal	0		Monthly/Calculated
Effluent	5/18/2017	5/31/2017	Cell 2	14						5.39	Mgal	0		Monthly/Calculated
Effluent	4/2/2018	4/6/2018	Cell 2	5						1.6	Mgal	0		Monthly/Calculated
Effluent	5/21/2018	5/23/2018	Cell 2	3						1.3	Mgal	0		Monthly/Calculated

Permit#	EI Name	Parameter	Start	End	Days	Lmax (MGD)	Daily Discharge in MGAL
ND0022799	Medora City Of	Drain MG	5/1/2001	5/4/2001	4	1.764	0.44
ND0022799	Medora City Of	Drain MG	7/24/2001	7/28/2001	5	0.98	0.20
ND0022799	Medora City Of	Drain MG	7/24/2001	7/28/2001	5	0.718	0.14
ND0022799	Medora City Of	Drain MG	9/12/2003	9/14/2003	2	0.735	0.37
ND0022799	Medora City Of	Drain MG	9/12/2003	9/14/2003	2	0.539	0.27
ND0022799	Medora City Of	Drain MG	3/18/2004	3/24/2004	6	3.593	0.60
ND0022799	Medora City Of	Drain MG	7/19/2005	7/26/2005	8	0.196	0.02
ND0022799	Medora City Of	Drain MG	10/13/2005	10/19/2005	7	2.94	0.42
ND0022799	Medora City Of	Drain MG	5/29/2009	6/3/2009	6	2.69	0.45
ND0022799	Medora City Of	Drain MG	9/5/2012	9/11/2012	7	6.288	0.90
ND0022799	Medora City Of	Drain MG	9/5/2012	9/11/2012	7	2.058	0.29
ND0022799	Medora City Of	Drain MG	5/8/2013	5/14/2013	7	2.94	0.42
ND0022799	Medora City Of	Drain MG	9/19/2013	9/23/2013	5	4.312	0.86
ND0022799	Medora City Of	Drain MG	5/8/2014	5/14/2014	7	8.984	1.28
ND0022799	Medora City Of	Drain MG	9/5/2015	9/10/2015	6	6.3	1.05
ND0022799	Medora City Of	Drain MG	5/18/2017	5/31/2017	14	5.39	0.39
ND0022799	Medora City Of	Drain MG	5/21/2018	5/23/2018	3	1.3	0.43
						Average	0.38

Table to Determine Average Discharge Amounts per Day -During the Recreational Period (May – September)

Date Printed: 12/13/2018

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '1/13/2001' AND '12/12/2018' AND Discharge End BETWEEN '1/13/2001' AND '12/12/2018'

Environmental Interest: Medora City Of Permit: ND0022799
Discharge Point: 001 A Parameter: E Coli Geo Mean

Disch	Discharge Dates		Treat		Concentration Data				Loading Data			No Di		
Type	Start	End	Struct	Duration	Min	Avg	Max	Units	Avg	Max	Units	No. Exc.	Code	Freq/Type
Effluent	9/19/2013	9/23/2013	Cell 3	5								0	9	/
Effluent	5/8/2014	5/14/2014	Cell 1	7				Num/100 mL				2		Weekly/Grab
Effluent	10/14/2014	10/20/2014	Cell 3	7	3	3	3	Num/100 mL				0		Weekly/Grab
Effluent	9/5/2015	9/10/2015	Cell 1	6	21	21	21	Num/100 mL				0		Weekly/Grab
Effluent	5/18/2017	5/31/2017	Cell 2	14	3	32	61	Num/100 mL				0		Weekly/Grab
Effluent	4/2/2018	4/6/2018	Cell 2	5								0	E	/
Effluent	5/21/2018	5/23/2018	Cell 2	3	1	1	1	Num/100 mL				0		Weekly/Grab

Appendix D
North Dakota Department of Environmental Quality, Division of Water Quality, DMR Data for The Burning Hills Amphitheater, WWTP

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/16/2018' AND '7/16/2018'

facilityName	permitNumber	DischargePoint	dischargeStart	ParameterCode	meterMin	meterMax	meterAvg	ConcentrationUnits	LoadAvg	LoadMax	LoadUnits
Burning Hills Ampitheater WWTP	NDG426905	1	7/16/2018	Drain MG	NULL	NULL	NULL	Num/100 mL	NULL	NULL	
Burning Hills Ampitheater WWTP	NDG426905	1	7/16/2018	E Coli	35.5	2420	NULL		NULL	NULL	MGAL