ESCHERICHIA COLI BACTERIA TOTAL MAXIMUM DAILY LOAD EVALUATION FOR PIPESTONE CREEK LOCATED IN MOODY AND MINNEHAHA COUNTIES, SOUTH DAKOTA.

South Dakota Department of
Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

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South Dakota Department of Environment and Natural Resources

Water Resources Assistance Program

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Pipestone Creek Total Maximum Daily Load

Entity ID:	SD-BS-R-PIPESTONE_01
Location:	HUC Code: 10170203
Size of Watershed:	45,993 acres
Water Body Type:	Stream
303(d) Listing Parameter:	*Escherichia coli* bacteria
Initial Listing Date:	2010
TMDL Priority Ranking:	5
Listed Stream Segment:	Pipestone Creek Occurring within South Dakota
Designated Use of Concern:	Immersion Recreation
Analytical Approach:	Load Duration Curve Framework
Target	Meet applicable water quality standards 74:51:01:55
Threshold Value	<126 cfu/100 ml geometric mean concentration with a <235 cfu/100 ml maximum single sample
Load Allocations:	
High Flow Zone LA	8.24E+14
High Flow Zone WLA	0
High Flow Zone MOS	2.55E+11
High Flow Zone TMDL	8.24E+14

1.0 Introduction

The intent of this document is to clearly identify the components of the Total Maximum Daily Load (TMDL) submittal to support adequate public participation and facilitate the United States Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the Federal Clean Water Act and guidance developed by the EPA. This TMDL document addresses the *Escherichia coli* (*E. coli*) bacteria impairment of Pipestone Creek contained within South Dakota.

1.1 Watershed Characteristics

Pipestone Creek drains 45,993 acres in eastern South Dakota (Figure 1) and discharges to Split Rock Creek within Minnesota east of Sherman, South Dakota. The stream receives runoff from agricultural operations. Land use is mainly cropland interspersed with rangeland/grassland (Table 1).

Table 1: Pipestone Creek watershed landuse.

Landuse	Percent
Cropland	82
Range/Grassland	17
Builtup land	1

The impaired reach of Pipestone Creek lies within Moody and Minnehaha Counties, near the town of Trent, SD (Figure 2). Common soil associations on the uplands in the watershed include Doland-Grovena-Houdek, Kranzburg-Houdek, Grovena-Dobalt-Flandreau, and Moody-Trent. The bottomland soil associations include Dempster-Flandreau-Lamo, Chaska-Davis-Bon, and Lamo-Graceville. The soil associations within this watershed primarily support cropland.

Moody and Minnehaha County have cold winters and hot summers. The average daily temperature during winter is 15 degrees F. The average daily temperature during summer is 70 degrees F. Average yearly precipitation is 21.98 inches. Over the year 75% of precipitation falls from April to September. Average yearly snow fall amounts to 30 inches.

Pipestone Creek was assessed as an individual portion of the larger Central Big Sioux River Watershed Assessment, which looked at individual streams such as Pipestone Creek as well as the entire drainage basin and the cumulative effects of the individual waterbodies.

Segment SD-BS-R-PIPESTONE-01 was listed as impaired by *E. coli* bacteria in the 2010 Integrated Report (SDDENR, 2010) and the TMDL will address this.

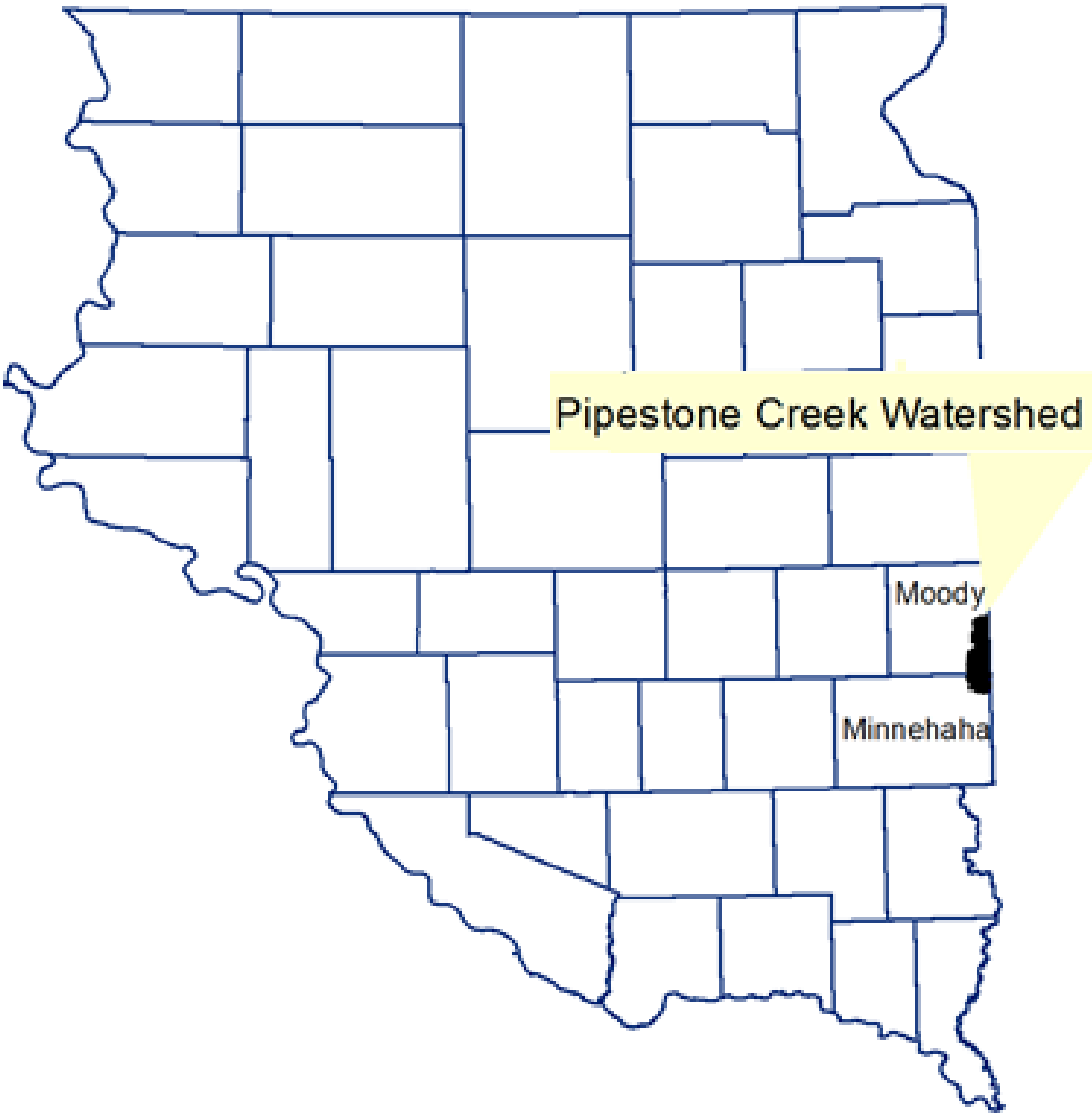

Figure 1: Pipestone Creek Watershed location within eastern South Dakota.

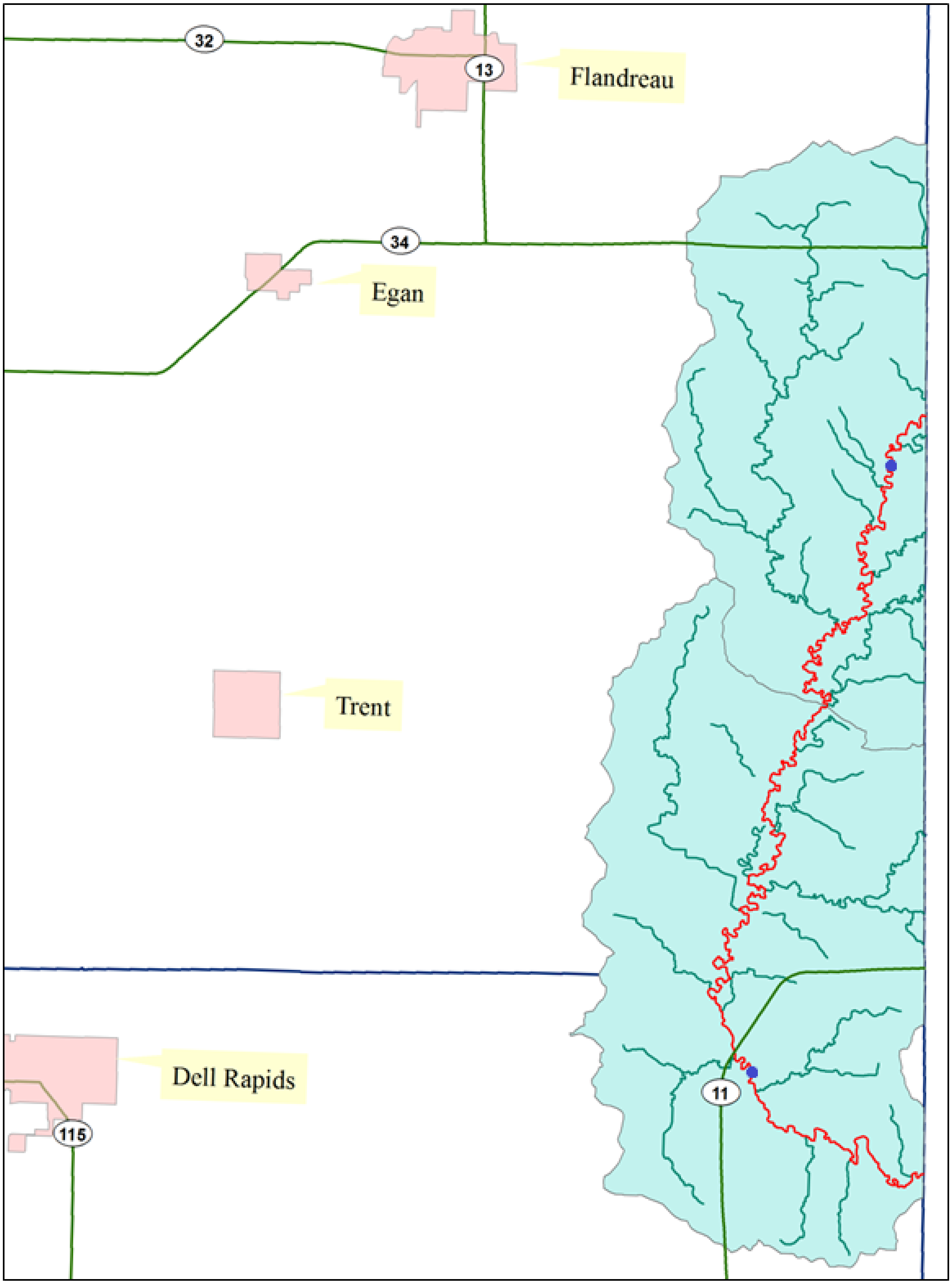

Figure 2: Pipestone Creek Watershed within South Dakota and listed segment indicated by red stream length, T28 indicated by a blue circle in the upper watershed and T29 is indicated by a blue circle in the lower watershed.

2.0 Water Quality Standards

Each waterbody within South Dakota is assigned beneficial uses. All waters (both lakes and streams) are designated the use of fish and wildlife propagation, recreation and stock watering. All streams are assigned the use of irrigation. Additional uses may be assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in South Dakota state statutes in support of these uses. These standards consist of suites of numeric criteria that provide physical and chemical benchmarks from which management decisions can be developed (Table 2).

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the State's water quality standards, this is the method used in the South Dakota Integrated Water Quality Report (IR) as well as in permit development.

Additional "narrative" standards that may apply can be found in the "Administrative Rules of South Dakota: Articles 74:51:01:05; 06; 08; 09, and 12". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, nuisance aquatic life, and biological integrity.

Pipestone Creek located within South Dakota has been assigned the beneficial uses of: warm water semi-permanent fish life, irrigation waters, immersion recreation, limited contact recreation, and fish and wildlife propagation, recreation, and stock watering. Table 1 lists the criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

The numeric TMDL target established for Pipestone Creek is 126 cfu/100 ml, which is based on the chronic standard for *E. coli*. The *E. coli* criteria for the immersion recreation beneficial use requires that 1) no sample exceeds 235 cfu/100 ml and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 126 cfu/100 ml. These criteria are applicable from May 1 through September 30.

Table 2: State Water Quality Standards for Pipestone Creek.

Parameters	Criteria	Unit of Measure	Beneficial Use Requiring this Standard
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L30 average May 1 to October 31	Warmwater Semi-Permanent Fish Life Propagation
	Equal to or less than the result from Equation 4 in Appendix A of Surface Water Quality Standards	mg/L 30 average November 1 to April 30	
	Equal to or less than the result from Equation c in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Dissolved Oxygen	≥5.0	mg/L	Warmwater Semi-Permanent Fish Life Propagation
Total Suspended Solids	≤90 (mean) ≤158 (single sample)	mg/L	Warmwater Semi-Permanent Fish Life Propagation
Temperature	>90	°C	Warmwater Semi-Permanent Fish Life Propagation
Fecal Coliform Bacteria (May 1 – Sept 30)	≤1,000 (geometric mean) ≤2,000 (single sample)	count/100 ml	Limited Contact Recreation
Escherichia coli Bacteria (May 1 – Sept 30)	≤630 (geometric mean) ≤1,178 (single sample)	count/100 ml	Limited Contact Recreation
Fecal Coliform Bacteria (May 1 – Sept 30)	≤200 (geometric mean) ≤400 (single sample)	count/100 ml	Immersion Recreation
Escherichia coli Bacteria (May 1 – Sept 30)	≤126 (geometric mean) ≤235 (single sample)	count/100 ml	Immersion Recreation
Alkalinity (CaCO3)	≤750 (mean) ≤1,313 (single sample)	mg/L	Fish and Wildlife Propagation, Recreation, and Stock Watering
Conductivity	≤2,500 (mean) ≤4,375 (single sample)	µmhos/cm @ 25° C	Irrigation Waters
Nitrogen, Nitrate as N	≤50 (mean) ≤88 (single sample)	mg/L	Fish and Wildlife Propagation, Recreation, and Stock Watering
pH (standard Units	≥6.5 to ≤9.0	units	Warmwater Semi-Permanent Fish Life Propagation
Solids, total dissolved	≤2,500 (mean) ≤4,375 (single sample)	mg/L	Fish and Wildlife Propagation, Recreation, and Stock Watering
Total Petroleum Hydrocarbon Oil and Grease	≤10 ≤10	mg/L mg/L	Fish and Wildlife Propagation, Recreation, and Stock Watering
Sodium Absorption Ratio	≤10	ratio	Irrigation Waters

3.0 Technical Analysis

3.1 Data Collection Method

Data on Pipestone Creek was collected during the Big Sioux River Watershed Assessment from two sampling points; T28 and T29. T28 was located near the Minnesota Border where Pipestone Creek enters South Dakota; T29 was located near the Minnesota Border where Pipestone Creek exits South Dakota. For this analysis T28 will be considered as a boundary condition site and T29 will represent the South Dakota reach. Average daily flows were tied to *E. coli* samples and this data was used to develop the load duration curve.

3.2 Sample Data

Samples were collected from 2001 to 2008. From site T29, 40 samples were collected and used in the TMDL analysis, 29 of which were modeled from fecal coliform sample data. From site T28, 52 samples were collected and used in the boundary condition analysis, 41 of which were modeled from fecal coliform sample data. Comparing flow and concentration resulted in a very weak relationship that was inadequate for use in predicting daily loads. From site T29, 27 samples exceeded the chronic threshold and 24 samples exceeded the acute threshold (Table 3). From site T28, 45 samples exceeded the chronic threshold and 42 samples exceeded the acute threshold.

Table 3: Actual and modeled *E. coli* samples, modeled *E. coli* samples indicated by red text.

Station Name	Date	Sample	Station Name	Date	Sample
CENTBSRT28	06/13/2000	1783.0	CENTBSRT28	05/07/2008	6.2
CENTBSRT28	07/10/2000	519.5	CENTBSRT28	06/11/2008	1356.1
CENTBSRT28	08/15/2000	6613.8	CENTBSRT28	07/08/2008	68.3
CENTBSRT28	09/19/2000	1356.1	CENTBSRT28	08/13/2008	940.2
CENTBSRT28	10/17/2000	1356.1	CENTBSRT28	09/09/2008	253.4
CENTBSRT28	04/02/2001	145.3	CENTBSRT28	10/09/2008	607.9
CENTBSRT28	04/12/2001	4253.3	CENTBSRT29	06/13/2000	1251.0
CENTBSRT28	04/23/2001	15348.3	CENTBSRT29	07/10/2000	1568.4
CENTBSRT28	05/07/2001	1783.0	CENTBSRT29	08/16/2000	262.7
CENTBSRT28	06/05/2001	940.2	CENTBSRT29	09/19/2000	1461.9
CENTBSRT28	06/13/2001	31280.7	CENTBSRT29	10/17/2000	93.5
CENTBSRT28	07/09/2001	737.4	CENTBSRT29	04/02/2001	102.0
CENTBSRT28	07/23/2001	20554.8	CENTBSRT29	04/12/2001	6254.6
CENTBSRT28	08/14/2001	2438.8	CENTBSRT29	04/23/2001	36767.1
CENTBSRT28	09/11/2001	1568.4	CENTBSRT29	05/07/2001	1891.1
CENTBSRT28	10/10/2001	5541.2	CENTBSRT29	06/05/2001	346.7
CENTBSRT28	04/02/2001	76.6	CENTBSRT29	06/13/2001	5423.0
CENTBSRT28	04/12/2001	4022.2	CENTBSRT29	07/09/2001	500.1
CENTBSRT28	04/23/2001	14067.4	CENTBSRT29	07/23/2001	4253.3
CENTBSRT28	05/07/2001	1675.4	CENTBSRT29	08/14/2001	365.6
CENTBSRT28	06/05/2001	1043.0	CENTBSRT29	09/11/2001	346.7
CENTBSRT28	06/13/2001	42321.2	CENTBSRT29	10/10/2001	337.2
CENTBSRT28	07/09/2001	637.6	CENTBSRT29	08/16/2000	299.8
CENTBSRT28	07/23/2001	5541.2	CENTBSRT29	04/02/2007	1550.0
CENTBSRT28	08/14/2001	1461.9	CENTBSRT29	04/02/2007	1300.0
CENTBSRT28	09/11/2001	1568.4	CENTBSRT29	10/24/2006	41.9
CENTBSRT28	10/10/2001	7822.4	CENTBSRT29	09/13/2006	980.0
CENTBSRT28	04/02/2007	1050.0	CENTBSRT29	08/08/2006	687.0
CENTBSRT28	10/24/2006	192.0	CENTBSRT29	07/13/2006	488.0
CENTBSRT28	09/13/2006	2420.0	CENTBSRT29	06/08/2006	23.5
CENTBSRT28	08/08/2006	2420.0	CENTBSRT29	05/03/2006	167.0
CENTBSRT28	07/13/2006	345.0	CENTBSRT29	04/05/2006	12.1
CENTBSRT28	06/08/2006	435.0	CENTBSRT29	10/25/2005	44.3
CENTBSRT28	06/08/2006	161.0	CENTBSRT29	04/17/2007	13.1
CENTBSRT28	05/03/2006	411.0	CENTBSRT29	05/23/2007	413.2
CENTBSRT28	04/05/2006	27.5	CENTBSRT29	06/21/2007	667.4
CENTBSRT28	10/25/2005	90.9	CENTBSRT29	07/19/2007	226.0
CENTBSRT28	04/17/2007	14.6	CENTBSRT29	08/22/2007	539.1
CENTBSRT28	05/23/2007	403.7	CENTBSRT29	09/19/2007	413.2
CENTBSRT28	06/21/2007	687.3	CENTBSRT29	10/10/2007	216.9
CENTBSRT28	07/19/2007	2772.5	CENTBSRT29	04/08/2008	6.2
CENTBSRT28	08/22/2007	1146.6	CENTBSRT29	05/07/2008	6.2
CENTBSRT28	09/19/2007	1043.0	CENTBSRT29	06/11/2008	102.0
CENTBSRT28	09/19/2007	940.2	CENTBSRT29	07/08/2008	68.3
CENTBSRT28	10/10/2007	1251.0	CENTBSRT29	08/13/2008	52.0
CENTBSRT28	10/10/2007	1783.0	CENTBSRT29	09/09/2008	28.3
CENTBSRT28	04/08/2008	6.2	CENTBSRT29	10/09/2008	413.2

Log transformed *E. coli* samples were correlated with log transformed fecal coliform samples. The resulting relationship was strong and was used to model *E. coli* concentrations from unpaired fecal coliform samples (Figure 3).

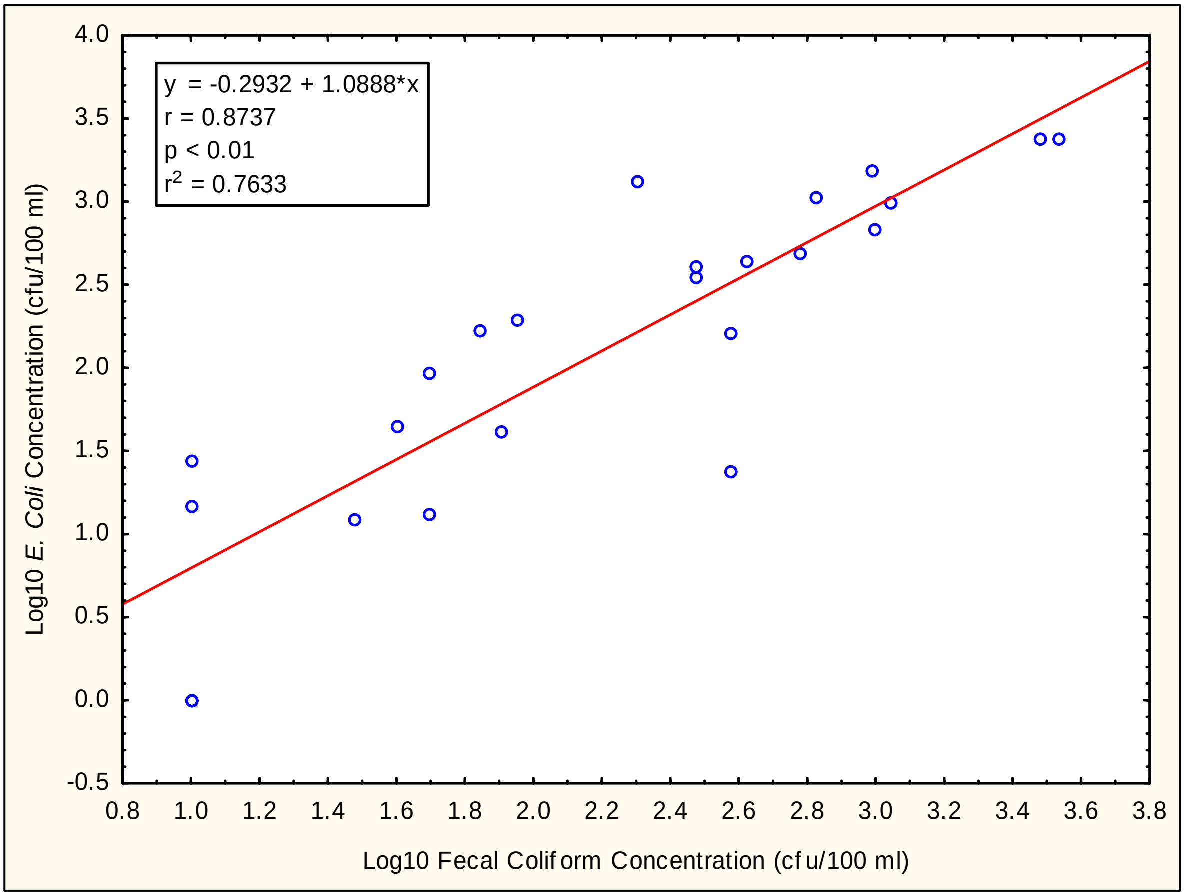

Figure 3: *E. coli* - fecal coliform regression relationship.

3.3 Flow Analysis

Flow data was collected at both T28 and T29 (Figures 4 and 5). In addition to this the USGS operates a gaging station (06482610) along Split Rock Creek near Corson, SD (Figure 6) and flow data was collected from Split Rock Creek near Sherman, SD. An Aquarius model was built using flow data from T28, T30 and USGS flow data. Flow data was used from T28 because it was found to be more reliable than flow data collected from T29. USGS flow data did not overlap with T28 flow data. T28 ended on 9/30/ 2001 and the USGS flow data started on 10/1/2001. Data collected from T30 overlapped with USGS flow data for the month of November 2001 and was corrected to better match USGS flow data within Aquarius. After this was completed, corrected T30 data was correlated with T28 data and a non-linear artificial neural model was created from the relationship. Flow data from USGS gaging station 06482610 collected from 10/1/2001 to 10/16/2011 was used as a surrogate to model a flow record for T28. The entire flow record from 06482610 was not used because it was desired that flow data would represent land use characteristics during the sampling decade. The modeled flow record for T28 was used to represent the impaired reach.

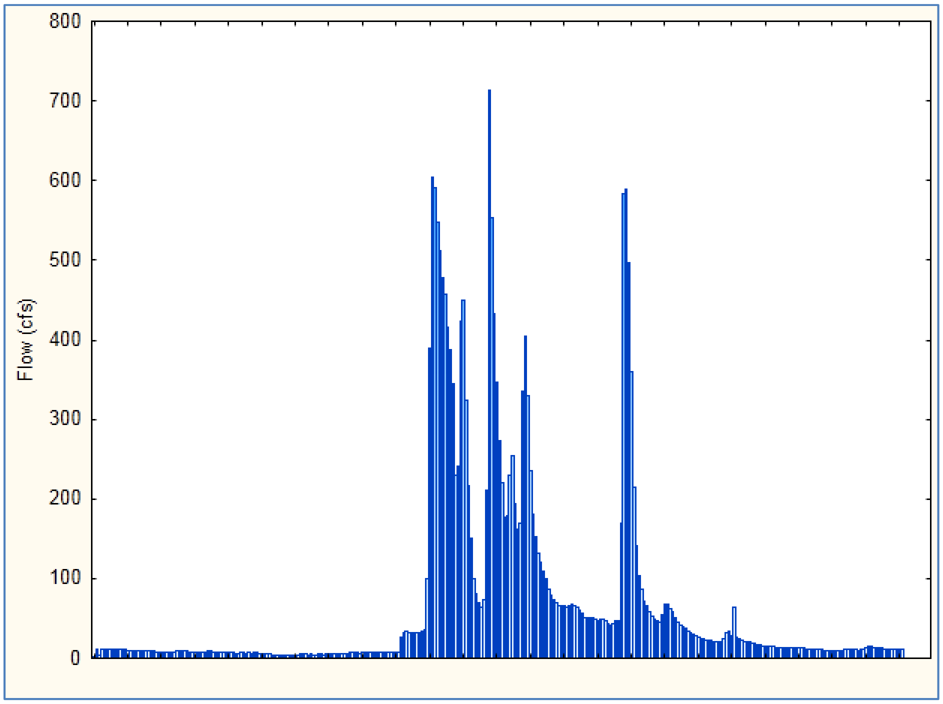

Figure 4: Flow record from T28 from 7/5/2000 to 9/30/2001.

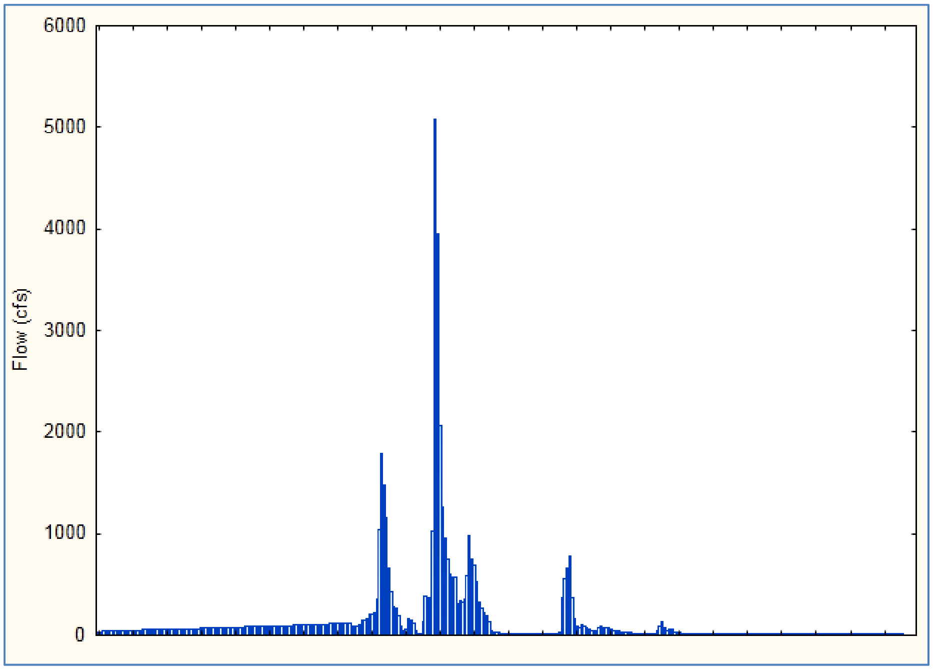

Figure 5: Flow record from T30 from 7/5/2000 to 10/31/2001.

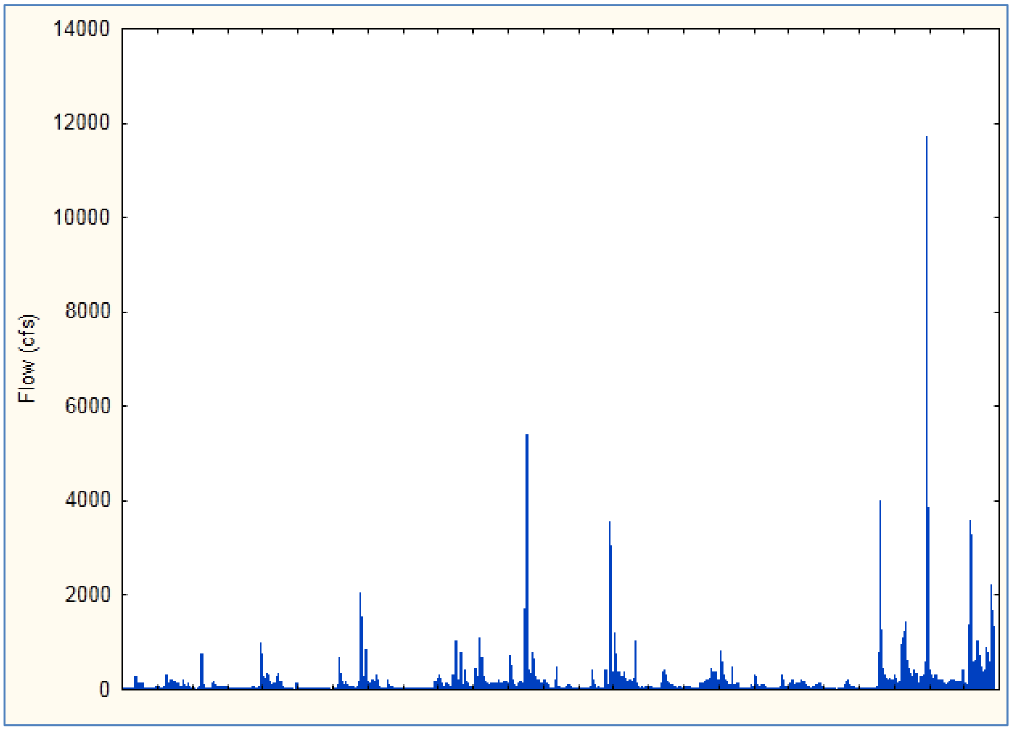

Figure 6: Flow record from USGS gage station 06482610 from 10/1/2001 to 10/16/2011.

This TMDL was developed using the Load Duration Curve (LDC) approach that results in a flow-variable target that considers the entire flow regime (Figure 7). The LDC is a dynamic expression of the allowable load for a given flow. Paired flow - *E. coli* samples from 2000, 2001, 2006, 2007, and 2008 were used to create a load duration curve. To aid in interpretation and implementation of the TMDL, the LDC flow intervals were grouped into five flow zones representing high flows (0-10 percent), moist conditions (10-40 percent), mid-range flows (40-60 percent), dry conditions (60-90 percent), and low flows (90-100 percent) (USEPA 2006).

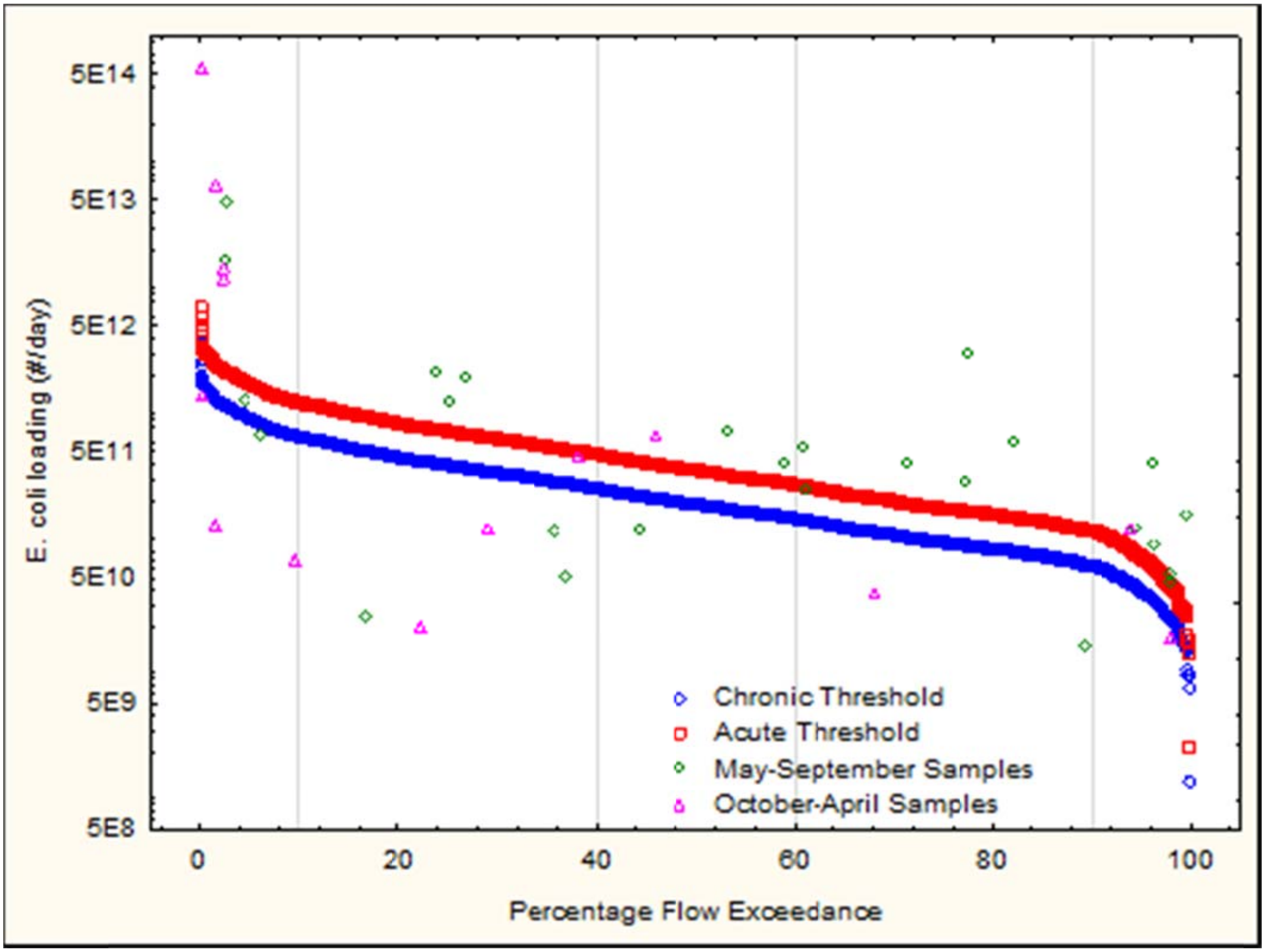

Figure 7: Load duration curve for T29.

4.0 Significant Sources

4.1 Point Sources
There are no point sources within the Pipestone Creek watershed.

4.2 Nonpoint Sources
Nonpoint pollution of *E. coli* in Pipestone Creek comes primarily from agricultural sources. Data from the 2003 and 2009 National Agricultural Statistic Survey (NASS) and from the 2002 South Dakota Game Fish and Parks county wildlife assessment were utilized for livestock and wildlife densities, respectively. Animal density information (Table 4) was used to estimate relative source contributions of bacteria loads.

4.2.1 Agriculture
Manure from livestock is a potential source of *E. coli* to the stream. Livestock in the basin are predominantly hogs and beef cattle. Livestock can contribute *E. coli* bacteria directly to the stream by defecating while wading in the stream. They also can contribute by defecating while

grazing on rangelands that get washed off during precipitation events. Table 4 allocates the sources for bacteria production in the watershed into four primary categories. The summary is based on several assumptions. Feedlot numbers were calculated as the sum of all dairy, hog, and the NASS estimate of beef in feeding areas. All remaining livestock were assumed to be on grass.

Table 4: *E. coli* source allocation for Pipestone Creek.

Source	Percentage
Feedlots	37%
Livestock on Grass	63%
Wildlife	< 0.01%
Human	< 0.01%

4.2.2 Natural background/wildlife

Wildlife within the watershed is a natural background source of *E. coli* bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (Table 5). Wildlife contributes 0.001% of the total *E. coli* load.

4.2.3 Human

An estimated 33 septic systems occur along Pipestone Creek within South Dakota. Data does not exist on the condition of such systems. Human density was estimated from the 2010 census and an estimated *E. coli* load was generated. The estimated loading is likely an overestimation of human contribution assuming that most of the waste is handled by municipalities and most septic systems are operating correctly.

Table 5: Pipestone Creek potential nonpoint sources.

Species	#/sq mile	#/acre	FC/Animal/Day	Fecal Coliform Daily Load (cfu/acre)	Percent
Dairy	8.08151	0.013	4.46E+10	5.63E+08	< 0.01
Hogs	45.4781	0.071	1.08E+10	7.67E+08	< 0.01
All other Cattle	78.7169	0.123	1.40E+14	1.72E+13	> 99.9
Sheep	5.9948	0.009	1.96E+10	1.84E+08	< 0.01
Horses	1.64235	0.003	5.15E+10	1.32E+08	< 0.01
Chicken[7]	4.01269	0.006	1.40E+08	8.78E+05	< 0.01
Human	12.4803	0.02	2.00E+09	3.90E+07	< 0.01
All Wildlife	Sum of all Wildlife			1.16E+08	< 0.01
Deer[3]	3.88421	0.006	3.47E+08	2.11E+06	
Turkey[1]	0.18153	3E-04	9.50E+07	2.69E+04	
Opossom[5]	2.55415	0.004	2.50E+08	9.98E+05	
Mink[5]	1.90732	0.003	2.50E+08	7.45E+05	
Beaver[3]	1.90805	0.003	2.00E+05	5.96E+02	
Muskrat[1]	5.81442	0.009	2.50E+07	2.27E+05	
Skunk[5]	5.40207	0.008	2.50E+08	2.11E+06	
Badger[5]	0.82544	0.001	2.50E+08	3.22E+05	
Coyote[4]	0.30829	5E-04	1.75E+09	8.43E+05	
Fox[4]	1.53278	0.002	1.75E+09	4.19E+06	
Raccoon[3]	4.05521	0.006	2.00E+05	1.27E+03	
Jackrabbit[5]	0.85716	0.001	2.50E+08	3.35E+05	
Cottontail[5]	23.4236	0.037	2.50E+08	9.15E+06	
Squirrel[5]	19.8222	0.031	2.50E+08	7.74E+06	
Partridge[2]	8.27293	0.013	1.40E+08	1.81E+06	
Canada Goose[6]	1.11945	0.002	4.90E+10	8.57E+07	

1 USEPA 2001

2 FC/Animal/Day copied from chicken (USEPA 2001) to provide an estimate of background affects of wildlife

3 Bacteria Indicator Tool worksheet

4 Best professional judgment based off of dogs

5 FC/Animal/Day copied from raccoon to provide a more conservative estimate of background affects of wildlife

6 FC/Animal/Day copied from goose (USEPA 2001) to provide an estimate of background effects of wildlife

7 Data from 2003 NASS

5.0 Boundary Conditions

T28 occurs near the Minnesota border where Pipestone Creek enters South Dakota. It was considered a boundary condition in respect to this document. All five flow zones were populated with 52 samples and a load duration curve was generated (Figure 8). *E. coli* concentrations occurring at this site largely originate from Minnesota.

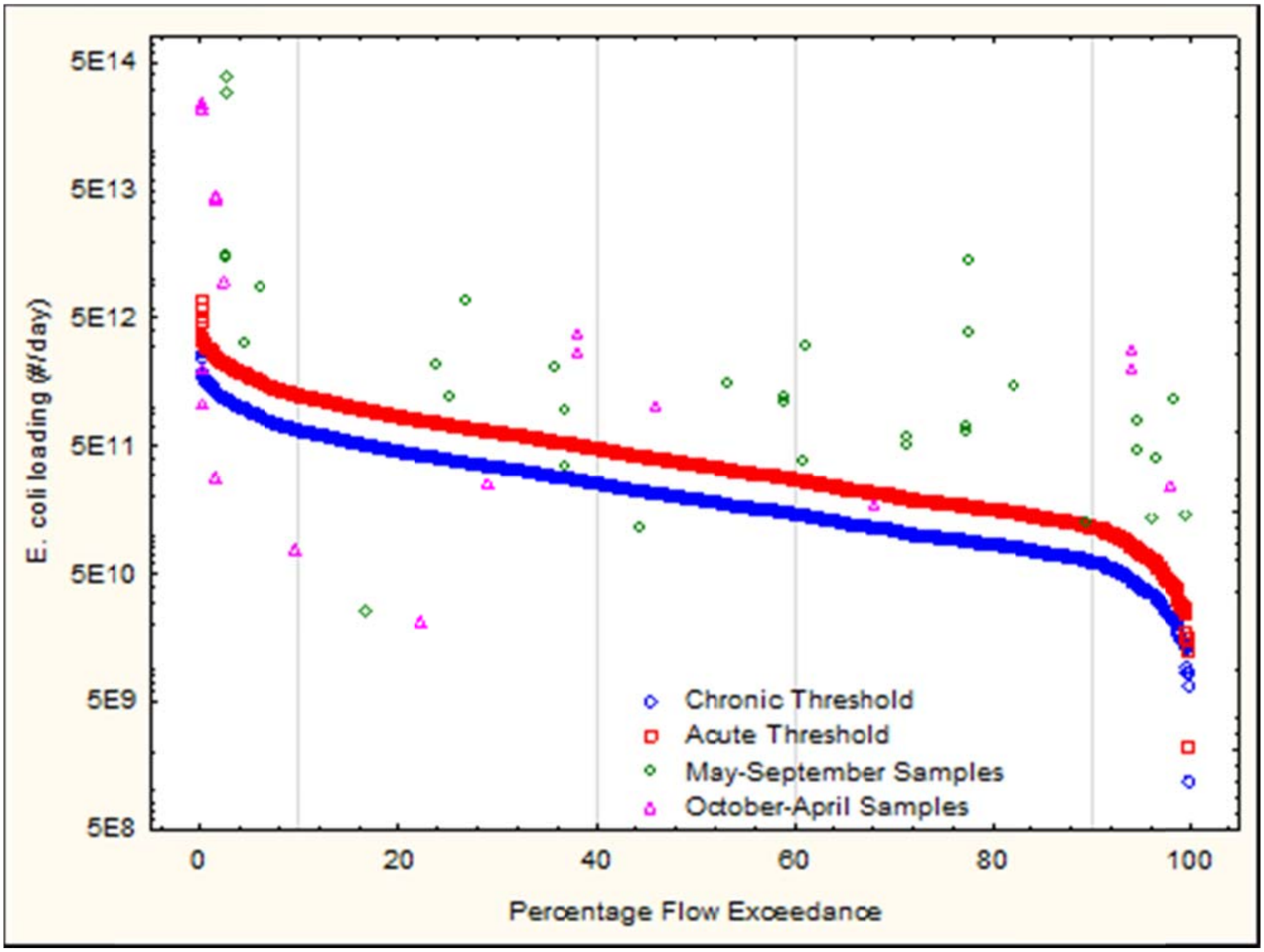

Figure 8: Boundary condition load duration curve.

Load reductions were required in all flow zones in order to meet the chronic threshold. The highest reduction was needed in the high flow zone (Table 6).

Table 6: Boundary conditions at T28.

Flow Zone	High	Moist Condition	Mid-Range	Dry	Low Flow
CFS	≥ 212.67	82.64 - 212.62	47.54 - 82.4	20.51 - 47.54	≤ 20.04
TMDL	8.45E+14	1.23E+14	1.94E+13	6.32E+12	1.24E+12
MOS	2.57E+11	1.32E+11	4.37E+10	3.14E+10	3.90E+10
LA	8.45E+14	1.23E+14	1.94E+13	6.29E+12	1.20E+12
Load Reduction (%)	99	89	84	98	97

6.0 TMDL and Calculations

6.0.1 High Flows

The high flow zone includes flows that exceed 213 cfs. Eleven samples were collected in the high flow zone. Of these one exceeded the chronic threshold but not the acute standard and six exceeded the chronic threshold and acute standard. A loading reduction of 99% is needed to bring *E. coli* concentrations into compliance with the chronic threshold. Table 7 depicts a TMDL for a flow of 517 cfs, which is the 95th percentile flow for high flows. Higher or lower flows within this zone may acceptably carry higher or lower flows as long as the concentration does not exceed the state standard.

The concentration of 235 cfu/100 ml represents the acute standard threshold. This may make an appropriate target because flows in excess of 213 cfs typically last for short periods of time.

While the acute threshold would have made an appropriate goal, a chronic threshold of 126 cfu/100 ml was used. Chronic exceedences are not likely in this flow zone but using the chronic threshold helps to ensure that water quality violations will be less likely.

Table 7: TMDL calculation for high flows for Pipestone Creek.

	Flow Zone (expressed as cfu/day)	
	High Flows	
	> 213 cfs	
LA	8.24E+14	Remaining load after deducting MOS and WLA from TMDL.
WLA	0	
MOS	2.55E+11	
TMDL @ 126 cfu/100 ml	8.24E+14	Standard multiplied by 95th% flow by zone.
Current Load	1.65E+17	95th% of observed *E. coli* bacteria loads for each zone multiplied by 95th% flow for zone.
Load Reduction	99%	Reduction of *E. coli* loading required of current loads to equal the load at the standard.

6.0.2 Moist Conditions

The moist condition flow zone occurs from 83 to 213 cfs. Within this flow zone nine samples were collected. Four samples exceeded both the chronic threshold and the acute standard. At a flow of 200 cfs (95th percentile flow) a load reduction of 70% will be needed to bring *E. coli* concentrations into compliance with the chronic standard (Table 8). Using the chronic threshold as a target helps to ensure that both the acute and chronic standards will not be violated. Flows higher or lower than 200 cfs can acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Table 8: TMDL calculation for moist conditions for Pipestone Creek.

	Flow Zone (expressed as cfu/day)	
	Moist Conditions	
	83 – 213 cfs	
LA	1.23E+14	Remaining load after deducting MOS and WLA from TMDL.
WLA	0	
MOS	1.33E+11	
TMDL @ 126 cfu/100 ml	1.23E+14	Standard multiplied by 95th% flow by zone.
Current Load	4.16E+14	95th% of observed *E. coli* bacteria loads for each zone multiplied by 95th% flow for zone.
Load Reduction	70%	Reduction of *E. coli* loading required of current loads to equal the load at the standard.

6.0.3 Mid-Range Flows

The mid-range flow zone is characterized by discharges ranging from 48 to 82 cfs.
Four samples were collected within the mid-range flow zone. Three samples exceeded both the chronic threshold and the acute standard. A reduction of 67% will be needed to meet the chronic threshold. A flow of 79 cfs (95th percentile) was used in calculating the TMDL (Table 9). Higher or lower flows can carry higher or lower loads as long as concentrations do not violate state standards.

Table 9: TMDL calculation for mid-range conditions for Pipestone Creek.

	Flow Zone (expressed as cfu/day)	
	Mid-Range Conditions	
	48 – 82 cfs	
LA	1.94E+13	Remaining load after deducting MOS and WLA from TMDL.
WLA	0	
MOS	4.37E+10	
TMDL @ 126 cfu/100 ml	1.94E+13	Standard multiplied by 95th% flow by zone.
Current Load	5.86E+13	95th% of observed *E. coli* bacteria loads for each zone multiplied by 95th% flow for zone.
Load Reduction	67%	Reduction of *E. coli* loading required of current loads to equal the load at the standard.

6.0.4 Dry Conditions

Dry conditions encompass flows of 21 to 48 cfs. Eight samples were collected within the flow zone. One samples exceeded the chronic threshold but not the acute standard and five exceeded both the chronic threshold and the acute standard. A flow of 45 cfs (95th percentile) was used in calculating the TMDL (Table 10). A reduction of 94% is needed to meet the chronic threshold. We chose to use the chronic threshold as a target as it helps ensure that both the chronic and the acute standards will be met. Higher or lower flows within the dry condition zone may acceptably carry higher or lower loads as along as the concentration does not exceed state standards.

Table 10: TMDL calculation for dry conditions for Pipestone Creek.

	Flow Zone (expressed as cfu/day)	
	Dry Conditions	
	21 – 48 cfs	
LA	6.29E+12	Remaining load after deducting MOS and WLA from TMDL.
WLA	0	
MOS	3.14E+10	
TMDL @ 126 cfu/100 ml	6.32E+12	Standard multiplied by 95th% flow by zone.
Current Load	9.86E+13	95th% of observed *E. coli* bacteria loads for each zone multiplied by 95th% flow for zone.
Load Reduction	94%	Reduction of *E. coli* loading required of current loads to equal the load at the standard.

6.0.5 Low Flows

Low flows occur from 0 to 21 cfs. Eight samples were collected from this flow zone. Seven samples exceeded both the chronic threshold but the acute standard. An 81% reduction is needed to meet the chronic threshold based on the available data. A flow of 20 cfs (95th percentile) was used in calculating the TMDL (Table 11). Higher or lower flows within this zone may acceptably carry higher or lower loads as long as state standards are not violated.

Table 11: TMDL calculation for low flows for Pipestone Creek.

	Flow Zone (expressed as cfu/day)	
	Low Flows	
	< 21 cfs	
LA	1.20E+12	Remaining load after deducting MOS and WLA from TMDL.
WLA	0	
MOS	3.89E+10	
TMDL @ 126 cfu/100 ml	1.24E+12	Standard multiplied by 95th% flow by zone.
Current Load	6.57E+12	95th% of observed *E. coli* bacteria loads for each zone multiplied by 95th% flow for zone.
Load Reduction	81%	Reduction of *E. coli* loading required of current loads to equal the load at the standard.

6.1 Wasteload Allocations (WLAs)

There are no point sources within this watershed. A WLA of 0 was therefore used in the TMDL calculation.

6.2 Load Allocations (LAs)

Approximately 99% of the watershed is comprised of agricultural land use. *E. coli* loading is attributed to these sources. Site T29 occurs within the lower part of the watershed. In the high flow zone at this site a reduction of 99% will be needed to meet the chronic threshold. A 70% reduction is needed in the moist condition flow zone. A 67% reduction is needed in the mid-range flow zone. A reduction of 94% is needed in the dry condition zone. A reduction of 81% is needed in the low flow zone.

7.0 Seasonality

T28 and T29 displayed distinct seasonality in terms of *E. coli* concentrations and flow. Flow tended to rise in late winter and peak during the spring (Figure 9). *E. coli* concentrations were higher June through September. Snow cover and spring runoff lead to increased flows during late winter and early spring. Spring showers create runoff which carries fecal matter into Pipestone Creek resulting in elevated *E. coli* concentrations. Summer is also a time of peak recreational use of Pipestone Creek. This fact coupled with elevated *E. coli* concentrations makes summer a critical time in which to reduce loading.

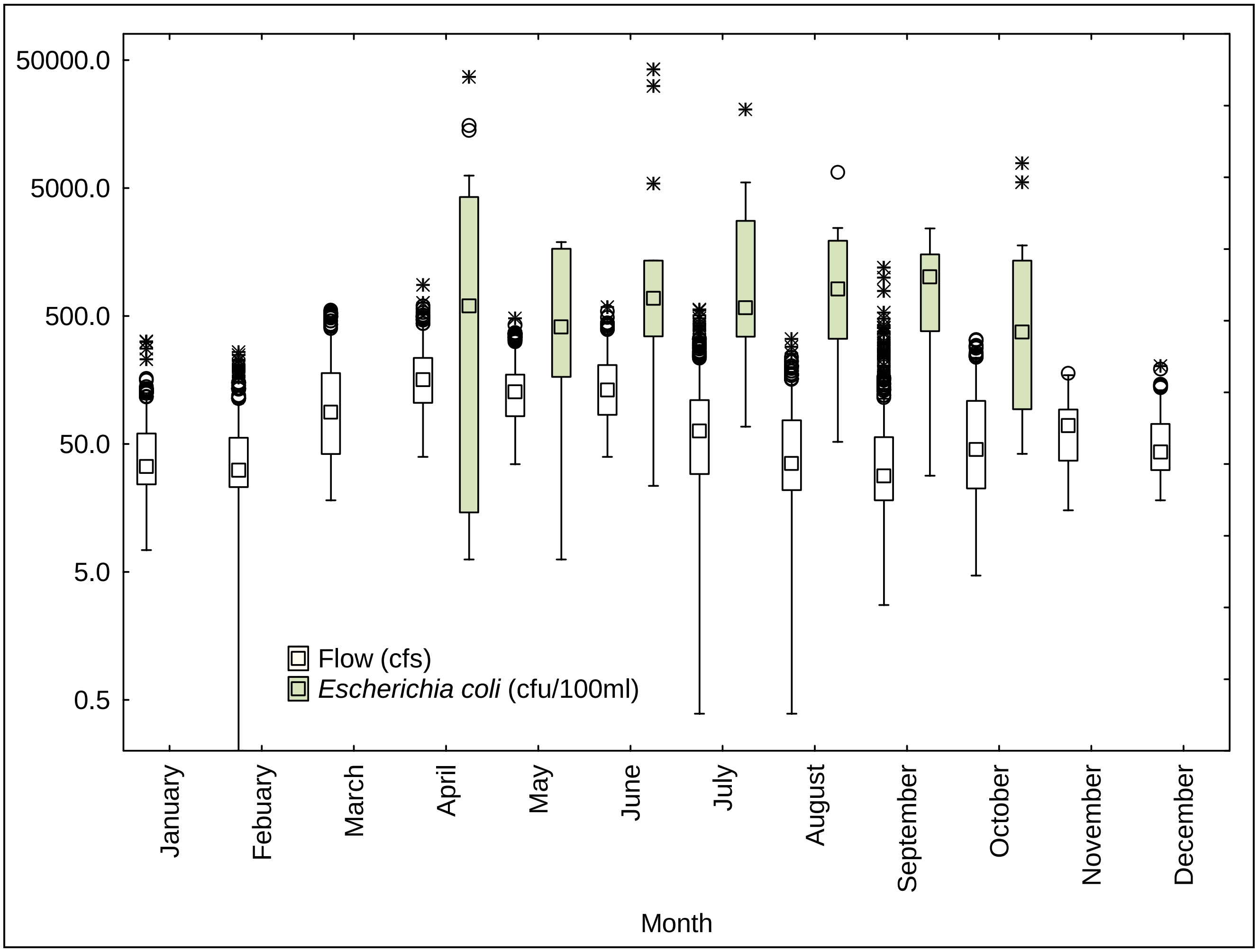

Figure 9: Seasonality of flow and *E. coli* concentrations.

8.0 Margin of Safety (MOS)

An explicit MOS identified using a duration curve framework is basically unallocated assimilative capacity intended to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). An explicit MOS was calculated as the difference between the loading capacity at the mid-point of each of the flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone as compared to the mid-point. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.

9.0 Follow-Up Monitoring and TMDL Review

The department may adjust the load allocations in this TMDL to account for new information or circumstances that are developed or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment of the load allocation will only be made following an opportunity for public participation. New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information and land use information. The department will propose adjustments only in the event that any adjusted LA will not result in a change to the loading capacity; the adjusted TMDL, including load allocations, will be set at a level necessary to implement the applicable water quality standards. The department will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

The Central Big Sioux River Implementation Project is currently assessing project effectiveness with models such as AnnAGNPS, RUSLE2, and STEPL. Water quality monitoring is not currently being done on this stream although occasional sampling may occur.

10.0 Restoration Strategy

Currently there is an implementation project targeting areas outlined by the Central Big Sioux River Implementation Project. Project goals for improving *E. coli* bacteria impairment include: reduced access to streams for livestock, increase alternative watering sources for livestock, rotational grazing, riparian management, and seventy-five animal waste management systems.

If the above mentioned BMPs are implemented in the Pipestone Creek watershed there is likelihood that the TMDL can be achieved.

11.0 Public Participation

Efforts were taken to gain public education, review, and comment during the development of the TMDL involved:

1. Various public meetings were held during the Central Big Sioux River Assessment phase.
2. A webpage was developed and used during the course of the assessment.
3. Presentations were given to local groups on findings of the assessment.
4. 30-day public notice (PN) period for public review and comment was used. A Public Notice was published in the Sioux Falls Argus Leader, Brookings Register, and the Moody County Enterprise.

12.0 Literature Cited

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