E. coli Bacteria TMDL for the Knife River in Dunn and Mercer Counties, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

The Knife River watershed is a 1,450,035 acre watershed in Mercer and portions of Morton, Oliver, and Dunn Counties in southwest North Dakota (Figure 1). For the purposes of this TMDL, the impaired segments are located in Dunn and Mercer Counties and comprise approximately 89.3 miles in length. The Knife River impaired segments lie within the Missouri Plateau (43a) and River Breaks (43c) level IV ecoregions.

Table 1. General Characteristics of the Knife River Watershed.

Legal Name	Knife River
Stream Classification	Class II
Major Drainage Basin	Missouri River
8-Digit Hydrologic Unit	10130201
Counties	Dunn and Mercer Counties
Level IV Ecoregions	Missouri Plateau (43a) and River Breaks (43c)
Watershed Area (acres)	1,450,035

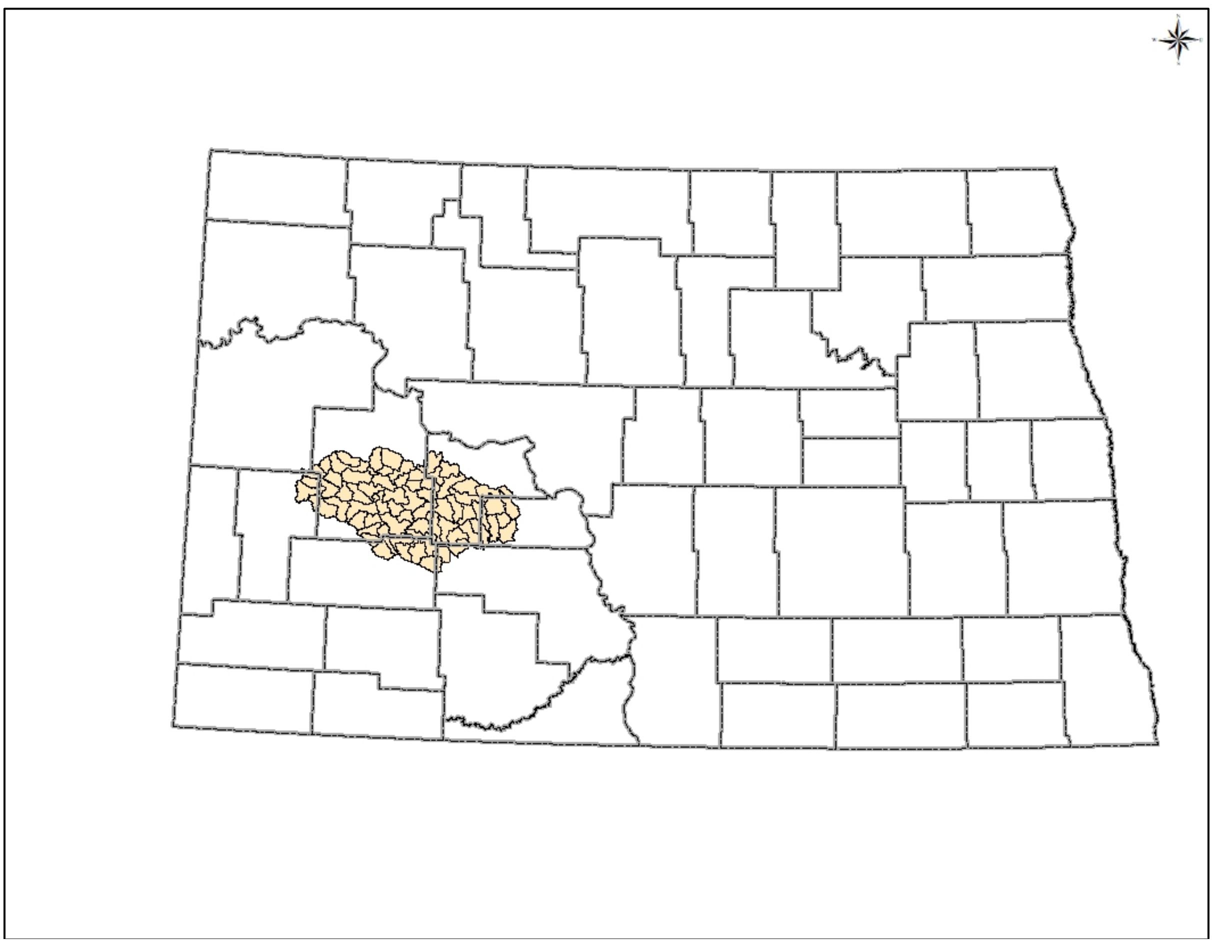


Figure 1. Knife River Watershed in North Dakota.

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2014 Section 303(d) List of Waters Needing TMDLs (NDDoH, 2014), the North Dakota Department of Health has identified a 36.06 mile segment (ND-10130201-042-S_00) of the Knife River from its confluence with Branch Knife River downstream to its confluence with Coyote Creek as not supporting for recreational uses, a 14.7 mile segment (ND-10130201-035-S_00) of the Knife River from its confluence with Coyote Creek downstream to its confluence with Spring Creek as fully supporting but threatened for recreational uses, a 17.94 mile segment (ND-10130201-003-S_00) of the Knife River from its confluence with Spring Creek downstream to its confluence with Antelope Creek as not supporting for recreational uses. The pollutant of concern is E. coli bacteria (Tables 2-4 and Figure 2).

Table 2. Knife River Section 303(d) Listing Information for Assessment Unit ID ND-10130201-042-S_00 (NDDoH, 2014).

Assessment Unit ID	ND-10130201-042-S_00
Waterbody Description	Knife River from its confluence with Branch Knife River downstream to its confluence with Coyote Creek. Located in Dunn and Mercer Counties.
Size	36.06 miles
Designated Use	Recreation
Use Support	Not Supporting
Impairment	E. coli Bacteria
TMDL Priority	High

Table 3. Knife River Section 303(d) Listing Information for Assessment Unit ID ND-10130201-035-S_00 (NDDoH, 2014).

Assessment Unit ID	ND-10130201-035 -S_00
Waterbody Description	Knife River from its confluence with Coyote Creek downstream to its confluence with Spring Creek. Located in Mercer County.
Size	14.7 miles
Designated Use	Recreation
Use Support	Fully Supporting but Threatened
Impairment	E. coli Bacteria
TMDL Priority	High

Table 4. Knife River Section 303(d) Listing Information for Assessment Unit ID ND-10130201-003-S_00 (NDDoH, 2014).

Assessment Unit ID	ND-10130201-003-S_00
Waterbody Description	Knife River from its confluence with Spring Creek downstream to its confluence with Antelope Creek. Located in Mercer County.
Size	17.94 miles
Designated Use	Recreation
Use Support	Not Supporting
Impairment	E. coli Bacteria
TMDL Priority	High

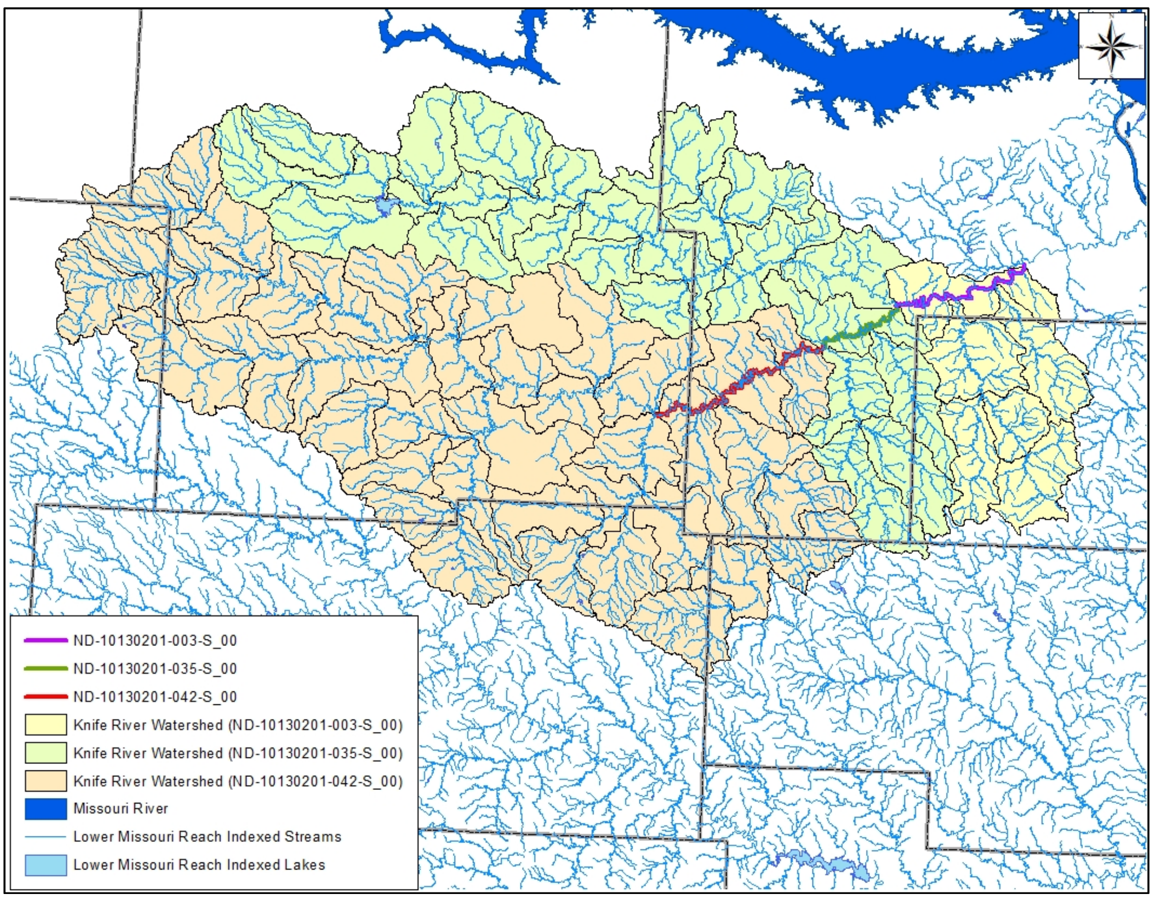


Figure 2. Knife River TMDL Listed Segments.

1.2 Ecoregions

The impaired reaches of the Knife River watershed lie within the Missouri Plateau (43a) and River Breaks (43c) level IV ecoregions and is characterized by rolling hills on the eastern side of the region and rough terrain, in the west, with large buttes, steep hills, and deep draws (USGS, 2006). Elevation ranges are from 1,670- feet (msl) where the Missouri River leaves the county to about 2,400-feet (msl) in the southwestern part of the county.

Soils vary greatly in different areas of the watershed and range from soft shale plains to extreme sand. The soils belong to the Orders Mollisols, Entisols, Aridisols, Vertisols, and Inceptisols. These soils are typically Cabba, Armor, Flasher, Vebar, Chama, and Zahl. A mosaic of small grains and grazing land covers the shortgrass prairie, but agriculture is limited by erratic precipitation patterns and limited opportunities for irrigation (USGS, 2006). Unique to Mercer County is the Knife River Flint used by the early Native Americans and early settlers.

Important artesian aquifers are located in the Fox Hills and Hell Creek formations of Late Cretaceous age and the Tongue River formations of Tertiary age. Most of the water used as domestic and livestock water for farms is derived from the lignite coal veins in Ft. Union shale.

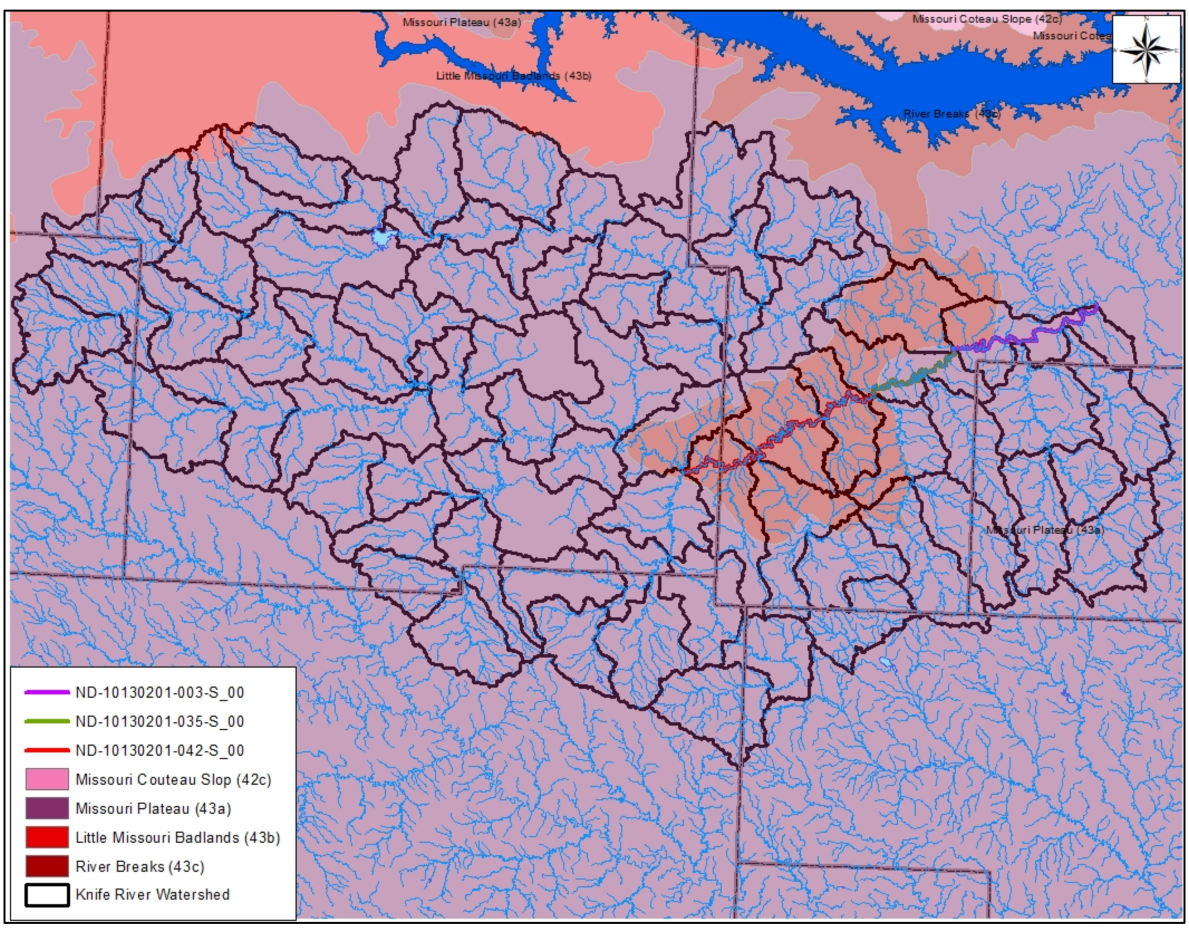


Figure 3. Level IV Ecoregions in the Knife River and TMDL Listed Segments.

1.3 Land Use

The dominant land use in the Knife River watershed is grasslands. According to the 2016 National Agricultural Statistical Service (NASS, 2016) land survey data, approximately 66 percent of the land is native and non-native grasslands, 27 percent is cropland including alfalfa or tilled acres, and seven percent includes wetlands, water, woods, and bare/roads/development. The majority of the crops grown consists of spring wheat, corn, sunflower, and hay other than alfalfa (Figure 4).

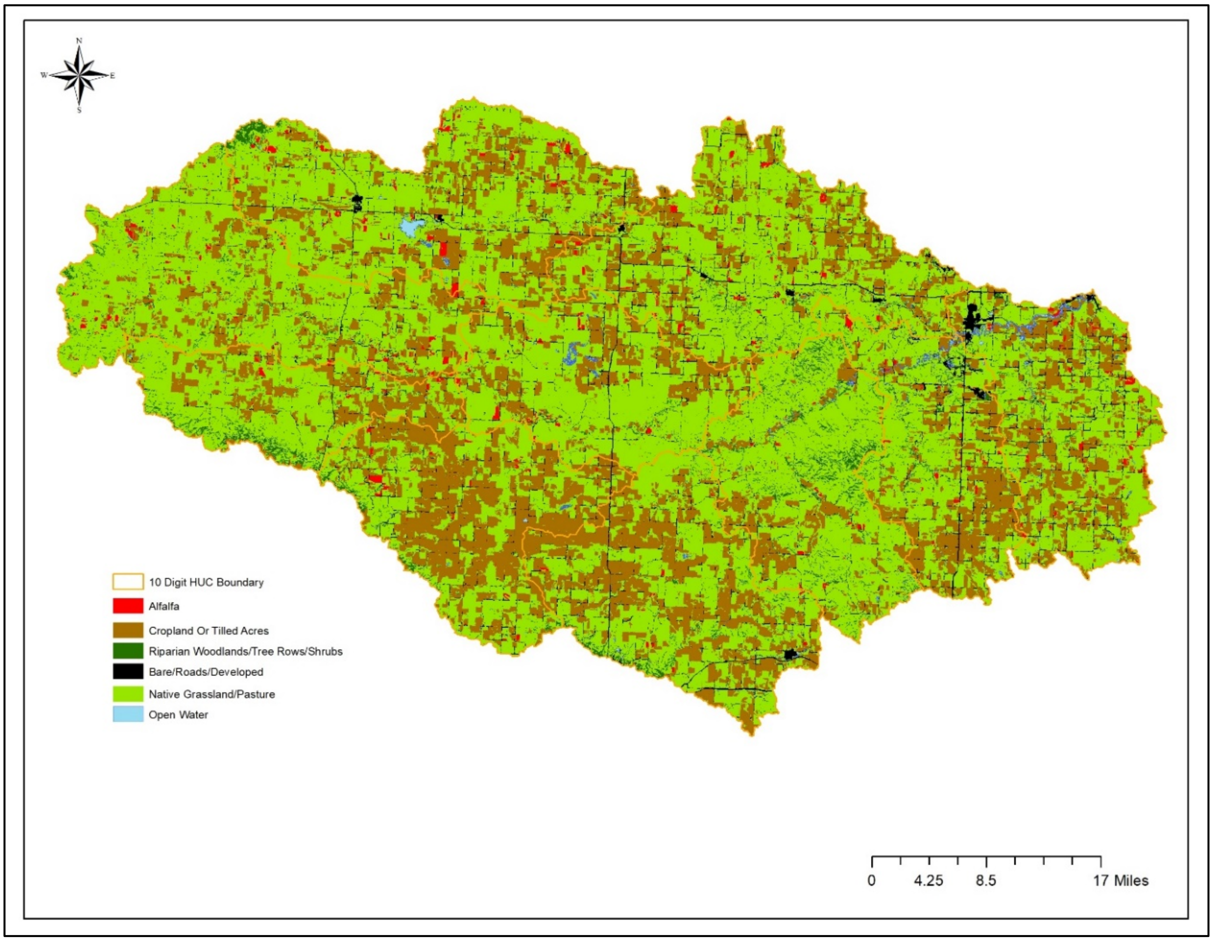


Figure 4. Land Use in the Knife River Watersheds (NASS, 2016).

1.4 Climate and Precipitation

Figures 5 and 6 show the monthly precipitation and average temperature for the Hazen, ND (Mercer County) North Dakota Agriculture Weather Network (NDAWN) station from 1994-2016. Mercer County has a subhumid climate characterized by warm summers with frequent hot days and occasional cool days. Average temperatures range from 17º F in winter to 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 17 inches.

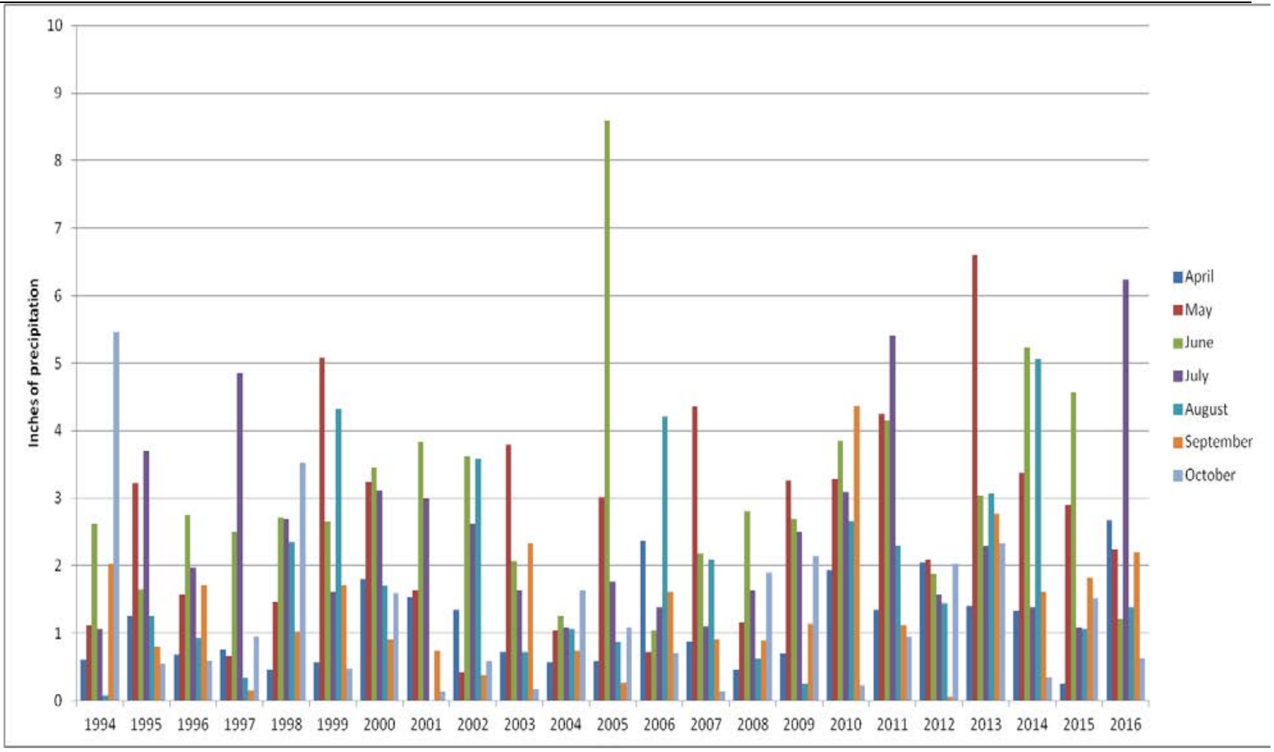


Figure 5. Monthly Precipitation at Hazen, North Dakota from 1994-2016. North Dakota Agricultural Weather Network (NDAWN).

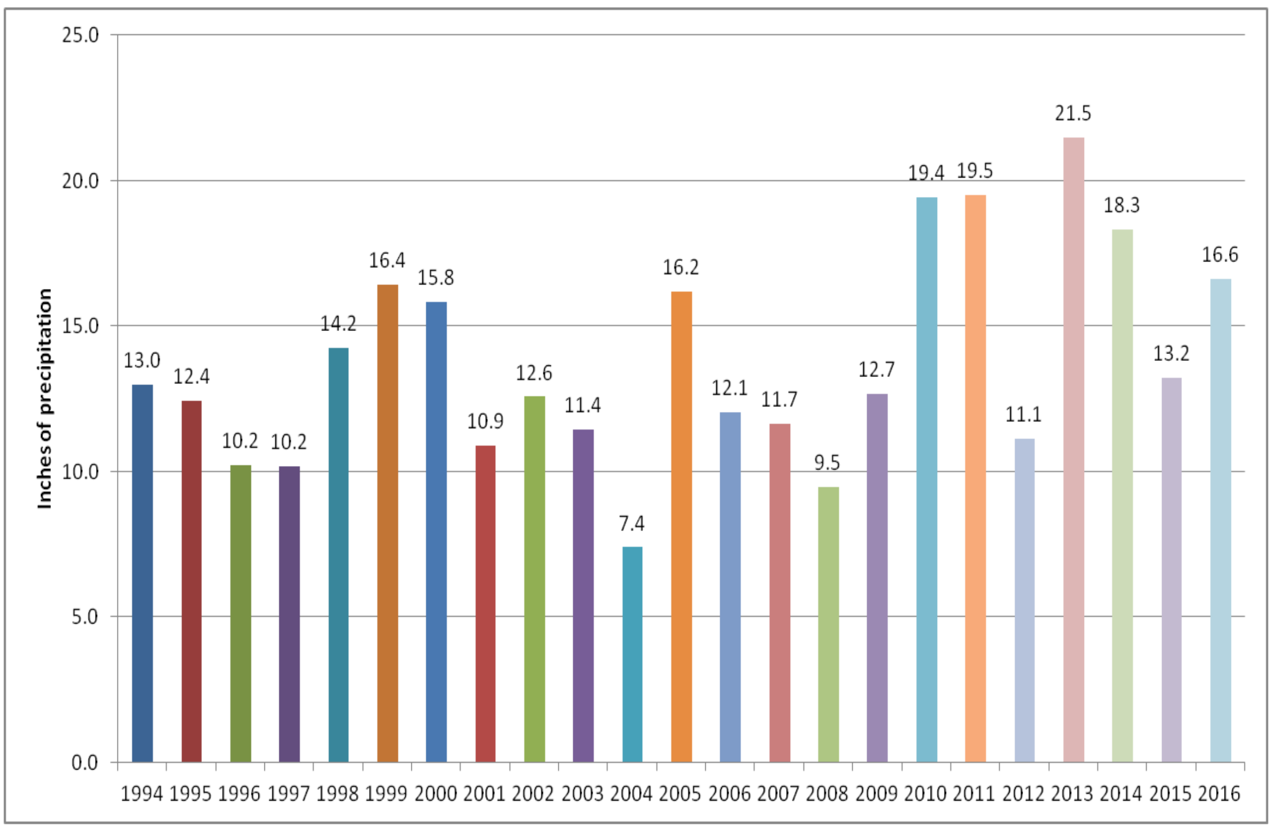


Figure 6. Annual Average Precipitation at Hazen, North Dakota from 1994-2016. North Dakota Agricultural Weather Network (NDAWN).

1.5 Available Data

1.5.1 E. coli Bacteria Data

E. coli bacteria samples were collected at four locations corresponding with each of the three impaired reaches addressed in this TMDL (Figure 7). Monitoring site 384131 is located in Mercer County near Golden Valley and is associated with assessment unit ND-10130201-042-S_00. Monitoring site 385452 is located south of Zap, North Dakota on County Road 13 and is associated with ND-10130201-035-S_00. Monitoring site 380087 is located on Knife River at Hazen, ND and is associated with assessment unit ND-10130201-003-S_00. All sites except (380087 and 384131) were monitored weekly or when flow conditions were present during the recreation season (May 1-September 30). Moniutoring sites 380087 and 384131 are part of the NDDoH Ambient Water Quality Network and are sampled on a monthly basis. Each monitoring station was sampled by the NDDoH or the Mercer County Soil Conservation District.

Tables 6-8 provide a summary of E. coli geometric mean concentrations, the percentage of samples exceeding 409 CFU/100mL for each month and the recreational use assessment by month. The geometric mean E. coli bacteria concentration and the percent of samples over 409 CFU/100ml were calculated for each month (May 1- September 30) using those samples collected during each month from 2001 through 2016 (384131 and 380087) and 2008 through 2009 for site 385452.

Table 5. Summary of E. coli Bacteria Data for Site 384131 Data Collected in 2001 - 2016.

Month	N	Geometric Mean Concentration (CFU/100mL)	Percentage of Samples Exceeding 409 CFU/100mL	Recreational Use Assessment
May	25	55	17%	Fully Supporting but Threatened
June	22	211	29%	Not Supporting
July	19	203	44%	Not Supporting
August	21	31	0%	Fully Supporting
September	17	35	12%	Fully Supporting but Threatened

Table 6. Summary of E. coli Bacteria Data for Site 385452 Data Collected in 2008 and 2009.

Month	N	Geometric Mean Concentration (CFU/100mL)	Percentage of Samples Exceeding 409 CFU/100mL	Recreational Use Assessment
May	9	45	22%	Fully Supporting but Threatened
June	9	111	11%	Fully Supporting but Threatened
July	9	240	33%	Not Supporting
August	9	127	11%	Not Supporting
September	9	98	11%	Fully Supporting but Threatened

Table 7. Summary of E. coli Bacteria Data for Sites 380087 Data Collected in 2001-2016.

Month	N	Geometric Mean Concentration (CFU/100mL)	Percentage of Samples Exceeding 409 CFU/100mL	Recreational Use Assessment
May	15	107	13%	Fully Supporting but Threatened
June	14	293	36%	Not Supporting
July	11	151	27%	Not Supporting
August	13	90	0%	Fully Supporting
September	10	96	10%	Fully Supporting

1.5.2 Hydraulic Discharge

The daily stream discharge record for water quality monitoring site 384131, corresponding to waterbody segment ND-10130201-042-S_00, was obtained from the United States Geological Survey (USGS) gauging station 06339500 located on Knife River near Golden Valley, ND (Figure 7). USGS station 06339500 has operated continuously since 1903 and is collocated with the North Dakota Department of Health (NDDoH) monitoring location 384131.

A daily stream discharge record was also developed for water quality monitoring site 380087, corresponding to waterbody segment ND-10130201-003-S_00, and was obtained from the USGS gauging station 06340500 located on the Knife River near Beulah, ND (Figure 7). USGS station 06340500 has operated continuously since 1929 and is collocated with NDDoH monitoring location 380087.

A discharge record was constructed for site 385452, corresponding to waterbody segment ND-10130201-035-S_00 using the Drainage Area Ratio Method (Ries et al., 2000 and Emerson et al., 2005) and the historical discharge measurements collected by the USGS at gauging station 06339500 from 2001 to 2016.

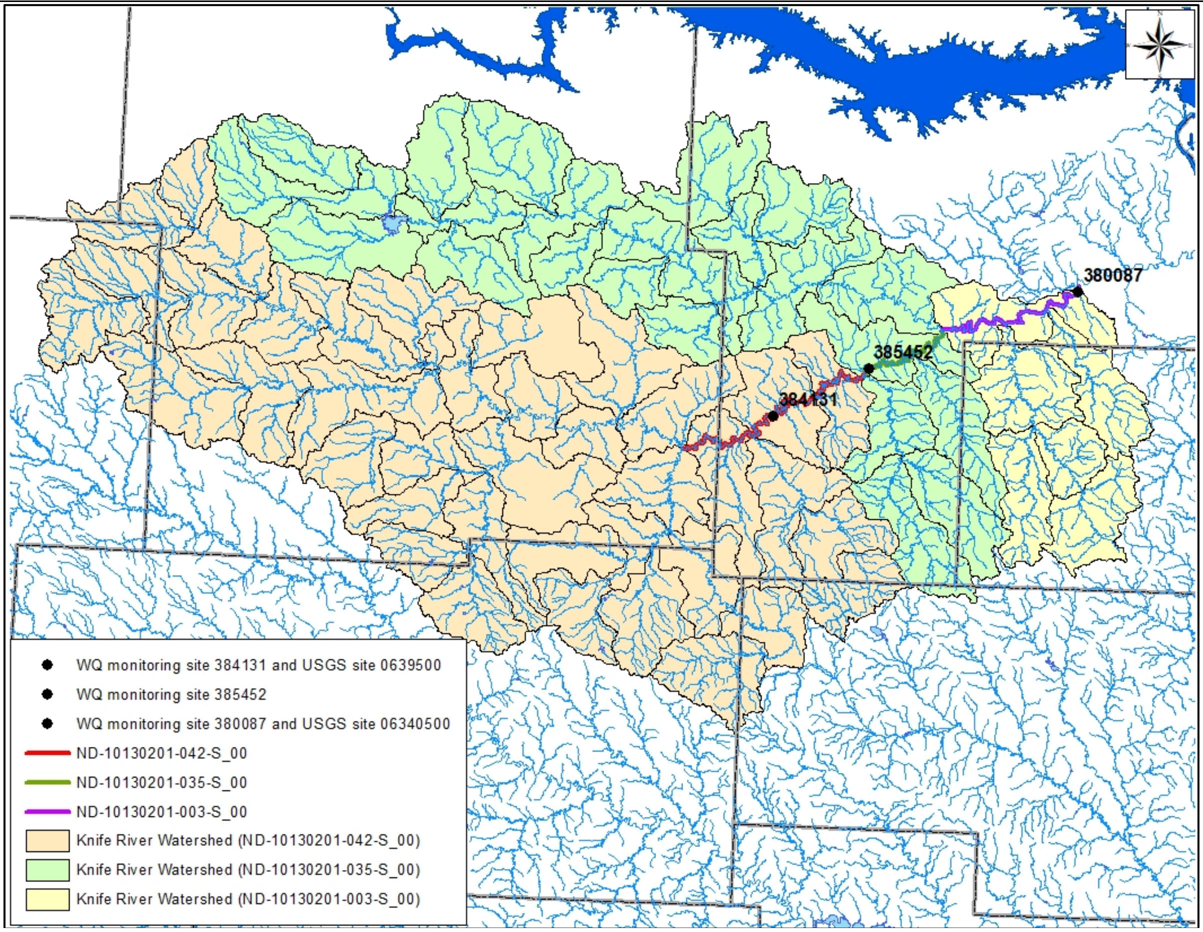


Figure 7. E. coli Bacteria Sample Sites and USGS Gaging Stations on the TMDL Listed Segments of the Knife River.

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 wasteload 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 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. Separate TMDLs are required to address each pollutant or cause of impairment, which in this case E. coli bacteria.

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters in the State. The narrative general water quality standards are listed below (NDDoH, 2014).

- 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 NDDoH has set 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” (NDDoH, 2014).

2.2 Numeric Water Quality Standards

The Knife River is a Class II stream. The NDDoH definition of a Class II stream is shown below (NDDoH, 2014).

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 9 provides a summary of the current numeric E. coli criteria which applies to all streams. The E. coli bacteria standard applies only during the recreation season of May 1 to September 30.

Table 9. North Dakota 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.

2.3 Antidegradation Policy

A third element called antidegradation is included in the water quality standards. Antidegradation policy and procedures have been established by NDDoH as necessary in the protection of waterbodies where their current water quality conditions are better than applicable standards. This was created to intentionally maintain these particular water resources at their high quality, above the level of water quality standards currently in place. This Policy is for activities such as Section 401, 402 and 404 of the Clean Water Act. (NDDoH, 2014).

The antidegradation implementation procedure delineates the process that will be followed by the North Dakota State Department of Health for implementing the antidegradation policy found in the Standards of Water Quality for the State of North Dakota, Rule 33-16-02.

Under this implementation procedure, all waters of the state are afforded one of three different levels of antidegradation protection. All existing users, and the water quality necessary for those uses, shall be maintained and protected. Antidegradation requirements are necessary whenever a regulated activity is proposed that may have some effect on water quality. Regulated actions include permits issued under Section 402 (NDPDES) and 404 (Dredge and Fill) of the Clean Water Act (CWA), and any other activity requiring Section 401 water quality certification. Nonpoint sources of pollution are not included as part of the antidegradation requirements. When reviewing 404 nationwide permits, the department will issue 401 certifications only where it determines that the conditions imposed by such permits are expected to result in attainment of the applicable water quality standards, including the antidegradation requirements. However, it is anticipated that the department will exclude certain nationwide permits from the antidegradation procedures for Category1 waters on the basis that the category of activities covered by the permit is not expected to have significant permanent effects on the quality and beneficial uses of those waters, or the effects will be appropriately minimized and temporary.

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 Knife River, is based on the State water quality standard for E. coli bacteria.

3.1 Knife River Target Reductions in E. coli Bacteria Concentrations

The three reaches of the Knife River listed in this TMDL are impaired because of E. coli bacteria. Reach ND-10130201-035-S_00 is listed as fully supporting, but threatened for recreational beneficial uses, and reaches ND-10130201-042-S_00 and ND-10130201-003-S_00 are listed as not supporting for recreational beneficial uses, because of E. coli bacteria counts exceeding the North Dakota water quality standard.

The North Dakota water quality standard for E. coli bacteria is a geometric mean concentration of 126 CFU/100 mL during the recreation season of May 1 to September 30. Thus, the TMDL target for this report is 126 CFU/100 mL. In addition, no more than ten percent of samples collected for E. coli bacteria should exceed 409 CFU/100 mL.

While the standard is intended to be expressed as the 30-day geometric mean, the target is based on the 126 CFU/100 mL geometric mean standards. Expressing the target in this way will ensure the TMDL will result in both components of the standard being met and recreational uses are restored.

4.0 SIGNIFICANT SOURCES

4.1 Point Source Pollution Sources

Within the watersheds of the TMDL listed reaches of the Knife River there is one wastewater treatment system permitted through the North Dakota Pollutant Discharge

Elimination System (NDPDES) Program. It is located in Beulah, North Dakota. The system is allowed to discharge on an "as needed" basis (Appendix D). There is a limited amount of E. coli data available for this system during discharges. Therefore, wasteload allocations will be given to the facility as described later in Section 5.4.

It should be noted that the town of Hazen, North Dakota is located at the edge of the listed segment ND-10130201-003-S_00 watershed and also has a permitted wastewater treatment system but discharges into segment ND-10130201-002-S_00. This segment is not addressed in this TMDL, therefore the city of Hazen, ND will not be given a wasteload allocation for segment ND-10130201-003-S_00.

There are 14 medium (<1,000 cattle) and six small (<400 cattle) permitted animal feeding operations (AFOs) which allow zero discharge, and no confined feeding operations (CAFOs) within the watershed. Unpermitted animal feeding operations are also present in the Knife River watershed, but their number and location are unknown.

4.2 Nonpoint Source Pollution Sources

The TMDL listed segments which are the focus of this report are experiencing E. coli bacteria, and presumably E. coli bacteria, pollution from nonpoint sources in the watersheds.

Through the analysis of landuse data, water quality sample results, recreational use assessment and development of a load duration curve were used to determine potential nonpoint pollution sources in the Knife River watershed.

Landuse data indicates roughly 66 percent of the watershed is pasture/grassland acres which would indicate cattle production to be dominate economic activity within the Knife River watershed. Riparian and upland grazing of these acres are largely utilized in the spring and summer months of the year. During the fall the cattle are rotated into harvested cropland fields for aftermath grazing. In winter the cattle are relocated to a confined feeding area or a field close to home. Overwinter cattle are usually bale fed or silage fed or combination.

During the summer grazing period the riparian area is an economical source of water for the cattle herd. If intensive season long grazing occurs in these areas the biomass of the area can be significantly reduced and fecal matter can build up in these areas. When a summer rain event occurs the reduced biomass of the field cannot function properly to filter out fecal matter running off from the landscape and ultimately entering the stream. Fecal matter can also be directly deposited in the channel by wallowing cattle. These contributions can raise E. coli bacteria levels within the stream.

Observed data and recreational use assessment indicated that the primary months that E. coli bacteria levels were exceeding state water quality samples were from June through August which is prime grazing time in our state. Analysis of the load duration curves indicated that the three listed segments had the moist and dry condition and low flow regime with E. coli bacteria exceedences in common and followed the same monthly pattern as the observed data and recreational use assessment determined.

Aftermath grazing in the fall of the year allows for the cattle herd to utilize a valuable energy source to assist with the brutally cold winters that North Dakota is famous for having. This grazing activity also allows for a cheap nutrient source for the crop fields to utilize during next years' growing season.

Winter feeding of cattle is also utilized to help the herd survive the brutal winter and feed supplies can vary depending on the harshness of the winter. During this time manure is either left in place or collected in a pile to be spread on cropland or hayland the following spring or fall.

Manure application occurring in the fall on cropland within the watershed as a means of economical and nutrient dense fertilizer for the fields. This manure will then remain on the field until the following spring when it is incorporated into the soil before planting occurs.

A study by the University of Regina titled *Survival and Overland Transport of Fecal Coliform under Canadian Prairie Conditions* 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 the fecal bacteria entering into a stationary phase once deposited outside of the body until conditions or environments become favorable for growth and propagation. This is usually accomplished during spring runoff as the fecal matter are transported over frozen ground to local streams and rivers.

Load duration curve analysis of the listed reaches did indicate that two of the sites had exceedences of the state water quality standard for E. coli bacteria in the high flow regime which usually occurs in late April and May in the region. Stream flows are usually highest during these times because of the increased amount of snowmelt runoff from the surrounding area. E. coli bacteria exceedences in the high flow regime could also come from intense summer rainfall events which transport manure into the stream system.

Other potential nonpoint source pollution could include failing septic systems, wildlife, and unpermitted animal feeding operations (AFOs) and "hobby farms" with fewer than 100 animals.

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).

Wildlife may also 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

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) 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" methodology was used.

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. The following technical analysis addresses the E. coli bacteria reductions necessary to achieve the secondary water quality standards 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. These events are represented by runoff in the high flow regime. The medium flow regime is represented by runoff that contributes to the stream over a longer duration. The low flow regime is characteristic of drought or precipitation events of small magnitude and do not contribute to runoff.

Flows for TMDL segment ND-10130201-035-S_00 were determined by utilizing the Drainage-Area Ratio Method developed by the USGS (Ries et. al, 2000). The Drainage-Area Ratio Method assumes that the streamflow at the ungauged site is hydrologically similar (same per unit area) to the stream gauging station used as an index. This assumption is justified since the ungauged site (385452) is nested on the same reach as the index station (0639500).

Streamflow data for the index station (0639500) was obtained from the USGS Water Science Center website. The index station (06349500) streamflow data was then divided by the drainage area to determine streamflows per unit area at the index station. Those values are then multiplied by the drainage area for the ungauged site to obtain estimated flow statistics for the ungauged site.

Mean daily discharge for TMDL segments (ND-10130201-42-S_00 and ND-10130201-003-S_00) were developed using stage and discharge data obtained from USGS gauge station sites (06339500 and 06340500) which were collocated with sites 384131 and 380087 for years of 2001 to 2016.

5.2 Flow Duration Curve Analysis

The flow duration curve serves as the foundation for the load duration curve used in the TMDL. Flow duration curve analysis looks at the cumulative frequency of historic flow data over a specified time period. A flow duration curve 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 8). 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 100 to the lowest flows in the record (i.e., drought). Therefore, as depicted in Figure 8, a flow duration interval of twenty five (25) percent, associated with a stream flow of 36 cfs, implies that 25 percent of all observed mean daily discharge values equal or exceed 36 cfs.

Once the flow duration curve 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 8, the flow duration curve for site 384131, representing TMDL segment ND-10130201-042-S_00, was divided into four zones, one representing high flows (0-11 percent), moist conditions (11-30 percent), dry conditions (30-65 percent) and one for low flows (65-98 percent). Based on the flow duration curve analysis, no flow occurred 3 percent of the time (98-100 percent).

Similarly, as depicted in Figure 9, the flow duration curve for water quality site 385452, representing TMDL segment ND-10130201-35-S_00, was also divided into four zones, one representing high flows (0-7 percent), another for moist conditions (7-40 percent), dry conditions (40-80 percent), and one for low flows (80-98 percent). Based on the flow duration curve analysis, no flow (or zero flow) occurred 3 percent of the time (98-100 percent).

In Figure 10, the flow duration curve for water quality site 380087, representing TMDL segment ND-10130201-003-S_00, had flow zones signifying high flows (0-20 percent), another for moist conditions (20-55 percent), dry conditions (55-90 percent), and one for low flows (90-97 percent), while no flow (or zero flow) occurred 3 percent of the time (97-100 percent).

These flows intervals were defined by examining the range of flows for the site for the period of record and then by looking for natural breaks in the flow record based on the flow duration curve plot and data clusters derived from the load duration curve (Figures 8-10). Where possible breaks were adjusted to try and include E. coli bacteria observations above the criterion in every flow regime. In no case were flow regime breaks adjusted by more than five percent.

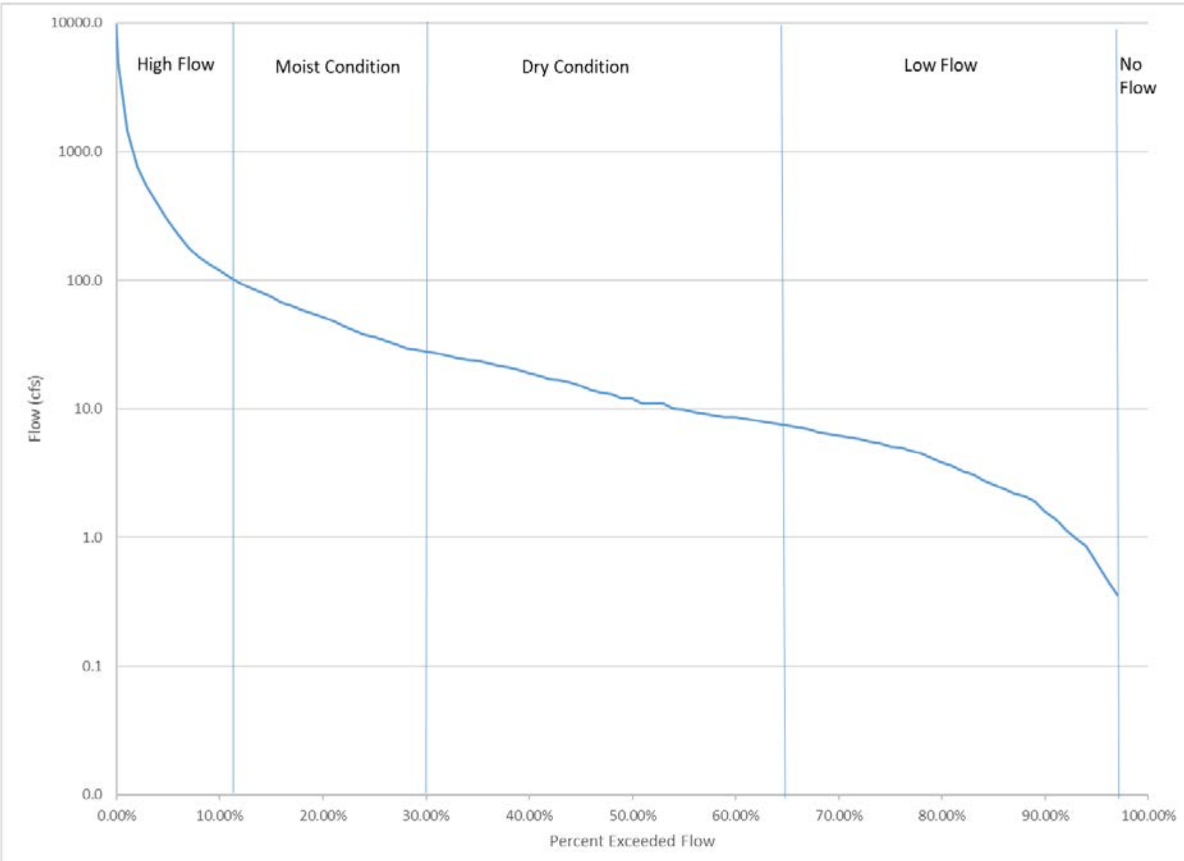


Figure 8. Flow Duration Curve for the Knife River Monitoring Station 384131; Located near Golden Valley, North Dakota.

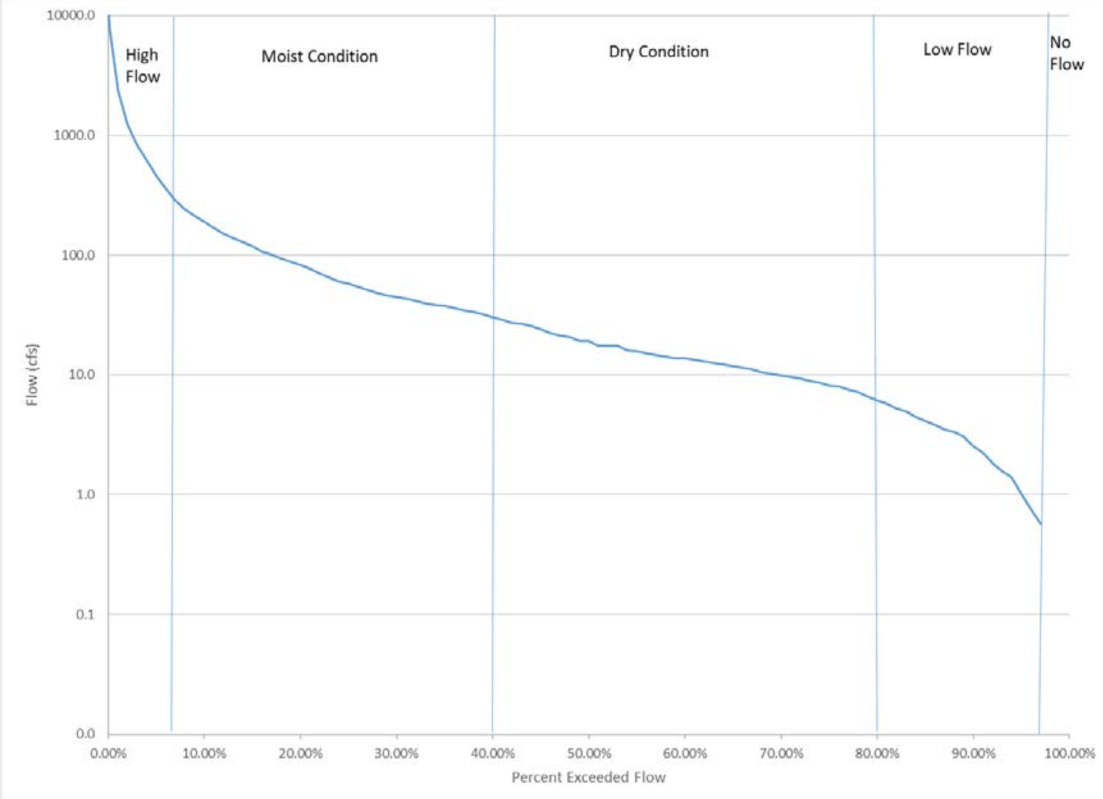


Figure 9. Flow Duration Curve for the Knife River Monitoring Station 385452; Located near Zap, North Dakota.

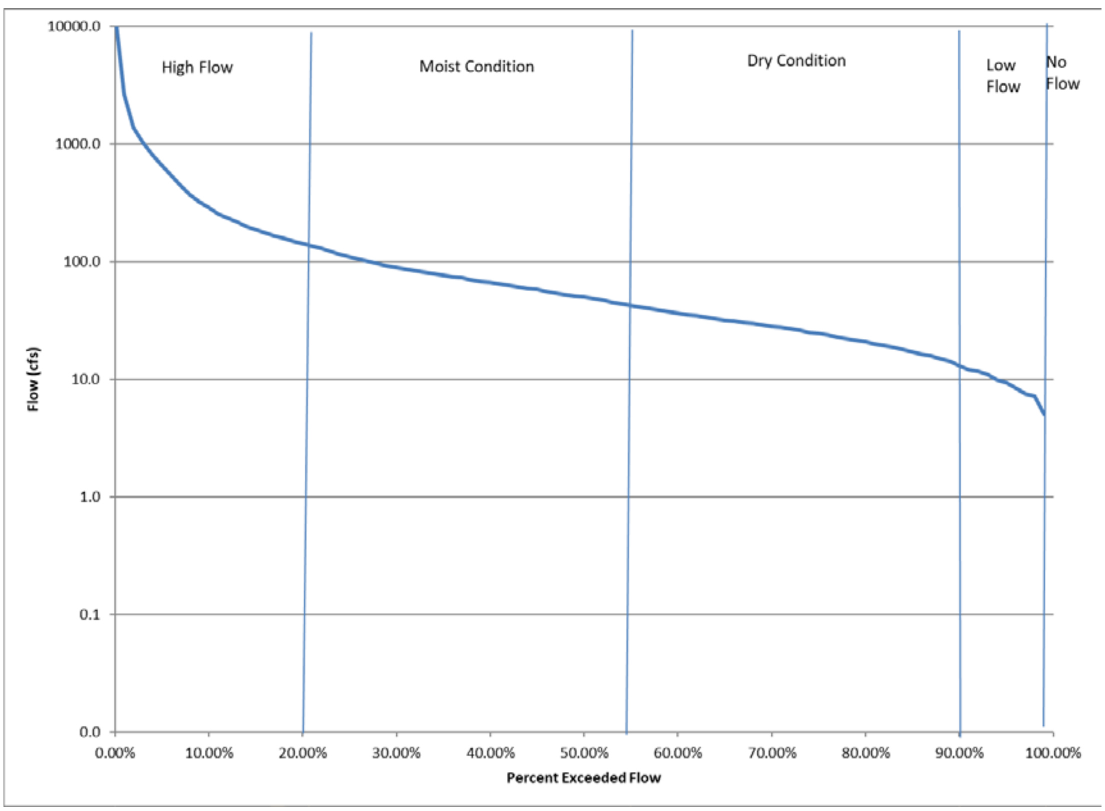


Figure 10. Flow Duration Curve for the Knife River Monitoring Station 380087; Located near Hazen, North Dakota.

5.3 Load Duration Analysis

An important factor in determining NPS pollution loads is variability in stream flows and loads associated with high and low flow. To better correlate the relationship between the pollutant of concern and the hydrology of the Section 303(d) TMDL listed segments, a load duration curve was developed for each of the Knife River TMDL listed segments. The load duration curves for the three TMDL listed reaches were 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 monitoring sites 385452 in 2008 to 2009 and 380087 and 384131 in 2001 to 2016 (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 exceeded of the flow on the day of sample collection (Figures 11, 12 and 13). Points plotted above the 126 CFU/100 mL target curve exceed the previous State water quality target. Points plotted below the curve are meeting the previous 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 the corresponding percent exceeded flow. The load duration curve for sites 384131, 385452, and 380087 depicting the regression relationship for each flow interval are provided in Figures 11, 12, and 13.

The regression lines for the high, moist and dry condition, and low flows for site 384131 were then used with the midpoint of the percent exceeded flow for that interval to calculate the existing E. coli bacteria load for that flow interval. For example, in Figure 11, the regression relationship between observed E. coli bacteria loading and percent exceeded flow for the high, moist and dry condition, and low flow interval are:

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 11 percent is 5.5 percent, the existing E. coli bacteria load is:

E. coli bacteria load (10^7 CFUs/day) = antilog (6.56 + (-14.88*0.055))
= 547,105 x 10^7 CFUs/day

Where the midpoint of the moist condition interval from 11 to 30 percent is 20.5 percent, the existing E. coli bacteria load is:

E. coli bacteria load (10^7 CFUs/day) = antilog (5.17 + (-2.80*0.205))
= 39,837 x 10^7 CFUs/day

Where the midpoint of the dry condition interval from 30 to 65 percent is 47.5 percent, the existing E. coli bacteria load is:

E. coli bacteria load (10^7 CFUs/day) = antilog (4.03+ (0.10*0.475))
= 11,820 x 10^7 CFUs/day

Where the midpoint of the low flow interval from 65 to 98 percent is 81.5 percent, the existing E. coli bacteria load is:

E. coli bacteria load (107 CFUs/day) = antilog (3.70+ (0.04*0.815))
= 5,339 x 107 CFUs/day

The midpoint for the flow intervals is also used to estimate the TMDL target load. In the case of the previous examples, the TMDL target load for the midpoints or 5.5, 20.5, 47.5 and 81.5 percent exceeded flow derived from the 126 CFU/100 mL TMDL target curves are 77,077 x 10^7 CFUs/day, 15,415 x 10^7 CFUs/day, 4,008 x 10^7 CFUs/day and 1,048 x 10^7 CFUs/day, respectively.

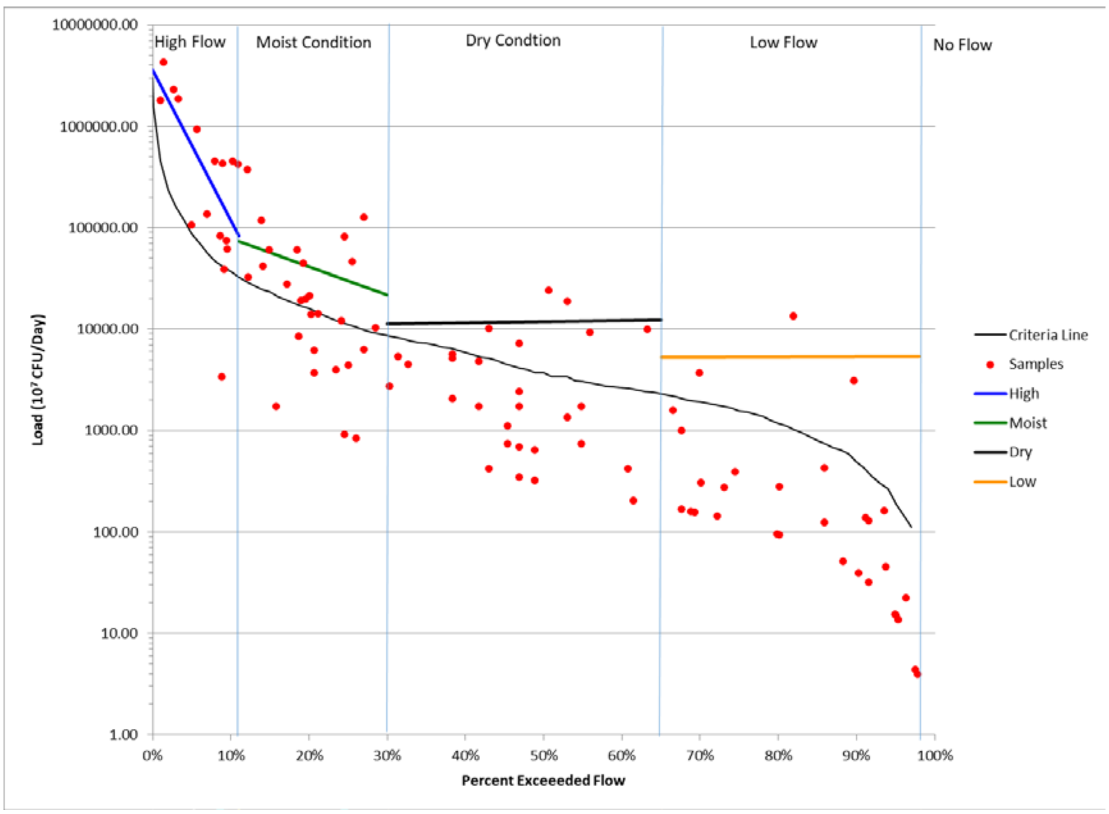


Figure 11. E. coli Bacteria Load Duration Curve for the Knife River Monitoring Station 384131. The curve reflects flows collected from 2001-2016.

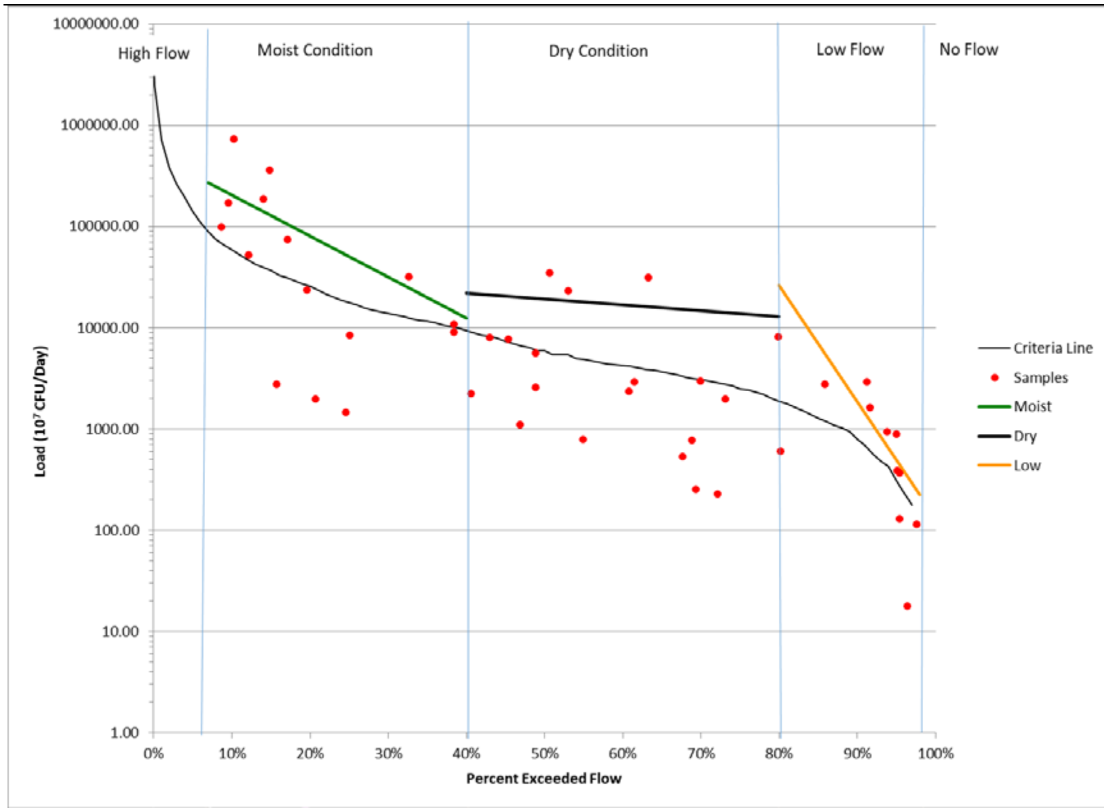


Figure 12. E. coli Bacteria Load Duration Curve for the Knife River Monitoring Station 385452. The curve reflects flows collected from 2001-2016.

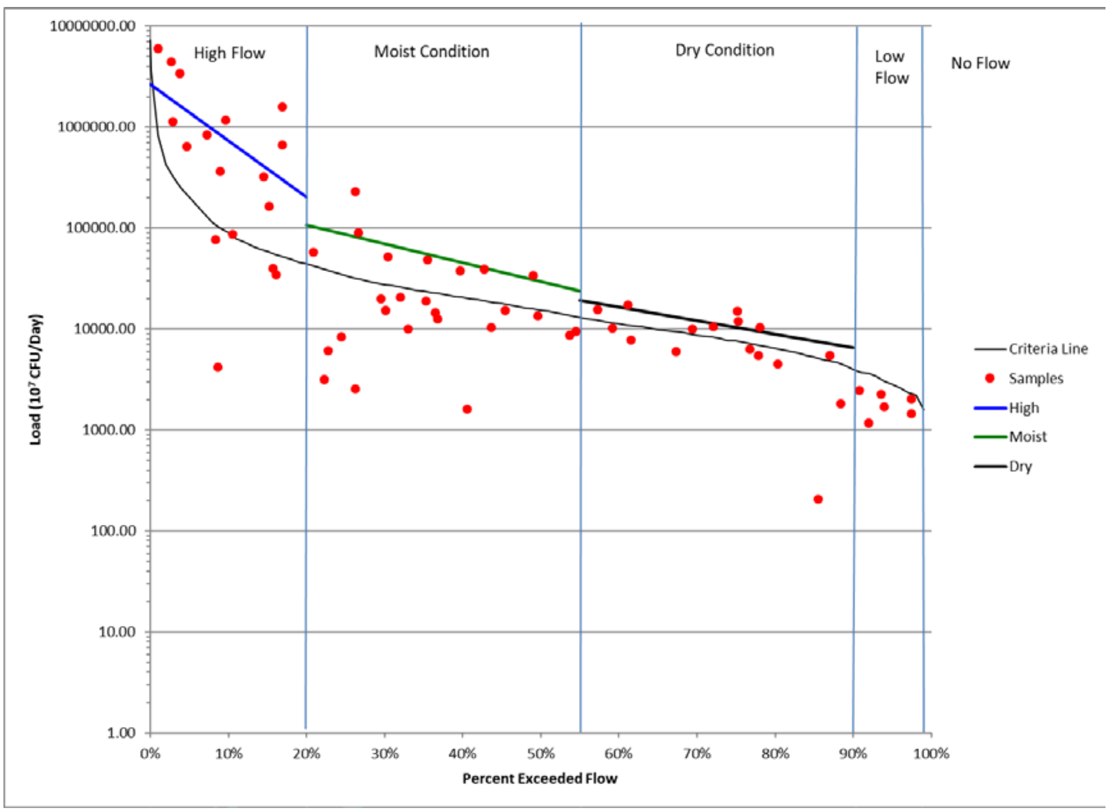


Figure 13. E. coli Bacteria Load Duration Curve for the Knife River Monitoring Station 380086. The curve reflects flows collected from 2001-2015.

5.4 Wasteload Allocation Analysis

Waste load allocation calculations for the city of Beulah, ND will be calculated based on the following criteria:

1) The maximum daily discharge will be used in wasteload allocation calculations. This value was chosen because it represents the highest discharge volume on record that the facility has produced and will allow for flexibility in bacterial loading, due to the variability of the facilities discharge volumes and durations.

2) Although E. coli bacteria data has been collected, the systems are assigned the water quality standards value of 126 CFU/100mL for this TMDL. This value was chosen both because it is the North Dakota water quality standard, and because those dischargers throughout the state that are required to sample for bacteria are assigned this same value in their permit.

It should also be noted that all of these facilities are allowed under their NDPDES permit to discharge on an “as needed” basis.

5.4.1 Beulah, ND Wastewater Treatment Systems

According to the NDPEDS permit the city of Beulah, ND, has two wastewater discharge points (Figure 2). These discharge points were identified in the DMR report as Outfall 001A and Outfall 002A (Appendix D). Outfall 001A had discharges during the recreation season (May 1-September 30) since 2009 there have been a total of 15 discharges. These discharges occurred in May and July of 2009, July 2010, May, June, July and August of 2011, July, August, and September 2012, July and September 2013, June and August 2014 and June 2015 (Appendix D). Outfall 002A also had two discharges but not during the recreation season, (Appendix D). The city of Beulah, ND will be given a maximum daily discharge value for each outfall (001A and 002A) of 7.8 and 2.2 MGD.

The wasteload allocation for Outfall 001A was determined by maximum daily discharge volume of 7.8 MGD multiplied by an E. coli bacteria concentration of 126 CFUs/100 mL, times appropriate conversion factors.

WLA-Outfall 001A = 7.8 million gallons/ day * 126 CFUs/100mL

= 7.8 million gallons/day * 3.7854 L/gal*1000mL/L* 126 CFU/100mL

= 3,720.2 x 10^7 CFUs/day

The wasteload allocation for Outfall 002A was determined by taking the maximum daily discharge volume of 2.2 MGD multiplied by an E. coli bacteria concentration of 126 CFUs/100 mL, times appropriate conversion factors.

WLA-Outfall 002A = 2.20 million gallons/ day * 126 CFUs/100mL

= 2.20 million gallons/day * 3.7854 L/gal*1000mL/L* 126 CFU/100mL

= 1,049.3 x 10^7 CFUs/day

5.5 Loading Sources

The majority of load reductions can generally be allotted to nonpoint sources. However, to account for uncertainty due to periodic discharges from permitted municipal facility (e.g., Beulah, ND), WLAs are included for the impaired segment ND-10130201-003-S_00.

Based on best professional judgment, the general focus of Best Management Practices (BMPs) and load reductions for the listed waterbody should be on unpermitted animal feeding operations, and riparian grazing adjacent to or in close proximity to the Knife 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). As previously described, exceedences of the E. coli bacteria standard was observed in all regimes (i.e., High, Moist and Dry Conditions, and Low Flow) at site 384131, representing assessment unit ND-10130201-042-S_00 (Figure 11), in three flow regimes (i.e., Moist and Dry Conditions and Low Flow) at site 385452, representing assessment unit ND-10130201-035-S_00 (Figure 12), in three flow regimes (i.e., High, Moist and Dry Condition Flow) at site 380087, representing assessment unit ND-10130201-003-S_00 (Figure13).

By relating runoff characteristics to each flow regime one can infer which sources are most likely to contribute to E. coli bacteria loading. 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 close 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 (Table 10). 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 impact at moderate flows (Table 10). 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. However, 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.

Table 10. 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

Note: Potential importance of nonpoint source area to contribute E. coli bacteria loads under a given flow regime. (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 explicit margin of safety was used for these TMDLs. The MOS was calculated as ten percent of the 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 Knife River (ND-10130201-042-S_00, ND-10130201-035-S_00 and ND-10130201-003-S_00) were developed using 2001 to 2016 flow data or 16 years of USGS gauge data 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 11 provides an outline of the critical elements of the E. coli bacteria TMDL for the four TMDL listed segments. TMDLs for Knife River (ND-10130201-042-S_00, ND-10130201-035-S_00, and ND-10130201-003-S_00) are summarized in Tables 12 through 14, respectively. The TMDLs provide a summary of average daily loads by flow regime necessary to meet the water quality target (i.e. TMDL). The TMDL for each segment and flow regime provide an estimate of the existing daily load, and an estimate of the average daily loads necessary to meet the primary

E. coli bacteria water quality target and the secondary E. coli bacteria target (i.e. TMDL load). The TMDL load includes a load allocation from known nonpoint sources and a 10 percent 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 11. TMDL Summary for the Knife River.

Category	Description	Explanation
Beneficial Use Impaired	Recreation	Contact Recreation (i.e. swimming, fishing)
Pollutants	E. coli Bacteria	See Section 2.1
Primary 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 to all segments (e.g. unpermitted AFOs and riparian grazing) and the city of Beulah for segment ND-10130201-003-S_00.
Margin of Safety (MOS)	Explicit	10 percent

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

LC = loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;
WLA = wasteload 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 12. E. coli Bacteria TMDL (10^7 CFU/day) for the Knife River Waterbody ND-10130201-042-S_00 as represented by Site 384131.

	Flow Regime			
	High Flow	Moist Conditions	Dry Conditions	Low Flow
Existing Load	547,105	39,837	11,820.3	5,339.2
TMDL	77,077.3	15,415.5	4,008	1,048.3
WLA	0	0	0	0
LA	69,369.57	13,874.35	3,607.2	943.47
MOS	7,707.73	1,541.15	400.8	104.83

[1]TMDL load is provided as a guideline for watershed management and BMP implementation.

Table 13. E. coli Bacteria TMDL (10^7 CFU/day) for the Knife River Waterbody ND-10130201-035-S_00 as represented by Site 385452.

	Flow Regime			
	High Flow	Moist Conditions	Dry Conditions	Low Flow
Existing Load		57,703.7	16,810.6	2,432.2
TMDL	256,353[1]	19,288.4	4,234	935.4
WLA	No Reduction Necessary	0	0	0
LA		17,359.56	3,810.6	841.86
MOS		1928.84	423.4	93.54

[1]TMDL load is provided as a guideline for watershed management and BMP implementation.

Table 14. E. coli Bacteria TMDL (10^7 CFU/day) for the Knife River Waterbody ND-10130201-003-S_00 as represented by Site 380087.

	Flow Regime			
	High Flow	Moist Conditions	Dry Conditions	Low Flow
Existing Load	731,869	50,724	11,218	
TMDL	89,718	21,982	8,047	2,862[1]
WLA-Outfall 001A	3,720.2	3,720.2	3,720.2	No Reduction Necessary
WLA-Outfall 002A	1,049.3	1,049.3	1,049.3	
LA	75,976.7	15,014.3	2,472.8	
MOS	8,971.8	2,198.2	804.7	

[1]TMDL load is provided as a guideline for watershed management and BMP implementation.

8.0 ALLOCATION

The permitted facility in Beulah, ND which has two discharges to segment ND-10130201-042-S_00, will have a portion of the TMDL, 3,720.2 x 10^7 CFUs/day and 1,049.3 x 10^7 CFUs/day, respectively have been allocated to these point sources. The remaining load has been allocated to nonpoint sources in the watershed.

To achieve the TMDL targets identified in the report, it will require the wide spread 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 land owner to meet nonpoint source pollution control needs, (EPA, 2001). This TMDL plan is put forth as a recommendation for what needs to be accomplished for the Knife River and associated watersheds to restore and maintain its recreational uses. Water quality monitoring should continue in order to measure BMP effectiveness and determine through adaptive management if loading allocation recommendations need to be adjusted.

Nonpoint source pollution is the sole contributor to elevated E. coli bacteria levels in the Knife River watershed. The E. coli bacteria samples and load duration curve analysis of the impaired reach identified the high, moist and dry condition flow regimes for TMDL segment ND-10130201-042-S_00; moist condition, dry condition and low flow for ND-10130201-035-S_00; high, moist condition and low flow for ND-10130201-003-S_00 as the time of E. coli bacteria exceedences for the 126 CFU/100 mL target. To reduce NPS pollution for the high, moderate, and low flow regimes, specific BMPs are described in Sections 8.1 and 8.2 and Tables 16-17 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 Knife River. The following describe in detail those BMPs that will reduce E. coli bacteria levels in Knife River.

Table 15. Management Practices and Flow Regimes Affected by Implementation of BMPs.

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 water quality and riparian areas through management of livestock and associated grazing land. Fecal matter from livestock, erosion from poorly managed grazing, land and riparian areas 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:

<u>Livestock exclusion from riparian areas</u>- 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.

Water well and tank development- Fencing animals from stream access requires and 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- 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 (NRCS) 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, (NRCS, 1998). In a study by Tiedemann et al. (1998), as presented by USEPA (1993), the effects of four grazing strategies on bacteria levels in thirteen watersheds in Oregon were studied during the summer of 1984. Results of the study (Table 16) showed that when livestock are managed at a stocking rate of 19 acres per animal unit month, with water developments and fencing, bacteria levels were reduced significantly.

Table 16. Bacterial Water Quality Response to Four Grazing Strategies (Tiedemann et al., 1988).

Grazing Strategy		Geometric Mean E. coli Count
Strategy A:	Ungrazed	40/L
Strategy B:	Grazing without management for livestock distribution; 20.3 ac/AUM.	150/L
Strategy C:	Grazing with management for livestock distribution: fencing and water developments; 19.0 ac/AUM	90/L
Strategy D:	Intensive grazing management, including practices to attain uniform livestock distribution and improve forage production with cultural practices such as seeding, fertilizing, and forest thinning; 6.9 ac/AUM	950/L

8.2 Other Recommendations

Waste management system- Waste management systems can be effective in controlling up to 90 percent of E. coli bacteria loading originating from confined animal feeding areas (Table 17). A waste management system is made up of various components designed to control non point 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- 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 (Table 17). 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 (NRCS, 2001).

Table 17. Relative Gross Effectiveness[a] of Confined Livestock Control Measures (Pennsylvania State University, 1992a).

Practice[b] Category	Runoff[c] Volume	Total[d] Phosphorus (%)	Total[d] Nitrogen (%)	Sediment (%)	E. coli (%)
Animal Waste System[e]	-	90	80	60	85
Diversion System[f]	-	70	45	NA	NA
Filter Strips[g]	-	85	NA	60	55
Terrace System	-	85	55	80	NA
Containment Structures[h]	-	60	65	70	90

NA = Not Available.
a Actual effectiveness depends on site-specific conditions. Values are not cumulative between practice categories.
b Each category includes several specific types of practices.
c - = reduction; + = increase; 0 = no change in surface runoff.
d Total phosphorus includes total and dissolved phosphorus; total nitrogen includes organic-N, ammonia-N, and nitrate-N.
e Includes methods for collecting, storing, and disposing of runoff and process-generated wastewater.
f Specific practices include diversion of uncontaminated water from confinement facilities.
g Includes all practices that reduce contaminant losses using vegetative control measures.
h Includes such practices as waste storage ponds, waste storage structures, waste treatment lagoons.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for the Knife River and a request for comment was mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy were as follows:

- Mercer County Soil Conservation District;
- Mercer County Water Resource Board;
- Natural Resource Conservation Service (State Office); and
- U.S. Environmental Protection Agency, Region VIII

In addition to mailing copies of this TMDL report to interested parties, the TMDL was posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.health.state.nd.us/WQ/sw/Z2_TMDL/TMDLs_Under_PublicComment/B_Under_Public_Comment.htm . A 30 day public notice soliciting comment and participation was also published in the Bismarck Tribune.

10.0 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.

Specifically, monitoring will be conducted for the variable that is currently causing impairments to the beneficial uses of the waterbody (i.e., E. coli bacteria). Once a watershed restoration plan (e.g. 319 PIP) is implemented, monitoring will be conducted in the stream beginning two years after implementation and extending five years after the implementation project is complete.

Currently, there are no 319 implementation projects directly addressing the Knife River; however, there is currently a 319 project in the Spring Creek watershed, a tributary to the Knife River and will be active through October 2019. Water quality monitoring will continue to be conducted in accordance with an approved Quality Assurance Project Plan (QAPP), which can be utilized for any future 319 Project Implementation Plans.

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 an important and required component of any PIP. As a part of the PIP, data are 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 are gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

12.0 REFERENCES

Baker-Ismail, S., Cade-Menun, B., McMartin, D.W. 2016.*Survival and Overland Transport of Fecal Coliform Under Canadian Prairie Conditions*. University of Regina, Environmental Systems Engineering, Regina, Saskatchewan, Canada.

Cleland. 2003. *TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet Weather Assessmen*t. America's Clean Water Foundation, Washington, D.C.

EPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA 840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA. 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA. 2002. Onsite Wastewater Treatment Systems Manual. EPA/625/R-00/008. U. S. Environmental Protection Agency. Office of Water, Office of Research and Development.

EPA. 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. EPA-841-B-07-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC. Available at http://www.epa.gov/owow/tmdl/techsupp.html

NASS. 2014. *North Dakota Agricultural Statistics Service*. Available at http://www.nass.usda.gov/Statistics_by_State/North_Dakota/index.asp.

NDAWN. 2016. Hazen, North Dakota Weather Station. North Dakota Agriculture Weather Network. North Dakota State University, Fargo, North Dakota. Available at http://ndawn.ndsu.nodak.edu/index.html

NDDoH. 2014. *Standards of Quality for Waters of the State.* Chapter 33-16-02 of the North Dakota Century Code. North Dakota Department of Health, Division of Water Quality. Bismarck, North Dakota.

NDDoH. 2014. *North Dakota 2014 Integrated Section 305(b) Water Quality Assessment Report and Section 303(d) List of Waters Needing Total Maximum Daily Loads.* North Dakota Department of Health, Division of Water Quality. Bismarck, North Dakota.

NRCS. 1998. *Natural Resources Conservation Service Practice Specification* 528. USDA-Natural Resources Conservation Service, North Dakota. Available at http://efotg.nrcs.usda.gov

NRCS. 2001. *Natural Resources Conservation Service Practice Specification 393* – Filter Strip (Acres) [Online]. USDA – Natural Resources Conservation Service, North Dakota. Available at http://www.nd.nrcs.usda.gov/resources/section4/standards/Section4.html.

Pennsylvania State University. 1992. Nonpoint Source Database. Pennsylvania State University, Department of Agricultural and Biological Engineering, University Park, PA.

Ries, K. G., III and P.J. Friesz.2000. *Methods for Estimating Low-Flow Statistics for Massachusetts Streams.* U.S. Geological Survey Water Resources Investigations Report 00-4135. U.S. Geological Survey, Reston, VA.

Tiedemann, A.R., D.A. Higgins, T.M. Quigley, H.R. Sanderson, and C. C. Bohn.1988. *Bacterial Water Quality Responses to Four Grazing Strategies – Comparison with Oregon Standards*.
USGS. 2006. *Ecoregions of North Dakota and South Dakota*. United States Geological Survey. Available at http://www.npwrc.usgs.gov/resource/habitat/ndsdeco/nodak.html.

Appendix A
E. coli Bacteria Data Collected for
Sites 384131, 385452, and 380087 for 2001-2016

Site 384131 on Knife River near Golden Valley, ND

	May		June		July		August		September	
	08-May-01	10	20-Jun-01	1600	31-Jul-01	1600	06-Aug-03	20	05-Sep-02	50
	22-May-02	10	26-Jun-02	80	31-Jul-02	10	08-Aug-05	20	16-Sep-03	70
	14-May-03	120	25-Jun-03	240	27-Jul-04	700	08-Aug-06	40	28-Sep-05	10
	04-May-04	30	22-Jun-04	390	16-Jul-07	1600	20-Aug-07	10	19-Sep-06	70
	11-May-05	1300	28-Jun-05	1600	01-Jul-08	330	04-Aug-08	70	02-Sep-08	10
	15-May-06	70	26-Jun-06	90	08-Jul-08	10	11-Aug-08	40	09-Sep-08	10
	08-May-07	30	13-Jun-07	590	15-Jul-08	10	12-Aug-08	40	15-Sep-08	10
	04-May-08	10	02-Jun-08	20	22-Jul-08	1600	18-Aug-08	10	22-Sep-08	10
	12-May-08	10	16-Jun-08	70	28-Jul-08	700	25-Aug-08	20	22-Sep-08	20
	19-May-08	10	23-Jun-08	10	29-Jul-08	510	04-Aug-09	20	29-Sep-08	10
	20-May-08	30	30-Jun-08	210	06-Jul-09	100	12-Aug-09	20	08-Sep-09	810
	20-May-08	10	01-Jun-09	150	14-Jul-09	310	18-Aug-09	40	16-Sep-09	20
	27-May-08	60	03-Jun-09	40	15-Jul-09	200	24-Aug-09	50	22-Sep-09	20
	06-May-09	10	09-Jun-09	900	21-Jul-09	50	25-Aug-09	10	30-Sep-09	240
	11-May-09	30	22-Jun-09	180	06-Jul-11	420	31-Aug-09	30	13-Sep-10	1200
	26-May-09	320	29-Jun-09	240	09-Jul-13	540	03-Aug-10	80	28-Sep-11	40
	27-May-09	1600	22-Jun-10	1600	07-Jul-14	240	16-Aug-11	120	18-Sep-12	10
	13-May-10	60	26-Jun-12	210	21-Jul-15	110	08-Aug-12	10		
	25-May-11	470	11-Jun-13	150	25-Jul-16	110	13-Aug-13	130		
	16-May-12	110	10-Jun-14	140			12-Aug-14	50		
	07-May-13	10	08-Jun-15	1600			22-Aug-16	40		
	21-May-13	1600	8-Jun-16	170						
	13-May-14	10								
	12-May-15	140								
	17-May-16	140								
Geomean	55		211		203		31		35	
% exceeded	16%		27%		42%		0%		12%	
Recreational Use Assessment	FSbT		NS		NS		FS		FSbT	

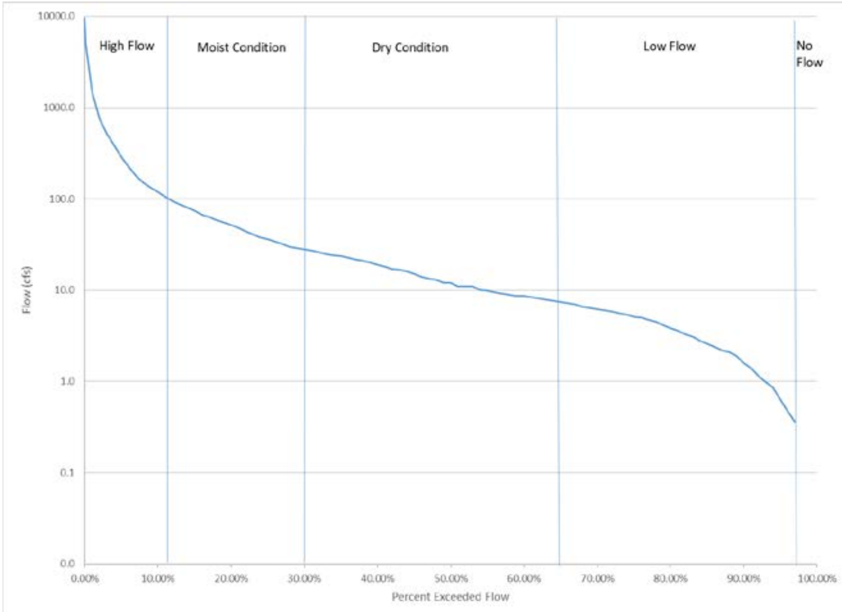
Site 385452 on Knife River south of Zap, ND

	May		June		July		August		September	
	04-May-08	10	02-Jun-08	90	08-Jul-08	30	04-Aug-08	280	02-Sep-08	160
	12-May-08	10	09-Jun-08	30	15-Jul-08	320	12-Aug-08	530	09-Sep-08	160
	19-May-08	530	16-Jun-08	310	22-Jul-08	1600	18-Aug-08	360	15-Sep-08	60
	20-May-08	40	23-Jun-08	90	28-Jul-08	530	25-Aug-08	260	22-Sep-08	10
	27-May-08	20	30-Jun-08	590	29-Jul-08	1000	04-Aug-09	20	29-Sep-08	170
	06-May-09	10	01-Jun-09	110	06-Jul-09	130	12-Aug-09	130	08-Sep-09	730
	11-May-09	10	09-Jun-09	10	15-Jul-09	350	18-Aug-09	110	16-Sep-09	50
	26-May-09	1200	22-Jun-09	300	21-Jul-09	60	25-Aug-09	110	22-Sep-09	70
	27-May-09	140	29-Jun-09	180	28-Jul-09	120	31-Aug-09	20	30-Sep-09	120
Geomean	45		111		240		127		98	
% exceeded	22%		11%		33%		11%		11%	
Recreational Use Assessment	FSbT		FSbT		NS		NS		FSbT	

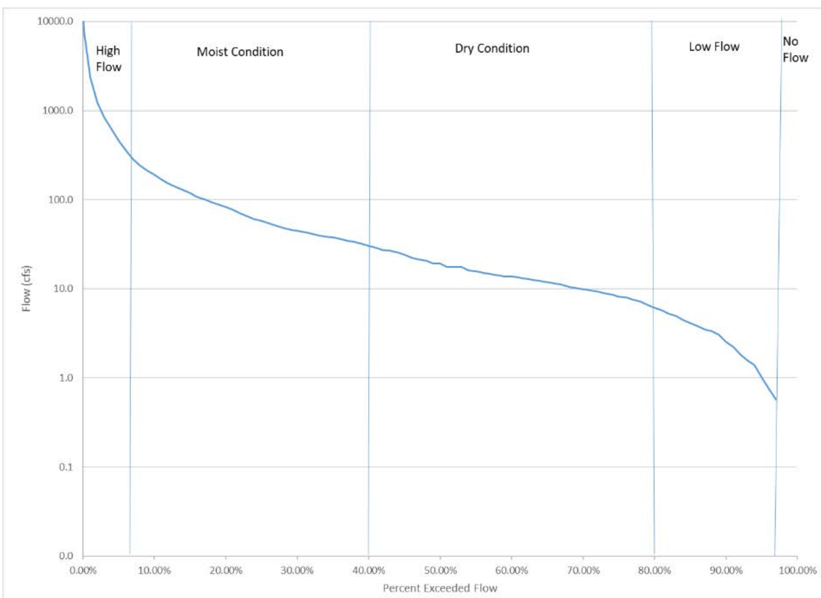
Site 380087 on Knife River near Hazen, ND

	May		June		July		August		September	
	5/8/2001	80	6/20/2001	430	7/31/2001	800	8/6/2003	140	9/12/2001	160
	5/22/2002	260	6/26/2002	230	7/31/2002	110	8/8/2005	110	9/5/2002	110
	5/14/2003	80	6/25/2003	270	7/27/2004	50	8/8/2006	110	9/16/2003	140
	5/4/2004	90	6/22/2004	200	7/16/2007	100	8/20/2007	70	9/28/2005	5
	5/11/2005	200	6/28/2005	1600	7/1/2008	100	8/11/2008	40	9/19/2006	80
	5/15/2006	90	6/26/2006	190	7/14/2009	90	8/24/2009	10	9/26/2007	90
	5/8/2007	160	6/13/2007	1600	7/6/2011	670	8/3/2010	260	9/22/2008	80
	5/20/2008	90	6/3/2009	20	7/9/2013	360	8/16/2011	360	9/13/2010	3800
	5/13/2010	10	6/22/2010	890	7/7/2014	460	8/8/2012	80	9/28/2011	10
	5/25/2011	860	6/26/2012	110	7/21/2015	30	8/13/2013	50	9/18/2012	250
	5/16/2012	70	6/11/2013	360	7/25/2016	70	8/12/2014	170		
	5/7/2013	70	6/10/2014	130			8/25/2015	100		
	5/21/2013	1600	6/8/2015	1600			8/22/2016	80		
	5/13/2014	5	6/8/2016	90						
	5/12/2015	90								
	5/17/2016	240								
Geomean	107		293		151		90		96	
% exceeded	13%		36%		27%		0%		10%	
Recreational Use Assessment	FSbT		NS		NS		FS		FS	

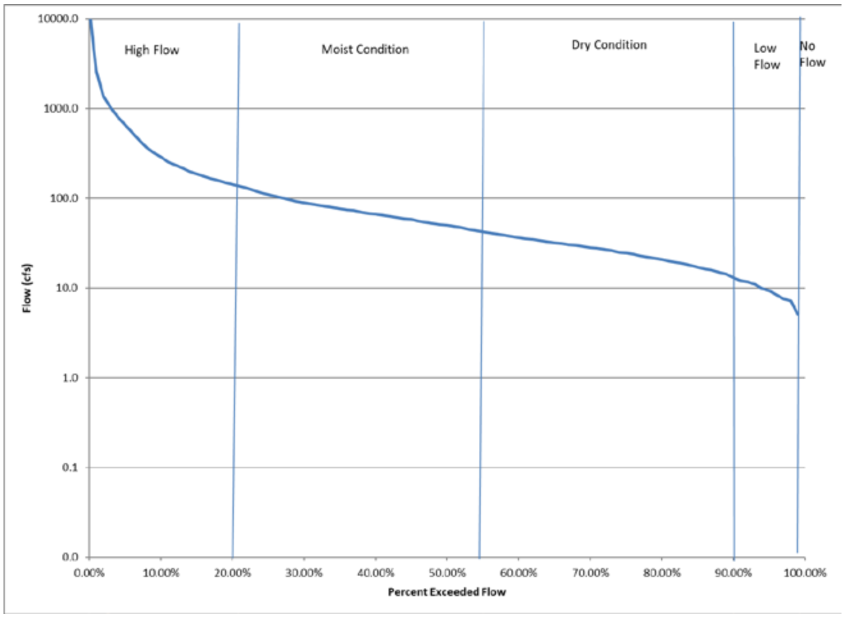
Appendix B
Flow Duration Curves for
Sites 384131, 385452, and 380087



Flow Duration Curve for 384131 (near Golden Valley, ND)



Flow Duration Curve for 385452 (near Zap, ND)

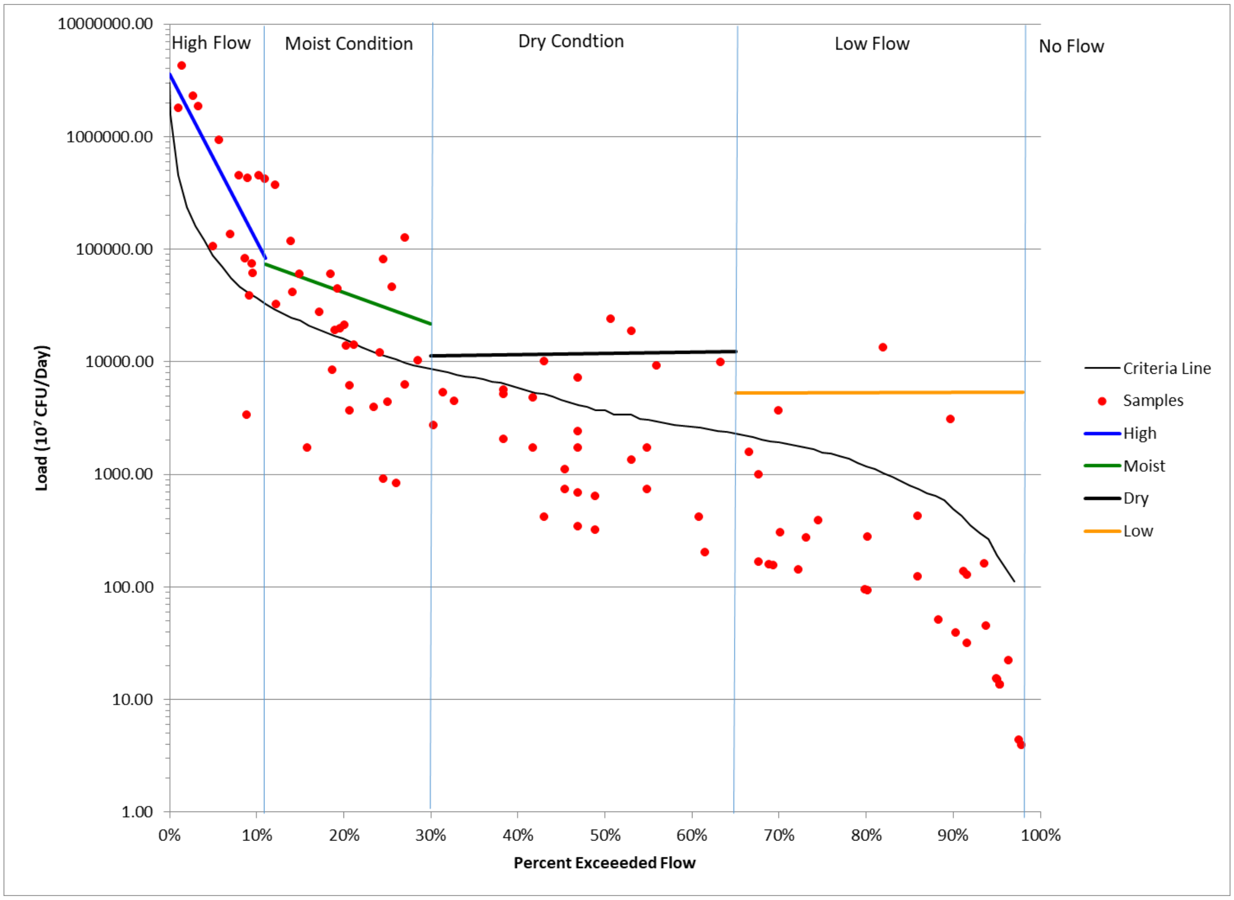


Flow Duration Curve for 380087 (near Hazen)

Appendix C
Load Duration Curve, Estimated Loads, TMDL Targets, and Percentage of Reduction Required for Sites 384131, 385452, and 380087

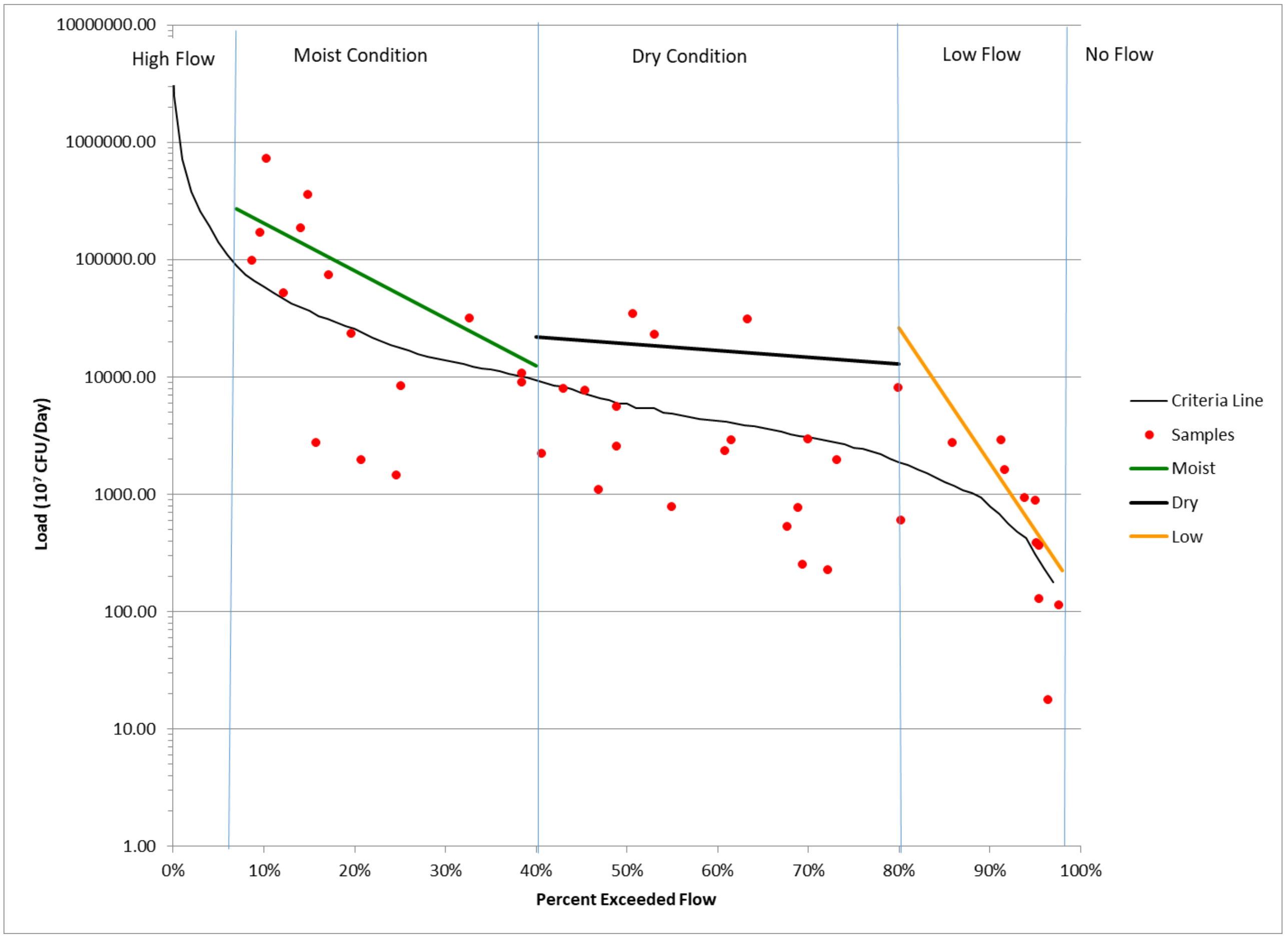
Load Duration Curve for 384131

	Load (10^7 CFUs/Day)				Load (10^7 CFUs/Period)		
	Median Percentile	Existing	TMDL	Days	Existing	TMDL	Percent Reduction
High	5.50%	547104.63	77077.31	40.15	21966250.74	3094654.08	85.91%
Moist	20.50%	39836.78	15415.46	69.35	2762680.87	1069062.32	61.30%
Dry	47.50%	11820.25	4008.02	127.75	1510036.97	512024.58	66.09%
Low	81.50%	5339.16	1048.25	120.45	643101.27	126261.89	80.37%
			Total	358	26882070	4802003	82.14%



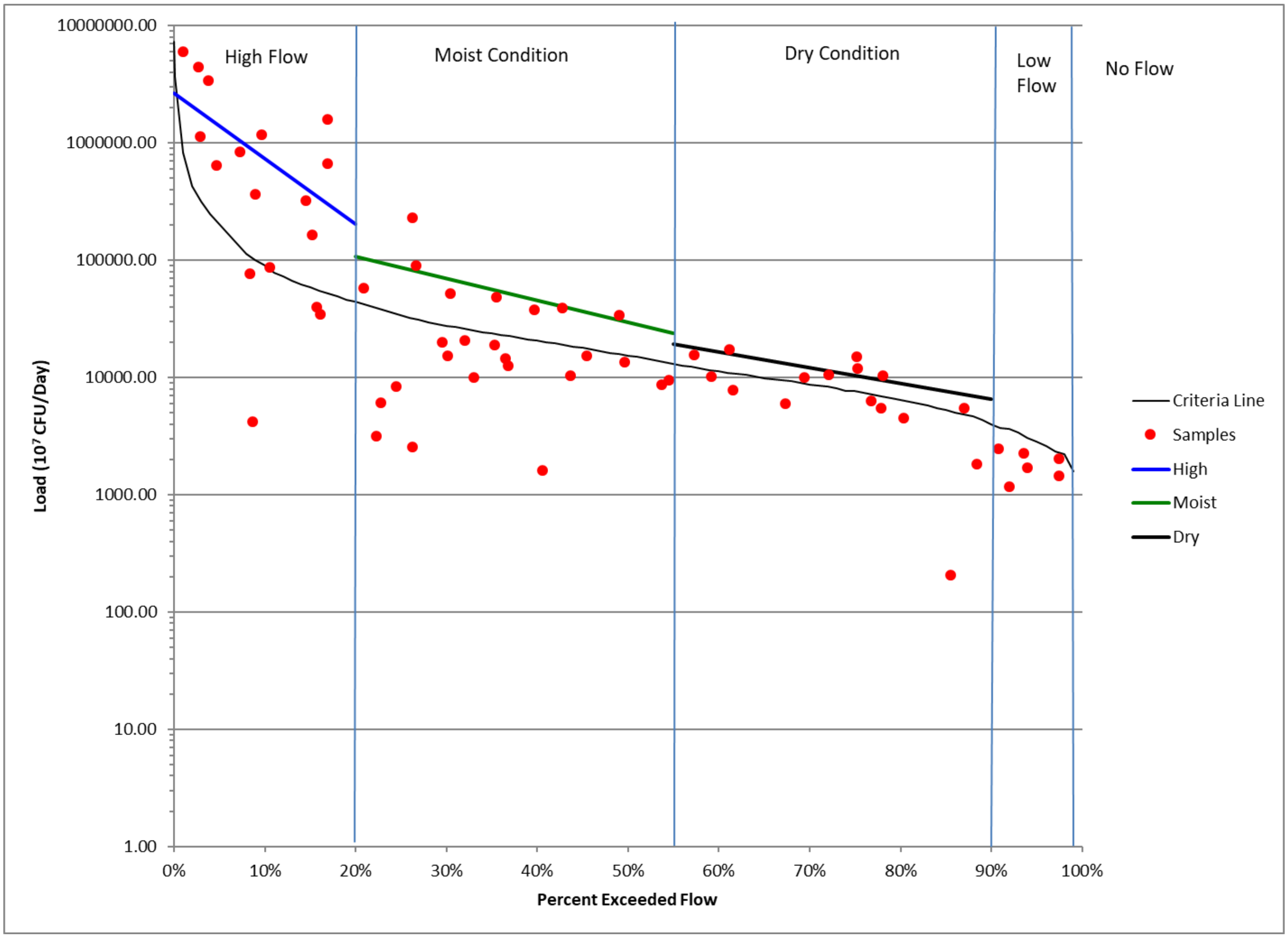
Load Duration Curve for 385452

	Load (10^7 CFUs/Day)				Load (10^7 CFUs/Period)		
	Median Percentile	Existing	TMDL	Days	Existing	TMDL	Percent Reduction
Moist	23.50%	57703.69	19288.39	120.45	6950409.66	2323286.15	66.57%
Dry	60.00%	16810.59	4233.90	146.00	2454346.16	618149.98	74.81%
Low	89.00%	2432.25	935.40	65.70	159798.94	61455.61	61.54%
			Total	332	9564555	3002892	68.60%



Load Duration Curve for 380086

	Load (10^7 CFUs/Day)				Load (10^7 CFUs/Period)		
	Median Percentile	Existing	TMDL	Days	Existing	TMDL	Percent Reduction
High	10.00%	731869.15	89717.99	73.00	53426447.85	6549413.37	87.74%
Moist	37.50%	50724.28	21982.45	127.75	6480027.15	2808257.92	56.66%
Dry	72.50%	11217.97	8046.87	127.75	1433095.55	1027987.82	28.27%
			Total	329	61339571	10385659	83.07%



Appendix D
North Dakota Department of Health Water Quality
NDPDES DMR Data for Beulah, North Dakota

Outfall 001A

Date Printed: 1/4/2016

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/1/2008' AND '12/31/2015' AND Discharge End BETWEEN '7/1/2008' AND '12/31/2015'

Environmental Interest: Beulah City Of Permit: ND0021211
Discharge Point: 001 A Parameter: Flow 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	11/4/2008	11/10/2008	Cell 3N	7					2.2	3.8	MGD	0		Daily/Calculated
Effluent	5/26/2009	5/31/2009	Cell 3N	6					3.9	5.8	MGD	0		Daily/Calculated
Effluent	7/8/2009	7/14/2009	Cell 3N	7					2.3	5.8	MGD	0		Daily/Calculated
Effluent	5/11/2010	5/17/2010	Cell 3N	7					3.6	4.8	MGD	0		Daily/Calculated
Effluent	7/6/2010	7/12/2010	Cell 3N	7					3.1	5.8	MGD	0		Daily/Calculated
Effluent	10/19/2010	10/25/2010	Cell 3N	7					3.1	3.9	MGD	0		Daily/Calculated
Effluent	4/28/2011	4/30/2011	Cell 3N	3					2.9	3.8	MGD	0		Daily/Calculated
Effluent	5/1/2011	5/4/2011	Cell 3N	4					2.7	3.88	MGD	0		Daily/Calculated
Effluent	6/28/2011	6/30/2011	Cell 3N	3					3.2	5.8	MGD	0		Daily/Calculated
Effluent	7/1/2011	7/4/2011	Cell 3N	4					3.9	5.8	MGD	0		Daily/Calculated
Effluent	8/16/2011	8/25/2011	Cell 3N	10					4.2	5.8	MGD	0		Daily/Calculated
Effluent	10/25/2011	10/31/2011	Cell 3N	7					3.1	5.8	MGD	0		Daily/Calculated
Effluent	11/28/2011	11/30/2011	Cell 3N	3					1.9	3.9	MGD	0		Daily/Calculated
Effluent	7/10/2012	7/15/2012	Cell 3N	6					0.23	3.9	MGD	0		Daily/Calculated
Effluent	8/28/2012	8/31/2012	Cell 3N	4					3.5	3.9	MGD	0		Daily/Calculated
Effluent	9/1/2012	9/3/2012	Cell 3N	3					3.6	3.9	MGD	0		Daily/Calculated
Effluent	7/11/2013	7/17/2013	Cell 3N	7					2.8	5.8	MGD	0		Daily/Calculated
Effluent	9/5/2013	9/11/2013	Cell 3N	7					3.1	3.9	MGD	0		Daily/Calculated
Effluent	11/13/2013	11/17/2013	Cell 3N	5					3.9	7.8	MGD	0		Daily/Calculated
Effluent	6/25/2014	6/30/2014	Cell 3N	6					2.9	5.8	MGD	0		Daily/Calculated
Effluent	8/20/2014	8/26/2014	Cell 3N	7					3.9	3.9	MGD	0		Daily/Calculated
Effluent	11/4/2014	11/10/2014	Cell 3N	7					3.9	5.8	MGD	0		Daily/Calculated
Effluent	6/16/2015	6/29/2015	Cell 3N	14					1.9	1.9	MGD	0		Daily/Calculated

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Date Printed: 1/4/2016

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/1/2008' AND '12/31/2015' AND Discharge End BETWEEN '7/1/2008' AND '12/31/2015'

Environmental Interest: Beulah City Of Permit: ND0021211
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	5/26/2009	5/31/2009	Cell 3N	6	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	7/8/2009	7/14/2009	Cell 3N	7	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	5/11/2010	5/17/2010	Cell 3N	7	10	44.7	200	Num/100 mL				0		Weekly/Grab
Effluent	7/6/2010	7/12/2010	Cell 3N	7	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	10/19/2010	10/25/2010	Cell 3N	7	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	4/28/2011	4/30/2011	Cell 3N	3	10	69.3	480	Num/100 mL				1		Weekly/Grab
Effluent	5/1/2011	5/4/2011	Cell 3N	4	480	480	480	Num/100 mL				2		Weekly/Grab
Effluent	6/28/2011	6/30/2011	Cell 3N	3	0	0	0	Num/100 mL				0		Weekly/Grab
Effluent	7/1/2011	7/4/2011	Cell 3N	4	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	8/16/2011	8/25/2011	Cell 3N	10	10	38.7	150	Num/100 mL				0		Weekly/Grab
Effluent	10/25/2011	10/31/2011	Cell 3N	7	10	10	10	Num/100 mL				0	B	Weekly/Grab
Effluent	7/10/2012	7/15/2012	Cell 3N	6	10	68.4	3200	Num/100 mL				1		Weekly/Grab
Effluent	8/28/2012	8/31/2012	Cell 3N	4	10	17.3	30	Num/100 mL				0		Weekly/Grab
Effluent	9/1/2012	9/3/2012	Cell 3N	3	10	17.3	30	Num/100 mL				0		Weekly/Grab
Effluent	7/11/2013	7/17/2013	Cell 3N	7	10	10	10	Num/100 mL				0		Weekly/Grab
Effluent	9/5/2013	9/11/2013	Cell 3N	7	10	10	10	Num/100 mL				0		Weekly/Grab

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ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/1/2008' AND '12/31/2015' AND Discharge End BETWEEN '7/1/2008' AND '12/31/2015'

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	6/25/2014	6/30/2014	Cell 3N	6	0	0	0	Num/100 mL				0		Weekly/Grab
Effluent	8/20/2014	8/26/2014	Cell 3N	7	9	10.8	13	Num/100 mL				0		Weekly/Grab
Effluent	6/16/2015	6/29/2015	Cell 3N	14	1	1	1	Num/100 mL				0		Weekly/Grab

Outfall 002A

Date Printed: 1/4/2016

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/1/2008' AND '12/31/2015' AND Discharge End BETWEEN '7/1/2008' AND '12/31/2015'

Environmental Interest: Beulah City Of Permit: ND0021211
Discharge Point: 002 A Parameter: Flow 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	3/3/2015	3/6/2015	Cell 3S	4					0.667	1.07	MGD	0		Weekly/Calculated
Effluent	4/20/2015	4/23/2015	Cell 3S	4					1.1	2.2	MGD	0		Weekly/Calculated

Date Printed: 1/4/2016

ND Dept of Health Water Quality NDPDES DMR Data Report

Discharge Start between '7/1/2008' AND '12/31/2015' AND Discharge End BETWEEN '7/1/2008' AND '12/31/2015'

Environmental Interest: Beulah City Of Permit: ND0021211
Discharge Point: 002 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	3/3/2015	3/6/2015	Cell 3S	4								0	9	/
Effluent	4/20/2015	4/23/2015	Cell 3S	4	0	17.6	310	Num/100 mL				0		Weekly/Grab

Appendix E
US EPA Region 8 TMDL Review Comments

1. **EPA Comment:** Does the City of Hazen have a discharge permit for their wastewater lagoons? If so, is there discharge data available?

2. **EPA Comment:** Why isn't monitoring site 380087 included on maps, text or data summary?

3. **EPA Comment:** A description of all designated uses should be provided for each waterbody segment, not just the designated use that is impaired.

4. **EPA Comment:** For segment ND-10130201-003-S_00, why not pair WQ data from monitoring site 380087 with flow from USGS gauge 0634500 to create the LDC?

5. **EPA Comment:** Load allocation values need to be provided in Tables on page 23.

6. **EPA Comment:** It's not clear why WLA values in Table 14 are zero for the Dry and Low flow regimes. Are their restrictions in the discharge permit that prevents the City from discharging during below a specific ambient flow?

7. **EPA Comment:** The WLA text at the bottom of page 23 should be in reference to segment ND-10130201-003-S_00 (i.e., the reference to segment ND-10130201-042-S_00 is incorrect).

8. **EPA Comment:** On page 21, it reads that a 10% explicit of MOS is incorporated in the TMDL, but this explicit MOS is not provided in Tables on page 23, please provide.

9. **EPA Comment:** We would like to discuss how the load reductions were calculated in more detail. Are the red dots in Figures 11-13 monthly averages or single samples?

10. **EPA Comment:** E. coli WQ data needs to be collected for segment ND-10130201-002-S_00 in order to create an approvable TMDL for this segment.

Appendix F
NDDoH Response to US EPA Region 8 Comments

1. NDDoH Response: Hazen, ND does have a NDPDES Permit and discharge data available, but does not discharge to the impaired reaches covered in this TMDL. The segment that the city of Hazen discharges to is ND-10130201-002-S_00.

2. NDDoH Response: Monitoring site 380087 was added to the TMDL with the appropriate language and data analysis requested by EPA.

3. NDDoH Response: The designated uses for the reaches covered in the TMDL are clearly stated in Section 2.2.

4. NDDoH Response: USGS gauge station 0634500 data was used to construct the LDC for monitoring station 380087.

5. NDDoH Response: Necessary values were added to tables on page 23.

6. NDDoH Response: The LDC was rerun and the TMDL load allocations were recalculated and WLA values were included in Table 14.

7. NDDoH Response: Language was changed to reflect EPA's comments.

8. NDDoH Response: MOS was included in Tables on page 23 to reflect EPA's comments.

9. NDDoH Response: The red dots in the LDCs in Figures 11-13 are single samples.

10. NDDoH Response: Segment ND-10130201-002-S_00 was not included in the TMDL. A plan will be developed to collect data in the future for this segment.