ESCHERICHIA COLI TOTAL MAXIMUM DAILY LOAD EVALUATION FOR WOLF CREEK, HUTCHINSON COUNTY, SOUTH DAKOTA

South Dakota Department of
Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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Wolf Creek Total Maximum Daily Load Summary Table

Entity ID:	SD-JA-R-WOLF-01
Location:	HUC Code: 10160010
Size of Watershed:	255,600 acres total
Waterbody Type:	Stream
303(d) Listing Parameter:	*Escherichia coli*
Initial Listing date:	2012 IR
TMDL Priority Ranking:	1
Listed Stream Miles:	41 miles from just above the Wolf Creek colony to S5, T103N, R56W
Designated Use of Concern:	Limited contact recreation
Analytical Approach:	Aquarius, EDNA, Load Duration Curve Framework
Target:	Meet all applicable water quality standards
Indicators:	*Escherichia coli* Concentration
Threshold Value:	<630 colonies/100 ml geometric mean concentration with maximum single sample concentrations of <1,178 colonies/100 ml
High Flow Zone LA:	2.02×10^{13} cfu/day
High Flow Zone WLA:	Bridgewater: 4.90×10^{10} cfu/day
	Emery: 6.69×10^{10} cfu/day
High Flow Zone MOS:	2.46×10^{12} cfu/day
High Flow Zone TMDL:	2.28×10^{13} cfu/day

Wolf Creek Total Maximum Daily Load Summary Table

Entity ID:	SD-JA-R-WOLF-02
Location:	HUC Code: 10160010
Size of Watershed:	255,600 acres total
Waterbody Type:	Stream
303(d) Listing Parameter:	*Escherichia coli*
Initial Listing date:	2012 IR
TMDL Priority Ranking:	1
Listed Stream Miles:	3.35 miles from the mouth to just above the Wolf Creek Colony
Designated Use of Concern:	Limited contact recreation
Analytical Approach:	Aquarius, EDNA, Load Duration Curve Framework
Target:	Meet all applicable water quality standards
Indicators:	*Escherichia coli* Concentration
Threshold Value:	<630 colonies/100 ml geometric mean concentration with maximum single sample concentrations of <1,178 colonies/100 ml
High Flow Zone LA:	2.03×10^{13} cfu/day
High Flow Zone WLA:	0 cfu/day
High Flow Zone MOS:	2.46×10^{12} cfu/day
High Flow Zone TMDL:	2.28×10^{13} cfu/day

1.0 Introduction:

The intent of this document is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate 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 EPA. This TMDL document addresses the total *Escherichia coli* (*E. coli*) impairments of Wolf Creek from the mouth of Wolf Creek to just above the Wolf Creek Colony (SD-JA-R-WOLF_01) and from just above the Wolf Creek Colony to S5, T103N, R56W (SD-JA-R-WOLF_02).

1.1 Watershed Characteristics

Wolf Creek drains about 255,600 acres in southeast South Dakota (Figure 1) and discharges to the James River southwest of the community of Bridgewater (Figure 2). The stream receives runoff from agricultural operations. During the assessment and monthly monitoring as part of the ambient water quality program, data was collected indicating the creek experiences periods of degraded water quality as a result of *E. coli* loads. The land use in the watershed is predominately agricultural consisting of 59% row crops, 23% grass, 6% developed (including farmsteads, roads, and small communities), 4% herbaceous, 4% close seeded/small grain, and 3% water and wetlands.

There are four small communities within the watershed that have permitted wastewater treatment facilities. These include Canova, Spencer, Emery, and Bridgewater.

The Wolf Creek watershed lies within Hutchinson (23%), Hanson (10%), McCook (52%), and Miner (15%) counties. In Hutchinson County, common soil associations on the uplands in this section of the drainage include the Clarno-Tetonka-Prosper and the Hand-Clarno-Davison associations. Soil associations found in the floodplain of the stream include the Ethan-Betts-Chaska association. Most areas of this association are maintained as pasture land. Some bottomland is used for agricultural production (USDA, 1978). McCook County upland soil associations include Clarno-Bonilla-Tetonka, Crossplain-Clarno-Tetonka, and Clarno-Ethan associations. Associations found in the floodplain of the section located in McCook County include the Ethan-Betts and Delmont-Hand-Chaska soil associations (USDA, 1980).

Wolf Creek's climate is considered humid continental and approaches semi-arid in some years. Temperatures range from over 100° to -30°. Most of the precipitation falls during the warm period, and rainfall is normally heaviest late in spring and early in summer. Average annual precipitation is 23 inches, of this, 18 inches usually falls in April through September. Snowfall accumulations typically total 36.6 inches annually (USDA, 1978).

Wolf Creek was assessed as an individual portion of the larger Lower James River Watershed Assessment, which looked at individual streams such as Wolf Creek as well as the entire drainage basin and the cumulative effects of the individual waterbodies. There are also two ambient water quality monitoring stations located on Wolf Creek.

Segments SD-JA-R-WOLF_01 and SD-JA-R-WOLF_02 were listed for *E. coli* in the 2012 Integrated Report (SDDENR, 2012). This TMDL will address the *E. coli* listings.

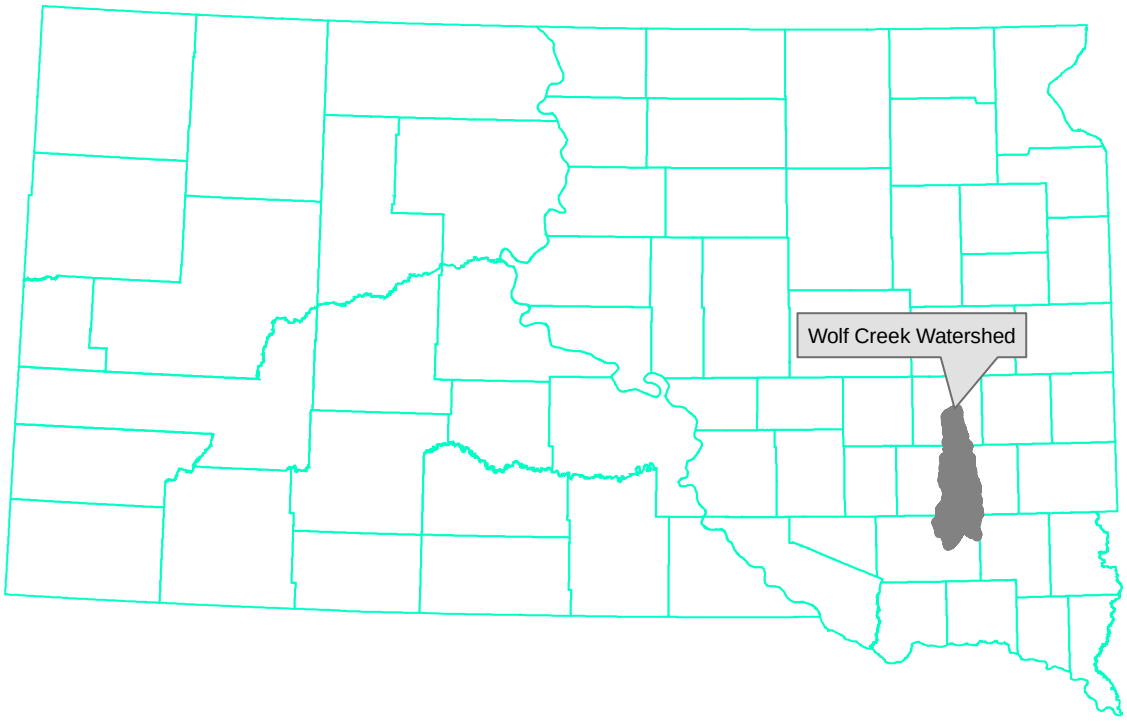

Figure 1. Wolf Creek Watershed Location in South Dakota.

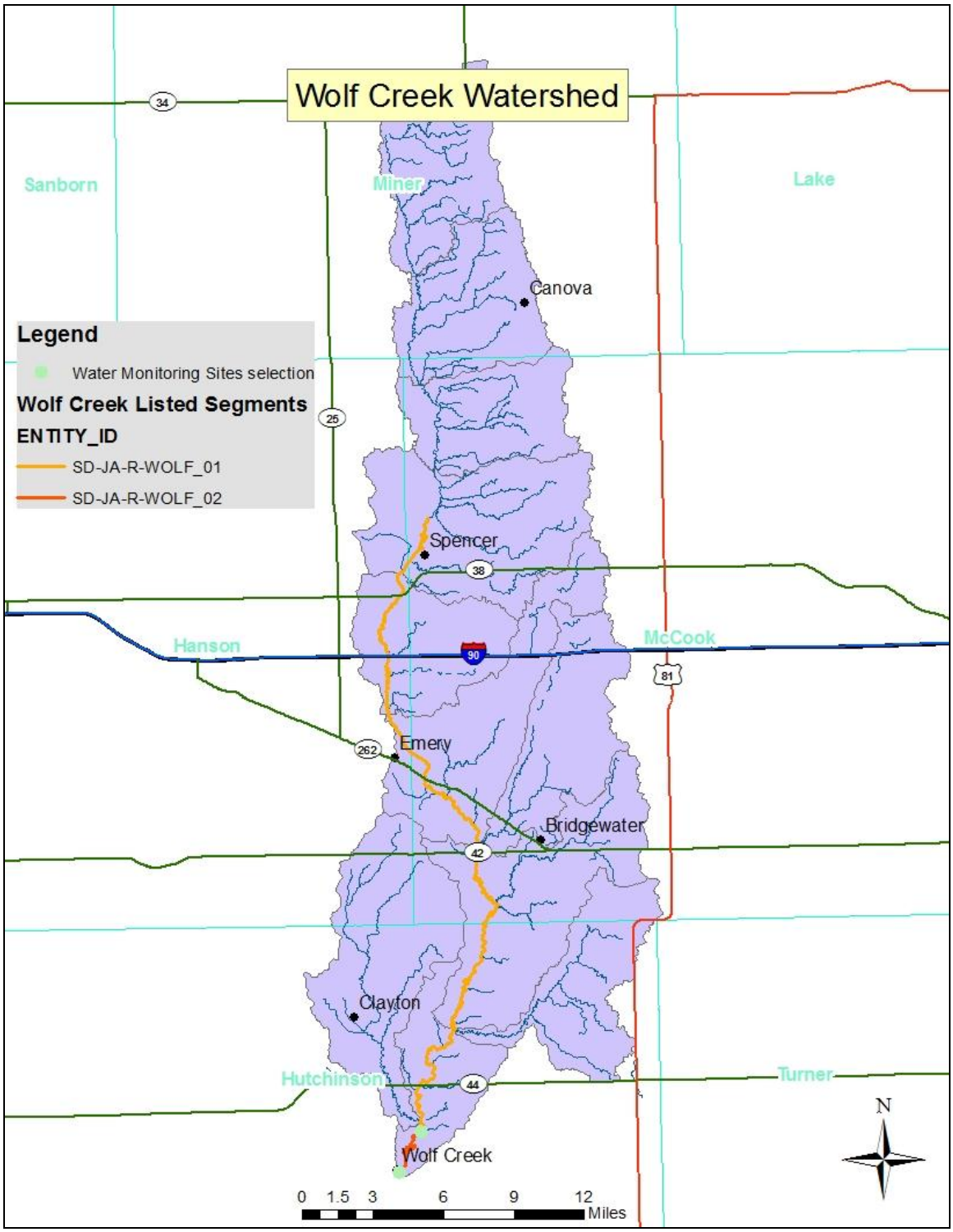

Figure 2. Wolf Creek Watershed.

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.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the states water quality standards, this is the method used in the states 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; and 09". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, nuisance aquatic life, and maintain biological integrity.

Wolf Creek has been assigned the beneficial uses of: warmwater marginal fish life propagation; irrigation waters, 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 Wolf Creek is 630 cfu/100 ml, which is based on the chronic standard for *E. coli*. The *E. coli* criteria for the limited contact recreation beneficial use requires that 1) no sample exceeds 1,178 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 630 cfu/100 ml. These criteria are applicable from May 1 through September 30.

Individual parameters determine the support of beneficial uses and compliance with standards. The most restrictive of each of these standards that apply to Wolf Creek are listed in Table 1.

Table 1. State Water Quality Standards for Wolf 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/L 30 average May 1 to October 31	Warmwater Marginal Fish 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 31	
	Equal to or less than the result from Equation c in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Dissolved Oxygen	≥4.0 (October-April) ≥5.0 (May-September)	mg/L	Warmwater Marginal Fish Propagation
Total Suspended Solids	≤150(mean) ≤263 (single sample)	mg/L	Warmwater Marginal Fish Propagation
Temperature	≤32	°C	Warmwater Marginal Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	≤1000 (geometric mean) ≤2000 (single sample)	count/100 mL	Limited Contact Recreation
Escherichia coli Bacteria (May 1- Sept 30)	≤630 (geometric mean) ≤1178 (single sample)	count/100 mL	Limited Contact Recreation
Alkalinity ($CaCO_3$)	≤750 (mean) ≤1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Conductivity	≤2,500 (mean) ≤4,375 (single sample)	µhos/cm @ 25° C	Irrigation Waters
Nitrogen, nitrate as N	≤50 (mean) ≤88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
pH (standard units)	≥6.0 to ≤9.0	units	Warmwater Marginal Fish Propagation
Solids, total dissolved	≤2,500 (mean) ≤4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon Oil and Grease	≤10 ≤10	mg/L	Wildlife Propagation and Stock Watering
Sodium Adsorption Ratio	<10	ratio	Irrigation Waters

3.0 Significant Sources

3.1 Point Sources

There are four permitted facilities in the watershed, however all these are either zero discharge or unlikely to discharge frequently. The cities of Emery, Bridgewater, and Canova are allowed to discharge to Wolf Creek. Spencer wastewater treatment facility is operated as a no-discharge facility.

The city of Canova's facility has discharged three times since 1999. The facility discharges into an unnamed wetland that drains into an unnamed tributary of Wolf Creek. Canova is located near the headwaters of Wolf Creek, over 15 stream miles north of the listed segment. The Canova facility is being upgraded to an entire retention system. This will eliminate its potential effect on Wolf Creek and will not be included as a portion of this TMDL.

The city of Emery's facility reported discharging twelve times since 2001. During the development of the NPDES/Surface Water Discharge permit for the facility, the potential impacts on the downstream segments were considered. This is a single cell bi-level stabilization pond system that serves the city of Emery with a population of 439 people. This facility is being upgraded to accommodate three total ponds but will still be allowed to discharge.

The city of Bridgewater's facility discharged seven times since 2001. This system consists of a three-cell stabilization pond followed by two artificial wetlands. This facility serves a population of 607 people. Neither facility can discharge until permission is granted by the SD DENR.

Table 2 includes the basic system information and permit numbers for each facility within the basin.

Table 2. Permitted Facilities within the Wolf Creek Drainage

Permit Number	Facility Name	System comments	Pond 1 (acres)	Pond 2 (acres)	Pond 3 (acres)	Wtlnd 1 (acres)	Wtlnd 2 (acres)
SD0020397	Spencer	Pond/wetland system	3	3		3.4	
SD0021512	Bridgewater	Pond/wetland system	4	3	1.9	2.5	2.5
SD0021521	Canova	Pond system	2.9				
SD0021741	Emery	Pond system	6.4				

Table 3 includes information used by SDDENR to calculate a maximum allowable discharge from each facility. The 80th percentile wastewater flow as reported on the discharge monitoring reports is multiplied times the acute water quality standard and then

converted to cfu/day. It is important to note that all discharges are required to meet state water quality concentration standards.

Table 3. Waste Load Allocation for Facilities in the Wolf Creek Drainage. Canova and Spencer will both be represented as zeros in the WLA of the TMDL.

Facility Name	80th% Flow (gpd) used in WLA	*E. coli* permit limit (cfu/100 mL)	*E. coli* permit limit converted to cfu/g	*E. coli* WLA (cfu/day)
Bridgewater	1100000	1178	44621	4.90E+09
Canova	*0	*No discharge	*0	*0
Emery	1500000	1178	44621	6.69E+10
Spencer	*0	*No discharge	*0	*0

3.2 Non-point Sources

Nonpoint sources of *E. coli* bacteria in the Wolf Creek watershed come primarily from agricultural sources. Data from the 2010 National Agricultural Statistic Survey (NASS) and the 2002 South Dakota Game Fish and Parks county wildlife assessment (Huxoll, 2002) were utilized for livestock and wildlife densities, respectively. Animal density information was used to estimate relative source contributions of bacteria loads (Table 5).

3.2.1 Agriculture

Manure from livestock is a potential source of *E. coli* bacteria to the stream. Livestock in the basin are predominantly beef cattle and hogs. Livestock can contribute bacteria directly to the stream by defecating while wading in the stream. They can also contribute by defecating while grazing on rangelands that get washed off during precipitation events. Table 4 allocates sources of bacteria production in the watershed into three 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 grazing land.

Table 4. *E. coli* source allocation for Wolf Creek watershed including county wide breakdowns. No portion of Miner County is located within any listed segment.

Source	Entire Watershed	Hanson County	Hutchinson County	McCook County	Miner County*
	Percentages (%)				
Feedlots	38.62	43.18	45.14	39.12	19.60
Grazing Livestock	60.99	56.36	54.61	60.53	79.69
Wildlife	0.39	0.46	0.25	0.35	0.71

The main source of *E. coli* bacteria in the Wolf Creek watershed is livestock from a combination of feedlots and grazing. Bacteria migration from feedlots and upland grazing is most likely occurring during major run-off events. Direct use of the stream by livestock is the most likely source of bacteria at low flows. Evidence of this is available in the load duration curves which indicate that elevated counts of *E. coli* occur throughout different

flow regimes. Beef cattle and hogs were found to contribute the most significant amount of bacteria to the Wolf Creek watershed (Table 5).

Table 5. Animal sources in Wolf Creek watershed.

Animal	Totals	Acres in Entire Watershed Counties	Square Miles in Entire watershed counties	#/sq mi	FC/Animal/Day	Acres in Wolf Creek Watershed	FC/Acre of Wolf Creek Watershed	Fecal Coliform	Percentage
Dairy cow	7500	1531309	2393	3.13	4.46E+10	255520	8.55E+02	2.18E+08	3.31%
Cattle on Grass	149293	1531309	2393	62.39	3.90E+10	255520	1.49E+04	3.80E+09	57.66%
Cattle on Feed	26739	1531309	2393	11.17	3.90E+10	255520	2.67E+03	6.81E+08	10.33%
Hog	233613	1531309	2393	97.62	1.08E+10	255520	6.45E+03	1.65E+09	24.98%
Sheep	12480	1531309	2393	5.22	1.96E+10	255520	6.25E+02	1.60E+08	2.42%
Horse	1785	1531309	2393	0.75	5.15E+10	255520	2.35E+02	6.00E+07	0.91%
All Wildlife									0.39%
Turkey (Wild)[1]	191	1531309	2393	0.08	1.10E+08	255520	5.37E-02	1.37E+04	
Sharptail Grouse, prairie chicken and Partridge[2]	10914	1531309	2393	4.56	1.40E+08	255520	3.91E+00	9.98E+05	
Deer[3]	6666	1531309	2393	2.79	3.47E+08	255520	5.91E+00	1.51E+06	
Beaver[3]	2680	1531309	2393	1.12	2.00E+05	255520	1.37E-03	3.50E+02	
Raccoon[3]	11248	1531309	2393	4.70	2.50E+08	255520	7.19E+00	1.84E+06	
Coyote/Fox[4]	5116	1531309	2393	2.14	1.75E+09	255520	2.29E+01	5.85E+06	
Muskrat[1]	15946	1531309	2393	6.66	2.50E+07	255520	1.02E+00	2.60E+05	
Opossom[5]	4910	1531309	2393	2.05	2.50E+08	255520	3.14E+00	8.02E+05	
Mink[5]	4172	1531309	2393	1.74	2.50E+08	255520	2.67E+00	6.81E+05	
Skunk[4]	9312	1531309	2393	3.89	2.50E+08	255520	5.95E+00	1.52E+06	
Badger[5]	2311	1531309	2393	0.97	2.50E+08	255520	1.48E+00	3.77E+05	
Jackrabbit[5]	12746	1531309	2393	5.33	2.50E+08	255520	8.14E+00	2.08E+06	
Cottontail[5]	32641	1531309	2393	13.64	2.50E+08	255520	2.09E+01	5.33E+06	
Squirrel[5]	27255	1531309	2393	11.39	2.50E+08	255520	1.74E+01	4.45E+06	

1 USEPA 2001

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

3.2.2 Human

Canova, Spencer, Emery and Bridgewater are communities located in the Wolf Creek watershed. Their wastewater treatment systems account for about 1340 of the approximate 3500 people in the watershed. Septic systems are assumed to be the primary human source for the rural population in the watershed. When included in the total load, the remaining population produced fecal coliform bacteria loads accounting for less than 0.5% of all fecal coliform produced in the watershed. Human fecal production may be estimated at 1.95E+9 (Yagow et al., 2001). These bacteria should all be delivered to a septic system, which if functioning correctly would result in no fecal coliform entering the creek. Septic system failure was not identified as a source of concern during the field investigation conducted in the Wolf Creek watershed.

3.2.3 Natural background/wildlife

Wildlife within the watershed is a natural background source of fecal coliform bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (Huxoll, 2002). The contribution of bacteria from wildlife in the Wolf Creek watershed was insignificant (0.39%) in comparison to livestock sources.

4.0 Technical Analysis

4.1 Data Collection Method

Data on Wolf Creek was collected from SD DENR ambient water quality monitoring sites, WQM 157 and WQM 158. Supplemental data was used from the Lower James River Watershed Assessment from one sampling point located near the mouth of the creek, same location as WQM 158. Figure 3 shows the locations of the sampling sites as well as the locations of the two listed segments.

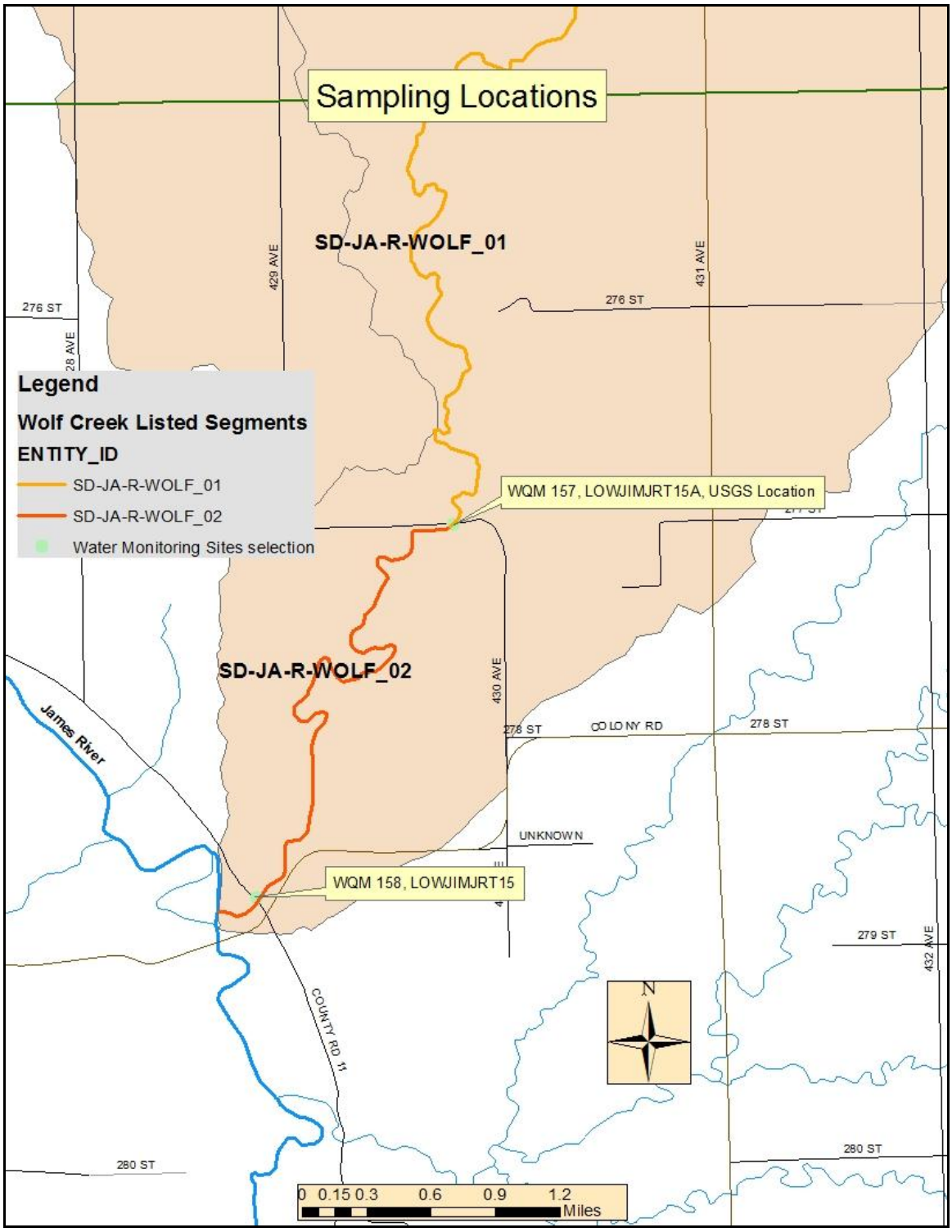

Figure 3. Sampling locations and listed segments of Wolf Creek.

E. coli samples were correlated with fecal coliform samples. The resulting relationship was strong and was used to model *E. coli* concentrations from unpaired fecal coliform samples (Figure 4).

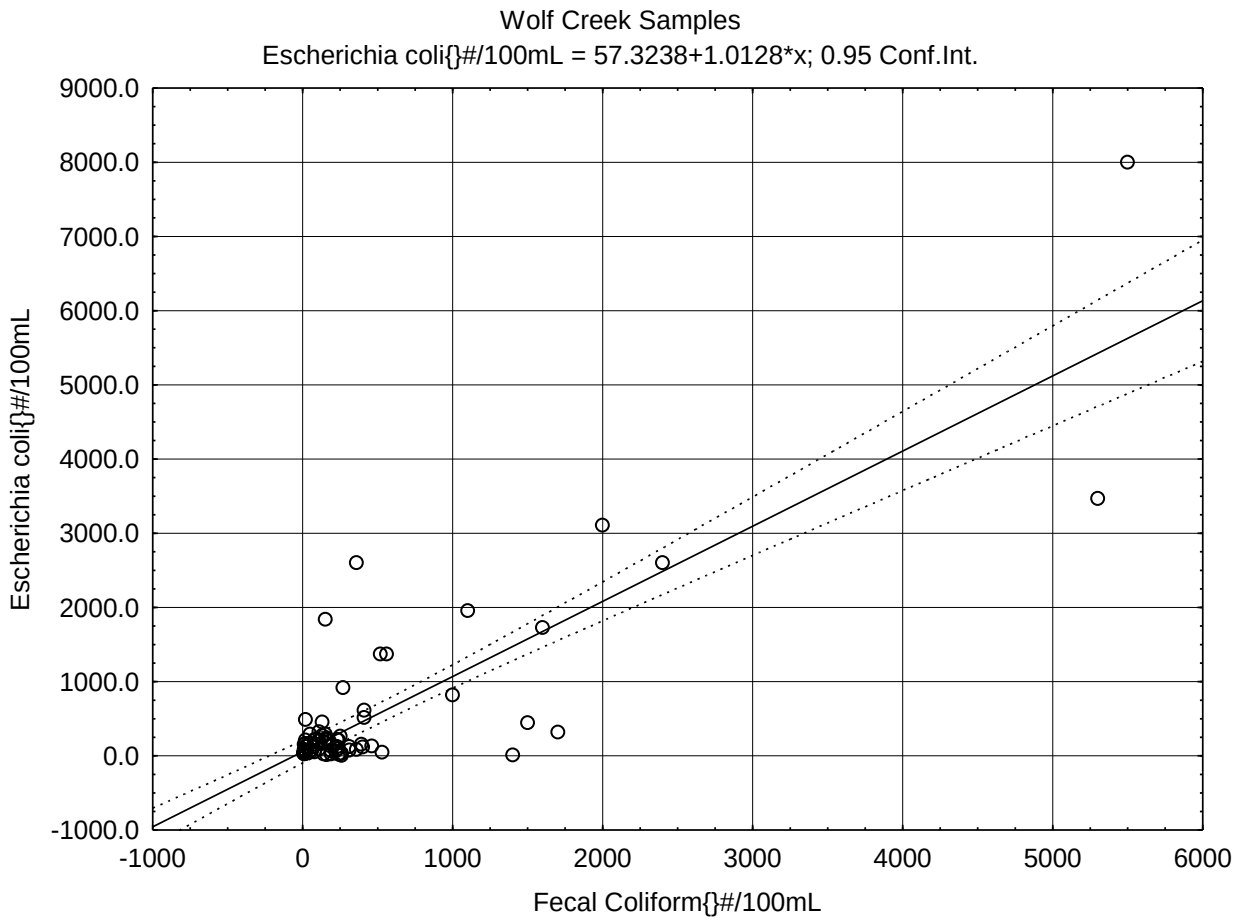

Figure 4. Correlation between paired *E. coli* and fecal coliform bacteria samples from Wolf Creek.

4.2 Flow Analysis

The Aquarius hydrologic statistics function was used to evaluate stream flows. Analysis performed with these programs was completed according to the most recent version of the Water Quality Modeling in South Dakota document (SDDENR, 2009), except where noted.

Water quantity data were collected during the project and supplemented with USGS data from station 06478390 located on Wolf Creek near Clayton, South Dakota. This USGS station is located a few miles upstream of the water quality monitoring station. The difference between the drainage areas for the two gauges is less than 2% with no significant tributaries entering the creek between the sites. Daily flows from over 10 years of data were used to generate the load duration curve. This relatively robust dataset provided the basis for a load duration curve that accurately represents the Wolf Creek

flow frequencies. Water quality data from the Lower James River Watershed Assessment as well as SDDENR ambient water quality monitoring were utilized in the development of this TMDL. Sites LOWJIMJRT15 and WQM 158 are both located at the same point on the creek.

4.2.1 TMDL for Upper Segment of Wolf Creek

4.2.1.1 Zone 1 – High Flow Zone

The high flow zone is composed of the highest 10% of flows that occurred in Wolf Creek. The 10th percentile equates to a flow of 99.83 cfs and is the division between flow zones 1 and 2 as defined in the EPA load duration curve guidance. This flow is slightly less than the $Q_{1.5,}$ which is approximately 135 cfs. This is still very close to the channel forming flow making the 90% flow exceedence a good division for flow zone 1. The chronic water quality threshold (630 cfu/100mL) was exceeded in three of the 10 samples collected from this zone, see Table 6. Of those three, two also exceeded the acute standard of 1,178 cfu/100mL.

Table 6. Data Collected from the High Flow Zone in the upper segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
06/15/2010	460157	3029.820	1370.0	520	1
06/14/2005	460157	496.640	***665.0***	600	1
08/10/2010	460157	495.059	3110.0	2000	1
07/13/2010	460157	336.966	36.6	260	1
05/15/2007	460157	261.432	***523.2***	460	1
06/17/2008	460157	237.894	***340.9***	280	1
07/21/2009	460157	226.300	68.2	190	1
06/14/2004	460157	212.423	***563.7***	500	1
09/08/2010	460157	117.392	159.0	390	1
06/05/2007	460157	106.852	***320.7***	260	1

The 95th percentile flow in this zone is 1477 cfs and is an example of the acceptable load at this particular flow. Table 7 depicts an example of a TMDL for a flow of 1477 cfs within flow zone 1. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

The concentration of 1178 mg/L represents the acute standard and may make an appropriate goal for this flow zone because flows in excess of 99.83 cfs typically only last for short periods of time (peak runoff events). By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. A load reduction of 73% is needed in this flow regime to fully support this segments designated beneficial uses.

Table 7. High Flow Zone for the upper segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	High Flow Zone	**>99.83**
LA	**2.02E+13**	*Remaining load after deducting WLA and MOS from TMDL*
Bridgewater WLA	**4.90E+10**	
Emery WLA	**6.69E+10**	
MOS	**2.46E+12**	
TMDL @ 630 cfu/day	**2.28E+13**	*Standard multiplied by 95th % flow for zone*
Current Load	**8.40E+13**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**73%**	*Reduction required to reduce the current load to the load at the standard*

4.2.1.2 Zone 2 – Moist Conditions (10% to 40% exceedance)

Zone 2 flows are characterized by above average moisture conditions in the watershed. Flows in this regime are generated by precipitation and snowmelt events. The upper bound of this flow regime is approximately the annual return event.

The chronic water quality threshold was exceeded in five of the twenty samples collected from this zone, see Table 8. Of those five, three also exceeded the acute standard of 1,178 cfu/100mL. Flows within this zone may be expected to persist for several weeks on a regular basis. As a result of insufficient data to accurately assess the chronic standard, reductions will be based on the chronic threshold of 630 cfu/100 mL. By utilizing 630 cfu/100mL as the reduction target for a single sample maximum, it insures that both the chronic and acute standards are fully supported.

Table 8. Data Collected from the Moist Conditions Zone in the upper segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/10/2007	460157	84.017	***452.3***	390	2
08/11/2009	460157	84.017	121.0	310	2
06/23/2009	460157	82.260	1730.0	1600	2
05/19/2004	460157	55.384	***270.0***	210	2
07/12/2011	460157	39.321	2600.0	2400	2
05/20/2008	460157	30.441	***108.0***	50	2
05/05/2009	460157	24.644	86.7	10	2
05/19/2010	460157	20.779	47.2	10	2
09/26/2006	460157	19.023	***715.6***	650	2
06/14/2011	460157	19.023	2600.0	360	2
08/21/2007	460157	18.320	***563.7***	500	2
05/10/2011	460157	15.510	125.0	20	2
05/17/2005	460157	14.456	***766.3***	700	2
07/16/2008	460157	13.226	***300.4***	240	2
08/02/2011	460157	13.208	12.2	1400	2
05/09/2006	460157	12.348	***148.5***	90	2
09/15/2003	460157	10.591	***239.6***	180	2
08/10/2004	460157	9.537	***270.0***	210	2
08/15/2006	460157	9.010	***290.3***	230	2
08/12/2008	460157	7.956	***219.4***	160	2

The 95th percentile flow in this zone is 78.75 cfs and is an example of the acceptable load at this particular flow. Table 9 depicts an example of a TMDL for a flow of 78.75 cfs within the moist condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard. A load reduction of 76% is needed in this flow regime to fully support this segments designated beneficial uses.

Table 9. Moist Conditions Flow Zone for the upper segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Moist Condition Zone	**99.82-7.43 cfs**
LA	**9.27E+11**	*Remaining load after deducting WLA and MOS from TMDL*
Bridgewater WLA	**4.90E+10**	
Emery WLA	**6.69E+10**	
MOS	**1.70E+11**	
TMDL @ 630 cfu/day	**1.21E+12**	*Standard multiplied by 95th % flow for zone*
Current Load	**5.01E+12**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**76%**	*Reduction required to reduce the current load to the load at the standard*

4.2.1.3 Zone 3 – Mid-range Flow (40% to 60% exceedance)

The mid-range flows extend from approximately 7.42 cfs down to 2.74 cfs. Of the seven samples collected from this flow regime, three exceeded the chronic threshold. One sample exceeded both the acute and chronic standard. By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported.

Table 10. Data Collected from the Mid-range Flow Zone in the upper segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/26/2005	460157	6.727	***624.5***	560	3
07/13/2004	460157	6.200	***553.6***	490	3
09/10/2002	460157	5.497	***654.9***	590	3
09/13/2011	460157	4.736	214.0	20	3
09/07/2004	460157	3.565	***1576.5***	1500	3
09/18/2007	460157	3.314	***624.5***	560	3
06/10/2003	460157	2.757	***1070.1***	1000	3

The 95th percentile flow in this zone is 6.90 cfs and is an example of the acceptable load at this particular flow. Table 11 depicts an example of a TMDL for a flow of 6.90 cfs within the mid-range flow condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard. A load reduction of 56% will be needed to fully support designated beneficial uses to the chronic water quality standard.

Because of the difficulty of accounting for facilities that are not continuous dischargers the WLA were adjusted in this zone. This is just an example of a situation that may occur. Calculations were made by subtracting the MOS from the TMDL target and then splitting the remaining load evenly between the LA and WLA. During the life of the permits for Emery and Bridgewater, only four discharges have been made in this zone (Table 27). One discharge was outside of the recreation season and the other three were below the state water quality standard for fecal coliform bacteria.

Table 11. Mid-Range Flow Zone for the upper segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Mid-Range Zone	**7.42-2.74 cfs**
LA	**3.94E+10**	*Remaining load after deducting WLA and MOS from TMDL*
Bridgewater WLA*	**1.97E+10**	
Emery WLA*	**1.97E+10**	
MOS	**2.73E+10**	
TMDL @ 630 cfu/day	**1.06E+11**	*Standard multiplied by 95th % flow for zone*
Current Load	**2.40E+11**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**56%**	*Reduction required to reduce the current load to the load at the standard*
**WLA adjusted*		

4.2.1.4 Zone 4 – Dry Conditions (60% to 76% exceedance)

The dry conditions zone extends from approximately 2.73 cfs down to 1.00 cfs. All fifteen samples in this zone were below both the acute standard and chronic threshold. By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. A load reduction is not needed because the designated beneficial uses are fully supported.

Table 12. Data Collected from the Dry Conditions Zone in the upper segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
08/19/2003	460157	2.476	***462.4***	400	4
05/07/2002	460157	2.159	219.0	80	4
06/18/2002	460157	1.720	***411.8***	350	4
08/30/2005	460157	1.457	***189.0***	130	4
09/14/2009	460157	1.457	79.2	310	4
06/13/2006	460157	1.187	***452.3***	390	4
09/20/2005	460157	1.184	***503.0***	440	4
07/18/2006	460157	1.115	***249.8***	190	4
09/23/2008	460157	1.040	***249.8***	190	4

The 95th percentile flow in this zone is 2.64 cfs and is an example of the acceptable load at this particular flow. Table 13 depicts an example of a TMDL for a flow of 2.64 cfs within the dry condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Table 13. Dry Conditions Zone for the upper segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Dry Conditions Zone	**2.73-1.00 cfs**
LA	**1.55E+10**	*Remaining load after deducting WLA and MOS from TMDL*
Bridgewater WLA*	**7.74E+09**	
Emery WLA*	**7.74E+09**	
MOS	**9.74E+09**	
TMDL @ 630 cfu/day	**4.07E+10**	*Standard multiplied by 95th % flow for zone*
Current Load	**3.15E+10**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**0%**	*Reduction required to reduce the current load to the load at the standard*
**WLA adjusted*		

Because of the difficulty of accounting for facilities that are not continuous dischargers the WLA were adjusted in this zone. This is just an example of a situation that may occur. Calculations were made by subtracting the MOS from the TMDL target and then splitting the remaining load evenly between the LA and WLA. During the life of the permits for Emery and Bridgewater, only one discharge has been made in this zone and it was outside of the recreation season (Table 27).

4.2.1.5 Zone 5 – Low Flow Conditions (76% to 100% exceedance)

The low flows extend from approximately 1 cfs down to no flow. The only sample in this zone met both the acute and chronic standards for *E. coli* bacteria. By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported.

Table 14. Data Collected from the Low Flow Conditions Zone in the upper segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/18/2002	460157	0.353	***189.0***	130	5

The 95th percentile flow in this zone is 0.93 cfs and is an example of the acceptable load at this particular flow. Table 15 depicts an example of a TMDL for a flow of 0.93 cfs within the low flow condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Since the flow is well below the combined capability of the treatment systems, the WLA is represented as a zero. This is an example of conditions that may occur.

Table 15. Low Flow Total Maximum Daily Load for the upper segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Low Flow Zone	**<1.00 cfs**
LA	**5.12E+09**	*Remaining load after deducting WLA and MOS from TMDL*
Bridgewater WLA*	**2.56E+09**	
Emery WLA*	**2.56E+09**	
MOS	**4.08E+09**	
TMDL @ 630 cfu/day	**1.43E+10**	*Standard multiplied by 95th % flow for zone*
Current Load	**4.30E+09**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**0%**	*Reduction required to reduce the current load to the load at the standard*
**WLA adjusted*		

Because of the difficulty of accounting for facilities that are not continuous dischargers the WLA were adjusted in this zone. This is just an example of a situation that may

occur. Calculations were made by subtracting the MOS from the TMDL target and then splitting the remaining load evenly between the LA and WLA. During the life of the permits for Emery and Bridgewater, no discharge has been made in this zone (Table 27).

4.2.2 TMDL for Lower Segment of Wolf Creek

This section is describing the lower segment of Wolf Creek that is located from the mouth of Wolf Creek to just above Wolf Creek Colony. The TMDL tables are calculated using the differences from the upstream and downstream samples in Table 16. The difference should represent what is actually occurring in the downstream listed segment. The 95th percentile concentration was used for the calculation of the current load for the lower segment of Wolf Creek. WLAs are not included in the calculations because they are accounted for in the upper segment of Wolf Creek.

Table 16. Differences between upstream and downstream samples. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations. The 95% concentration was used to calculate the current load for the lower segment of Wolf Creek.

Flow Percentage	*E. coli* samples from WQM 157 (upstream)	*E. coli* samples from WQM 158 (downstream)	Difference between samples	95% Concentration from the difference between sample
0.02%	1370	1370	0	2513.55 High Flow Zone
0.68%		3470	3470	
2.19%	***665***	***695.4***	***30.4***	
2.21%	3110	4841	1731	
3.64%	36.6	62.2	25.6	
4.98%	***523.2***	***685.3***	***162.1***	
5.42%	***340.9***	***290.3***	***-50.6***	
5.71%	68.2	98	29.8	
6.01%	***563.7***	***432.1***	***-131.6***	
8.31%		272	272	
9.06%	159	91	-68	
9.57%	***320.7***	***189***	***-131.7***	
11.12%	***452.3***	***178.9***	***-273.4***	273.4 Moist Conditions Zone
11.14%	121	142	21	
11.25%	1730	1960	230	
12.45%		292	292	
13.97%	***270***	***320.7***	***50.7***	
15.20%		30.9	30.9	
16.84%	2600	4841	2241	
17.73%		56.2	56.2	
19.18%	***108***	***87.7***	***-20.3***	
21.38%	86.7	53.7	-33	
22.74%		199	199	
23.72%	47.2	30.1	-17.1	

24.75%	***715.6***	***442.2***	***-273.4***	
24.75%		211	211	
24.82%	2600	1840	-760	
25.09%	***563.7***	***371.3***	***-192.4***	
27.57%	125	6.3	-118.7	
28.39%	***766.3***	***381.4***	***-384.9***	
28.52%		93.3	93.3	
29.86%	***300.4***	***219.4***	***-81***	
29.87%	12.2	23.2	11	
30.76%	***148.5***	***108***	***-40.5***	
33.34%	***239.6***	***351***	***111.4***	
35.28%	***270***	***320.7***	***50.7***	
36.33%	***290.3***	***158.6***	***-131.7***	
36.33%		19.1	19.1	
38.83%	***219.4***	***158.6***	***-60.8***	
42.36%	***624.5***	***968.8***	***344.3***	
43.95%	***553.6***	***685.3***	***131.7***	
44.46%		57.6	57.6	
46.18%	***654.9***	***472.6***	***-182.3***	259.26 Mid-Range Zone
49.12%	214	231	17	
51.50%		48.1	48.1	
54.89%	***1576.5***	***827.1***	***-749.4***	
56.03%	***624.5***	***280.1***	***-344.4***	
59.93%	***1070.1***	***867.6***	***-202.5***	
62.00%		26.5	26.5	
62.16%	***462.4***	***1374***	***911.6***	
64.88%	219		-219	
68.46%	***411.8***	***4209.8***	***3798***	
72.31%	***189***	***138.3***	***-50.7***	
72.49%	79.2	23	-56.2	2327.41 Dry Conditions Zone
73.03%		222	222	
73.32%		219	219	
75.68%	***452.3***	***168.7***	***-283.6***	
75.69%	***503***	***290.3***	***-212.7***	
76.16%	***249.8***	***1374***	***1124.2***	
77.74%	***249.8***	***178.9***	***-70.9***	
78.44%		***199.1***	***199.1***	
87.83%	***189***		***-189***	183.87 Low Flow Zone
90.98%		46.8	46.8	

4.2.2.1 Zone 1 – High Flow Zone

The high flow zone is composed of the highest 10% of flows that occurred in Wolf Creek. The 10th percentile equates to a flow of 99.83 cfs and is the division between flow zones 1 and 2 as defined in the EPA load duration curve guidance. This flow is slightly less than the $Q_{1.5,}$ which is approximately 135 cfs. This is still very close to the channel forming flow making the 90% flow exceedence a good division for flow zone 1. The chronic water quality threshold (630 cfu/100mL) was exceeded in five of the 12 samples collected from this zone, see table 16. Of those five, three also exceeded the acute standard of 1,178 cfu/100mL.

Table 17. Data Collected from the High Flow Zone in the lower segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
06/15/2010	460158	3029.820	1370.0	560	1
06/14/2005	460158	496.640	***695.4***	630	1
08/10/2010	460158	495.059	>4840	5500	1
07/13/2010	460158	336.966	62.2	220	1
05/15/2007	460158	261.432	***685.3***	620	1
06/17/2008	460158	237.894	***290.3***	230	1
07/21/2009	460158	226.300	98.0	240	1
06/14/2004	460158	212.423	***432.1***	370	1
09/08/2010	460158	117.392	91.0	110	1
06/05/2007	460158	106.852	***189.0***	130	1
05/07/2007	LOWJIMJRT15	1287.281	3470.0	5300	1
05/31/2007	LOWJIMJRT15	134.958	272.0	130	1

The 95th percentile flow in this zone is 1477 cfs and is an example of the acceptable load at this particular flow. Table 18 depicts an example of a TMDL for a flow of 1477 cfs within flow zone 1. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

The concentration of 1178 mg/L represents the acute standard and may make an appropriate goal for this flow zone because flows in excess of 99.83 cfs typically only last for short periods of time (peak runoff events). By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. A load reduction of 75% is needed in this flow regime to fully support this segments designated beneficial uses.

Table 18. High Flow Zone for Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	High Flow Zone	**>99.83**
LA	**2.03E+13**	*Remaining load after deducting WLA and MOS from TMDL*
WLA		*No Waste Load Allocation*
MOS	**2.46E+12**	
TMDL @ 630 cfu/day	**2.28E+13**	*Standard multiplied by 95th % flow for zone*
Current Load**	**9.08E+13**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**75%**	*Reduction required to reduce the current load to the load at the standard*
*** Current Load is calculated using the difference from the upper segment and lower segment samples*		

4.2.2.2 Zone 2 – Moist Conditions (10% to 40% exceedance)

Zone 2 flows are characterized by above average moisture conditions in the watershed. Flows in this regime are generated by precipitation and snowmelt events. The upper bound of this flow regime is approximately the annual return event.

The chronic water quality threshold was exceeded in three of the twenty-seven samples collected from this zone, see Table 19. All three of those samples also exceeded the acute standard of 1,178 cfu/100mL. Flows within this zone may be expected to persist for several weeks on a regular basis. As a result of insufficient data to accurately assess the chronic standard, reductions will be based on the chronic threshold of 630 cfu/100 mL. By utilizing 630 cfu/100mL as the reduction target for a single sample maximum, it insures that both the chronic and acute standards are fully supported. No load reduction is needed in this flow regime to fully support this segments designated beneficial uses.

Table 19. Data Collected from the Moist Conditions Zone in the lower segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/10/2007	460158	84.017	***178.9***	120	2
08/11/2009	460158	84.017	142.0	200	2
06/23/2009	460158	82.260	1960.0	1100	2
05/19/2004	460158	55.384	***320.7***	260	2
07/12/2011	460158	39.321	>4840	15000	2
05/20/2008	460158	30.441	***87.7***	30	2
05/05/2009	460158	24.644	53.7	10	2
05/19/2010	460158	20.779	30.1	10	2
09/26/2006	460158	19.023	***442.2***	380	2
06/14/2011	460158	19.023	1840.0	150	2
08/21/2007	460158	18.320	***371.3***	310	2
05/10/2011	460158	15.510	6.3	<10	2
05/17/2005	460158	14.456	***381.4***	320	2
07/16/2008	460158	13.226	***219.4***	160	2
08/02/2011	460158	13.208	23.2	190	2
05/09/2006	460158	12.348	***108.0***	50	2
09/15/2003	460158	10.591	***351.0***	290	2
08/10/2004	460158	9.537	***320.7***	260	2
08/15/2006	460158	9.010	***158.6***	100	2
08/12/2008	460158	7.956	***158.6***	100	2
07/25/2007	LOWJIMJRT15	47.128	30.9	250	2
06/25/2007	LOWJIMJRT15	34.832	56.2	80	2
05/02/2006	LOWJIMJRT15	22.536	199.0	180	2
08/22/2007	LOWJIMJRT15	20.428	292.0	150	2
09/26/2006	LOWJIMJRT15	19.023	211.0	240	2
05/10/2006	LOWJIMJRT15	14.280	93.3	<10	2
08/15/2006	LOWJIMJRT15	9.010	19.1	160	2

The 95th percentile flow in this zone is 78.75 cfs and is an example of the acceptable load at this particular flow. Table 20 depicts an example of a TMDL for a flow of 78.75 cfs within the moist condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Table 20. Moist Conditions Flow Zone for Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Moist Conditions Zone	**99.82-7.43 cfs**
LA	**1.04E+12**	*Remaining load after deducting WLA and MOS from TMDL*
WLA		*No Waste Load Allocation*
MOS	**1.70E+11**	
TMDL @ 630 cfu/day	**1.21E+12**	*Standard multiplied by 95th % flow for zone*
Current Load**	**5.26E+11**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**0%**	*Reduction required to reduce the current load to the load at the standard*
*** Current Load is calculated using the difference from the upper segment and lower segment samples*		

4.2.2.3 Zone 3 – Mid-range Flow (40% to 60% exceedance)

The mid-range flows extend from approximately 7.42 cfs down to 2.74 cfs. Of the nine samples collected from this flow regime, four exceeded the chronic threshold. No sample exceeded either the acute standard or the chronic threshold (Table 21). By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. No load reduction is needed in this flow regime to fully support this segments designated beneficial uses.

Table 21. Data Collected from the Mid-range Flow Zone in the lower segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/26/2005	460158	6.727	***968.8***	900	3
07/13/2004	460158	6.200	***685.3***	620	3
09/10/2002	460158	5.497	***472.6***	410	3
09/13/2011	460158	4.736	231.0	90	3
09/07/2004	460158	3.565	***827.1***	760	3
09/18/2007	460158	3.314	***280.1***	220	3
06/10/2003	460158	2.757	***867.6***	800	3
05/16/2006	LOWJIMJRT15	6.024	57.6	20	3
05/31/2006	LOWJIMJRT15	4.223	48.1	50	3

The 95th percentile flow in this zone is 6.90 cfs and is an example of the acceptable load at this particular flow. Table 22 depicts an example of a TMDL for a flow of 6.90 cfs within the mid-range flow condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Table 22. Mid-Range Flow Zone for the lower segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Mid-Range Flow Zone	**7.42-2.74 cfs**
LA	**7.90E+10**	*Remaining load after deducting WLA and MOS from TMDL*
WLA		*No Waste Load Allocation*
MOS	**2.73E+10**	
TMDL @ 630 cfu/day	**1.06E+11**	*Standard multiplied by 95th % flow for zone*
Current Load**	**4.38E+10**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**0%**	*Reduction required to reduce the current load to the load at the standard*
*** Current Load is calculated using the difference from the upper segment and lower segment samples*		

4.2.2.4 Zone 4 – Dry Conditions (60% to 76% exceedance)

The dry conditions zone extends from approximately 2.73 cfs down to 1.00 cfs. Of the thirteen samples, three exceeded the chronic threshold. One of those three samples also exceeded the acute standard. By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. A load reduction of 73% is needed in this flow regime to fully support this segments designated beneficial uses.

Table 23. Data Collected from the Dry Conditions Zone in the lower segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
08/19/2003	460158	2.476	***1374.0***	1300	4
06/18/2002	460158	1.720	***4209.8***	4100	4
08/30/2005	460158	1.457	***138.3***	80	4
09/14/2009	460158	1.457	23.0	240	4
06/13/2006	460158	1.187	***168.7***	110	4
09/20/2005	460158	1.184	***290.3***	230	4
07/18/2006	460158	1.115	***1374.0***	1300	4
09/23/2008	460158	1.040	***178.9***	120	4
08/30/2006	LOWJIMJRT15	2.511	8.4	260	4
08/30/2006	LOWJIMJRT15	2.511	26.5	140	4
06/06/2006	LOWJIMJRT15	1.407	222.0	230	4
06/06/2006	LOWJIMJRT15	1.407	173.0	150	4
05/23/2006	LOWJIMJRT15	1.369	219.0	160	4

The 95th percentile flow in this zone is 2.64 cfs and is an example of the acceptable load at this particular flow. Table 24 depicts an example of a TMDL for a flow of 2.64 cfs

within the dry condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Table 24. Dry Conditions Zone TMDL for the lower segment of Wolf Creek.

	Flow Zone (expressed as cfu/Day)	
	Dry Conditions Zone	**2.73-1.00 cfs**
LA	**3.09E+10**	*Remaining load after deducting WLA and MOS from TMDL*
WLA		*No Waste Load Allocation*
MOS	**9.81E+09**	
TMDL @ 630 cfu/day	**4.07E+10**	*Standard multiplied by 95th % flow for zone*
Current Load**	**1.50E+11**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**73%**	*Reduction required to reduce the current load to the load at the standard*
*** Current Load is calculated using the difference from the upper segment and lower segment samples*		

4.2.2.5 Zone 5 – Low Flow Conditions (76% to 100% exceedance)

The low flows extend from approximately 1 cfs down to no flow. Both samples in this zone met both the acute standard and chronic threshold for *E. coli* bacteria. By utilizing the chronic threshold instead of the acute criteria, reductions are calculated to reduce the maximum daily concentration to 630 mg/L. This provides assurance that both the acute and chronic criteria are fully supported. No reduction is needed in this flow regime to fully support this segments designated beneficial uses.

Table 25. Data Collected from the Low Flow Conditions Zone in the lower segment of Wolf Creek. Bold *E. coli* numbers represent calculated concentrations based on observed fecal coliform concentrations.

Sample Date	Station ID	Flow	*E. coli* concentration	Fecal coliform concentration	Flow Zone
07/16/2002	460158	0.955	***199.1***	140	5
07/26/2006	LOWJIMJRT15	0.227	46.8	530	5

The 95th percentile flow in this zone is 0.93 cfs and is an example of the acceptable load at this particular flow. Table 26 depicts an example of a TMDL for a flow of 0.93 cfs within the low flow condition regime. Higher and lower flows within this zone may acceptably carry higher or lower loads as long as the concentration does not exceed the state standard.

Since the flow is well below the combined capability of the treatment systems, the WLA is represented as a zero. This is an example of conditions that may occur.

Table 26. Low Flow Total Maximum Daily Load for the lower segment of Wolf Creek

	Flow Zone (expressed as cfu/Day)	
	Low Flow Zone	**<1.00 cfs**
LA	**1.02E+10**	*Remaining load after deducting WLA and MOS from TMDL*
WLA		*No Waste Load Allocation*
MOS	**4.08E+09**	
TMDL @ 630 cfu/day	**1.43E+10**	*Standard multiplied by 95th % flow for zone*
Current Load**	**4.18E+09**	*95th Percentile of calculated E. coli load for each zone*
Load Reduction	**0%**	*Reduction required to reduce the current load to the load at the standard*
*** Current Load is calculated using the difference from the upper segment and lower segment*		

4.3 Load Duration Curve

The load duration curves located in Figure 5 and 6 depict the flow zones and sample data as described in section 4.2.

None of the waste load allocations were taken into consideration and included within the TMDL calculations and table. The individual waste load allocations for each of these facilities were not included in the graphic due to their infrequent discharges and distance from listed segment. Arbitrarily adding these loads across all of the flow regimes would be a misrepresentation of how the system(s) function, essentially suggesting a continuous discharge.

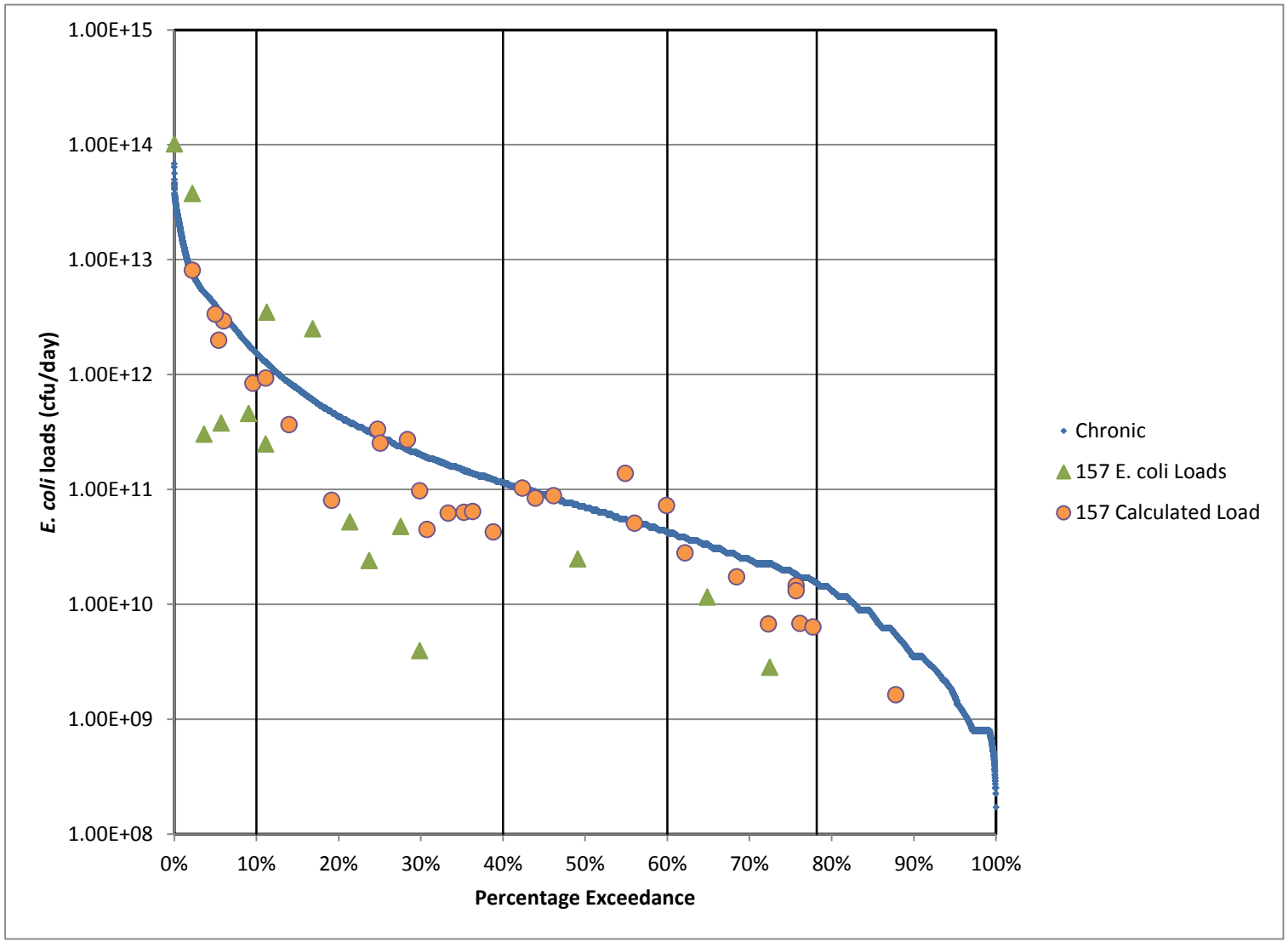

Figure 5. Upper segment of Wolf Creek Load Duration Curve for *E. coli*.

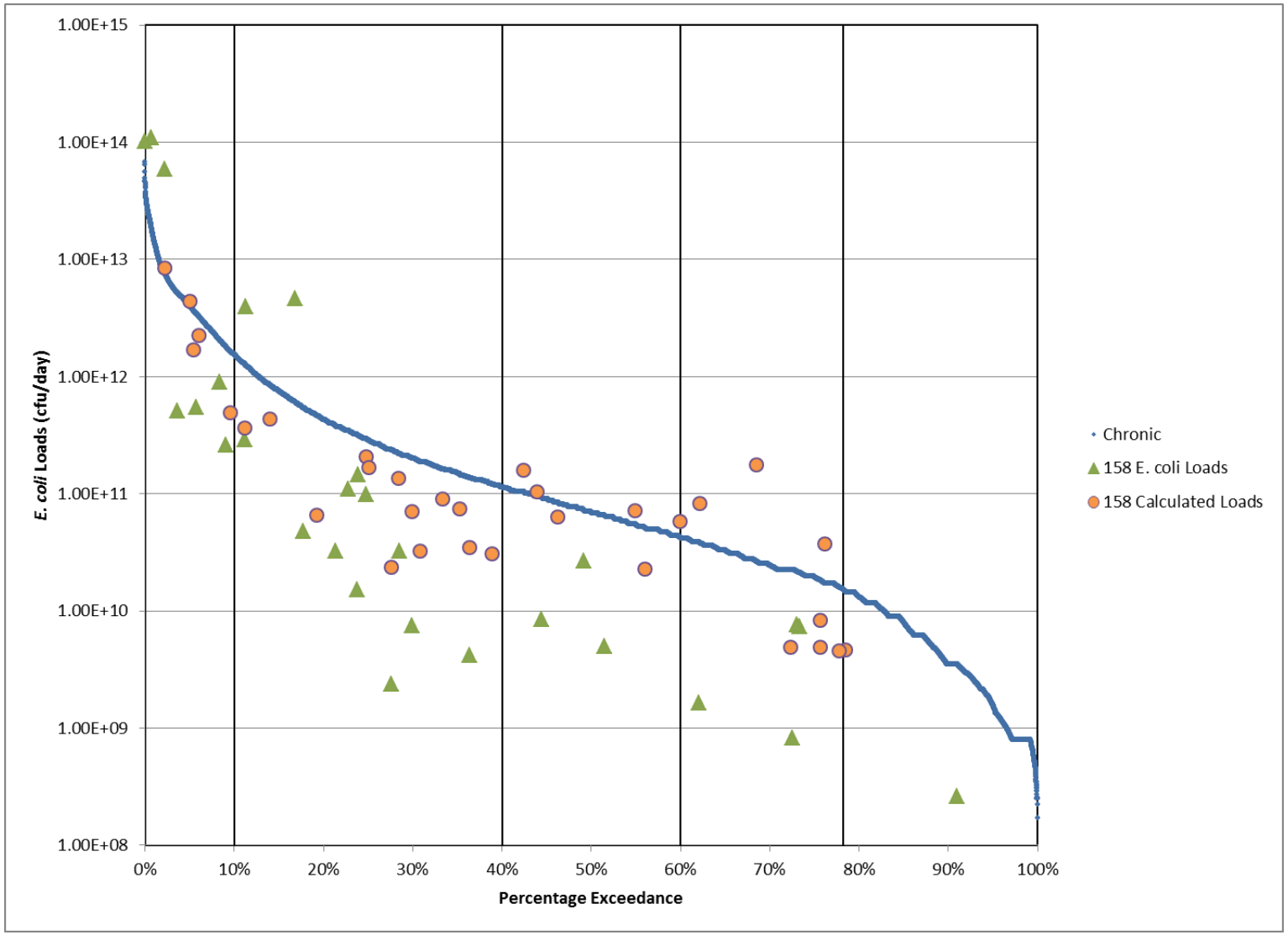

Figure 6. Lower segment of Wolf Creek Load Duration Curve for *E. coli*.

5.0 TMDL and Allocations

5.1 Load Allocations (LAs)

5.1.1 Upper Segment of Wolf Creek

A 73% reduction in *E. coli* concentrations in the upper segment of Wolf Creek is required in the high flow regime to fully attain the current water quality standards. Load reductions are possible in this flow regime, but a 73% reduction may be difficult or impossible to achieve. Consideration for creating a high flow off ramp should be given for Wolf Creek.

A 76% reduction in *E. coli* concentrations is required in the moist conditions flow regime to fully attain the current water quality standards. A 56% reduction in mid-range flow regime *E. coli* concentrations is required for full attainment of water quality standards. To achieve the specified reductions primary focus should be placed on reducing bacteria inputs from feedlots and livestock grazing.

No load reduction is need in the upper segment of Wolf Creek in the dry conditions and low flow regimes.

5.1.2 Lower Segment of Wolf Creek

A 75% reduction in *E. coli* concentrations in the lower segment of Wolf Creek is required in the high flow regime to fully attain the current water quality standards. Load reductions are possible in this flow regime, but a 75% reduction may be difficult or impossible to achieve. Consideration for creating a high flow off ramp should be given for Wolf Creek.

A 73% reduction in *E. coli* concentrations in the lower segment of Wolf Creek is required in the dry conditions flow regime to fully attain the current water quality standards. High concentrations are most likely related to livestock in direct contact with the stream in this flow regime. To achieve specified reductions in this flow regime focus should be placed on reducing livestock ability to be in direct contact with the stream by providing offstream watering sources.

No load reductions are needed in the other three flow regimes (Moist conditions, Mid-range, and low flow) in the lower segment of Wolf Creek.

5.2 Wasteload Allocations (WLAs)

There are four point sources of pollutants in the Wolf Creek watershed. The cities of Spencer and Canova were not included in the TMDL analysis due to being “no discharge” facilities. The cities of Bridgewater and Emery were both included in the analysis of the TMDL. Bridgewater’s facility consists of a three-cell stabilization pond system, followed by two artificial wetlands. The facility discharges into an unnamed

tributary that flows about two miles until it enters Wolf Creek. Emery's facility consists of a 6.4 acre, single cell bi-level stabilization pond. This facility has been upgraded to include two more stabilization ponds. The facility discharges into Wolf Creek. Both facilities rarely discharge to Wolf Creek (Table 27). Nonetheless, a wasteload allocation was incorporated into the upper segment TMDL due to the discharge that can occur during the recreation season.

Table 27. Discharge Monitoring Report data for Bridgewater and Emery Wastewater Facilities.

Facility	DMR Date	Effluent Flow Rate, Daily Max, MGD	Duration of Discharge, days	Fecal Coliform, 30-day Geomean, Limit 1000/100mL	Fecal Coliform, Daily Max, Limit 2000/100mL	Wolf Creek Modeled Flows (Flow Zone)
Bridgewater	May 31, 2007	0.222	22	20	40	134.9577 (1)
Bridgewater	August 31, 2009	0.1	13	17	30	4.96995 (3)
Bridgewater	September 30, 2009	0.1	30	70	160	5.89447 (3)
Bridgewater	March 31, 2010	1.2	13	Outside of Recreation Season	Outside of Recreation Season	50.64132 (2)
Bridgewater	July 31, 2010	1.1	7	8.3	180	661.935 (1)
Bridgewater	August 31, 2010	0.26	8	7.8	100	85.77314 (2)
Bridgewater	May 31, 2011	1.01	10	10	Below Detection	222.7872 (1)
Emery	April 30, 2001	NA	NA	Outside of Recreation Season	Outside of Recreation Season	
Emery	February 28, 2002	NA	NA	Outside of Recreation Season	Outside of Recreation Season	
Emery	December 31, 2002	1.96	NA	Outside of Recreation Season	Outside of Recreation Season	6.550888 (3)
Emery	June 30, 2005	1.27	NA	93.33	190	61.18087 (2)
Emery	May 31, 2006	NA	NA	780	780	4.223404 (3)
Emery	April 30, 2007	0.02	7	Outside of Recreation Season	Outside of Recreation Season	59.42428 (2)

Emery	June 30, 2008	0.18	7	***4900***	***4900***	94.90742 (2)
Emery	December 31, 2008	0.18	2	Outside of Recreation Season	Outside of Recreation Season	1.456774 (4)
Emery	July 31, 2009	0.18	2	***7900***	***7900***	55.9111 (2)
Emery	October 31, 2009	0.14	3	Outside of Recreation Season	Outside of Recreation Season	64.69405 (2)
Emery	May 31, 2010	NA	7	***1650***	NA	148.1321 (1)
Emery	August 31, 2010	NA	15	***19743***	***19743***	85.77314 (2)
Emery	June 30, 2011	0.44	14	41.27	41.27	375.6107 (1)

Neither facility is allowed to discharge until permission is granted by SDDENR. The request to discharge must explain why a discharge is needed, when the discharge would start, the expected duration of the discharge and the approximate volume of water to be discharged. Wolf Creek's flow condition must also be reported.

6.0 Margin of Safety (MOS) and Seasonality

6.1 Margin of Safety

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 standard error 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.

6.2 Seasonality

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. Some seasonal variation in the *E. coli* load would be expected.

These TMDLs exclusively address the recreational season which is defined as May 1 through September 30. Because there are two WQM locations, thirty-two *E. coli* and 124 fecal coliform bacteria additional samples were collected outside the recreation season from Wolf Creek. Only one fecal coliform sample exceeded the chronic water quality

standard. This indicates that Wolf Creek is most vulnerable to elevated bacteria counts during the recreation season. During this time period the creek is most likely to experience higher temperatures (encouraging livestock use of the stream) and peak recreational use of the waters.

7.0 Public Participation

STATE AGENCIES
South Dakota Department of Environment and Natural Resources (SD DENR) was the primary state agency involved in completion of this assessment. SD DENR provided technical support and equipment throughout the course of the project.

FEDERAL AGENCIES
Environmental Protection Agency (EPA) provided the primary source of funds for the completion of the Lower James River Assessment project.

LOCAL GOVERNMENT, INDUSTRY, ENVIRONMENTAL, AND OTHER GROUPS, AND PUBLIC AT LARGE
The primary local sponsor for this project was the James River Water Development District. The district held bi-monthly board meetings in which, short updates on the progress of the assessment project were presented. The updates were followed by a question and answer session for board members and public attendees. TMDL activities in the district were presented and discussed at nearly every meeting since project planning began in 2005.

During the summer sampling seasons, project personnel frequently met with landowners in the field. These meetings were most often initiated by landowners stopping to ask questions while coordinators were engaged in data collection. Although informal in nature, these meetings provide an important medium for obtaining local landowner views and opinions.

This TMDL was placed on public notice during April 2012 in the Mitchell Daily Republic as well as the Freeman Courier, Bridgewater Tribune and Parkston Advance. The document was made available on the DENR website (http://denr.sd.gov/) and advertised on its home page during the same time period.

8.0 Monitoring Strategy

The Department may adjust the load and/or wasteload 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 and waste 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 or WLA will not result in a change to the loading capacity; the adjusted TMDL, including its WLAs and LAs, will be set at a level necessary to implement the applicable water quality standards; and any adjusted WLA will be supported by a demonstration that load

allocations are practicable. The Department will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

Monitoring will continue throughout the Lower James River watershed. Wolf Creek sites WQM 157 and WQM 158 will be monitored monthly as part of the ambient water quality monitoring program. The results from this monitoring can be used to supplement the modeling to judge project effectiveness or TMDL adjustments.

9.0 Implementation Plan

There have been 13 contracts signed into the Conservation Reserve Enhancement Program (CREP). These contracts total about 1413 acres of environmentally sensitive land in the Wolf Creek watershed.

Five feeding areas were assessed and prioritized based on water quality data and a simple matrix involving the AFO's distance from the stream and the number of livestock in the AFO (Figure 7). AFOs located in areas where TSS was increasing were targeted and then assessed using the matrix. A 1-10 rating score was given for each criteria (distance from stream and number of livestock) and the five AFOs were ranked. Addressing these five feedlot areas will also improve the *E. coli* impairments on both segments of Wolf Creek.

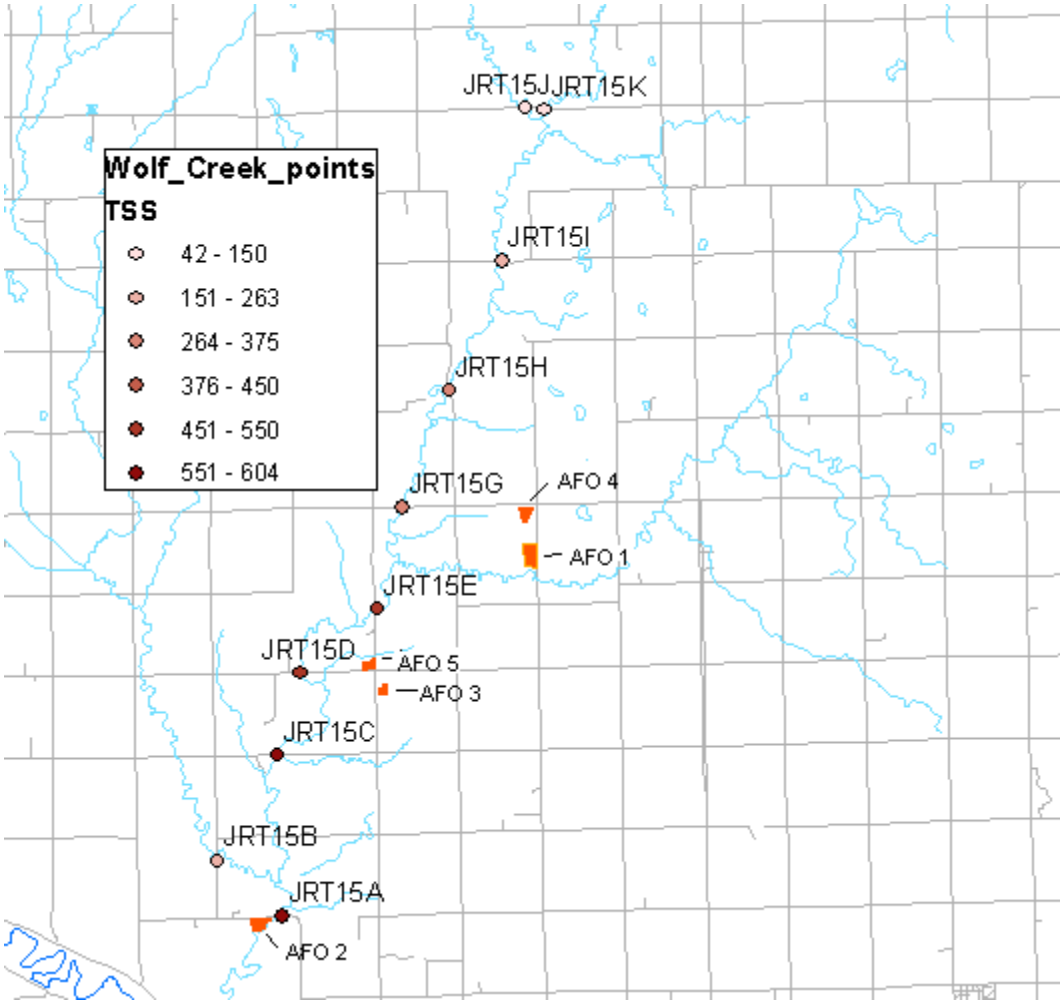

Figure 7. Wolf Creek feeding areas. AFOs are numbered according to implementation prioritization.

10.0 Literature Cited

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