Escherichia coli Bacteria Total Maximum Daily Load (TMDL) for Skunk Creek Segment 1 Minnehaha County, South Dakota

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Acronym List

Acronym	Definition
AUM	Animal Unit Month
ARSD	Administrative Rules of South Dakota
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations (U.S.)
cfs	Cubic Feet Per Second
CFU	Colony Forming Unit
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DANR	Department of Agriculture & Natural Resources (South Dakota)
EDWDD	East Dakota Water Development District
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentive Standards
GM	Geometric Mean
GFP	Game, Fish, & Parks (South Dakota)
GIS	Geographical Information System
Ha	Hectares
HUC	Hydrologic Unit Code
ID	Identification
IR	Integrated Report (South Dakota's Water Quality Integrated Report)
LA	Load Allocation
mL	Milliliter
MOS	Margin of Safety
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
SSM	Single Sample Maximum
SWMP	Storm Water Management Program
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Wasteload Allocation
WPP	Watershed Protection Program (South Dakota)
WQM	Water Quality Monitoring
WQS	Water Quality Standards
WRP	Watershed Restoration Plan
WFT	Wastewater Treatment Facilities

Document Summary

EPA delegates authority to the South Dakota Department of Agriculture & Natural Resources (DANR) under the Clean Water Act (CWA) to develop impaired waters lists (i.e. section 303(d)) and associated total maximum daily loads (TMDLs). Under this authority, DANR drafts TMDLs and EPA makes the final decision on the document. A TMDL serves as a planning document to characterize impairment and recommend measures to achieve compliance with water quality standards (WQS).

This document describes the *Escherichia coli* (*E. coli*) TMDL and water quality improvement plan for SD-BS-R-SKUNK_01 or Skunk Creek Segment 1 (**Figure 2-1)**. This document only addresses *E. coli* as a cause of impairment in Skunk Creek Segment 1.

Skunk Creek Segment 1 begins in Lake County, South Dakota from Brandt Lake to the confluence with the Big Sioux River. The Skunk Creek Segment 1 watershed contains other smaller tributaries like Willow Creek, Colton Creek, Buffalo Creek, and West Branch Skunk Creek. The majority of Skunk Creek Segment 1 watershed is located in central to western Minnehaha County and extends up to the southeast side of Lake County. The project area is approximately 128,569 hectares (ha) with a predominate land use agriculture cropland with rangeland located in low lying areas or in soils not conducive for row crops.

***E. coli* TMDL**

High concentrations of *E. coli* can put humans at risk for contracting water-borne illnesses. Elevated concentrations of *E. coli* can lead to impairment of the waterbody's designated beneficial uses. DANR's water quality assessment methods for *E. coli* impairment focus on the most sensitive recreation use to ensure protection. The TMDL was developed using the single sample maximum (SSM) for immersion recreation. The selected criteria is protective of downstream use as immersion recreation is designated for the Big Sioux River and not Skunk Creek Segment 1.

This document summarizes *E. coli* production for all nonpoint sources such as human, agricultural and wildlife. All point sources of *E. coli* are identified and waste load allocations (WLAs) are provided where appropriate. A margin of safety (MOS) is applied to the TMDL to account for data uncertainty. MS4 waste load calculation for the city of Sioux Falls was developed using the Jurisdictional Area Method. All variables in the TMDL equation were calculated over five flow zones. A summary of state and federal programs that guide TMDL development as well as an implementation strategy to reduce *E. coli* concentrations is discussed.

Total Maximum Daily Load Summary

Skunk Creek Segment 1 - SD-BS-R-SKUNK_01

Waterbody Type: River/Stream

Assessment Unit Identification: SD-BS-R-SKUNK_01

303(d) Listing Parameter: *Escherichia coli* (*E. coli*)

Designated Uses of Concern: Immersion Recreation Use*

Location: Hydrologic Unit Code (eight-digit HUC 10170203)

Size of Impaired Waterbody: Segment length approximately 101.7 km

Size of Watershed: Sub watershed 128,569 hectares (ha) (HUC 12)

Indicator(s): Concentration of *Escherichia coli* (colony forming units per 100ml)

Analytical Approach: Load Duration Curve Framework

TMDL Priority Ranking: Priority 1 (2024 IR)

Target (Water Quality Standards): *Escherichia coli* (*E. coli*) - Maximum daily concentration of ≤ 235 CFUs/100mL and a geometric mean of < 126 CFUs/100mL based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period.

Immersion Recreation E. Coli TMDL Component	Skunk Creek Flow Zones Expressed as (CFU/day)				
	High Flows	Moist Conditions	Mid-Range Conditions	Dry Conditions	Low Flows
LA	1.50E+13	2.91E+12	6.60E+11	1.45E+11	3.95E+10
MS4 - City of Sioux Falls	4.78E+11	9.30E+10	2.11E+10	4.61E+09	1.26E+09
MS4 - Sioux Falls Future Growth	4.78E+11	9.30E+10	2.11E+10	4.61E+09	1.26E+09
WLA - City of Hartford	3.02E+10	3.02E+10	3.02E+10	3.02E+10	3.02E+10
WLA - Chester	1.01E+10	1.01E+10	1.01E+10	1.01E+10	1.01E+10
10% Explicit MOS	1.77E+12	3.49E+11	8.25E+10	2.16E+10	9.14E+09
TMDL @ 235 CFU/100mL*	1.77E+13	3.49E+12	8.25E+11	2.16E+11	9.14E+10
Current Load	3.65E+14	1.24E+14	1.68E+13	7.66E+11	2.45E+11
Load Reduction	95%	97%	95%	72%	63%

* Skunk Creek is assigned limited contact recreation use, however the TMDL is written to protect downstream uses

1.0 TMDL Overview

The intent of this document is to clearly identify the components of the Total Maximum Daily Load (TMDL), support adequate public participation, and facilitate the United States Environmental Protection Agency (EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act (CWA) and guidance developed by EPA. This TMDL document addresses the *E. coli* impairment for Skunk Creek Segment 1 or Assessment Unit **SD-BS-R-SKUNK_01** (Brandt Lake to Big Sioux River) (**Figure 2-1**). This impairment has been assigned a priority category 1 (High-Priority) in the 2024 South Dakota 303(d) list and was first listed as impaired for *E. coli* in 2014.

1.1 CWA Section 303(d)

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the CWA. The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." The CWA requires states to develop beneficial uses for waters and water quality standards (WQS) to protect those uses.

Waterbodies in South Dakota are designated beneficial uses based on a use attainability assessment. South Dakota has established WQS and criteria to protect beneficial uses designated to waters of the state (ARSD 74:54:01). When a waterbody fails to comply with one or more WQS the use(s) are considered not supporting or impaired. States are required to monitor water quality and assess beneficial use support and impairment status of all waters through the Integrated Report (IR) process.

DANR is required to submit an Integrated Report for Surface Water Quality Assessment to EPA by April 1st of every even year. The report provides a comprehensive account of the surface water quality in the state. In addition, the report contains the 303(d) list of impaired waterbodies that require TMDL development. A TMDL serves as a planning document directed to achieve and maintain WQS attainment.

1.2 Document Contents

This document addresses required components of a TMDL including an implementation and monitoring strategy. In addition to this introductory section, this document includes:

Section 2.0 Skunk Creek Segment 1 Background: Provides background information, physical features and social profile of the Skunk Creek Segment 1 Watershed

Section 3.0 South Dakota Water Quality Standards: Discusses the WQS that apply to the Skunk Creek Segment 1 Watershed.

Section 4.0 Impairment Assessment Methods: Documents the decision-making process to define whether WQS are met.

Section 5.0 Developing Numeric Targets for *E. coli.* Discusses applying numeric *E. coli* criteria for TMDL targets.

Section 6.0 Water Quality Data and Discharge Information: Discusses the collection of water quality data and measured discharges which will be used to calculate the TMDL for Skunk Creek Segment 1.

Section 7.0 Skunk Creek Segment 1 Source Assessment and Allocation: Identifies all bacteria sources in the watershed and provides a calculation of bacteria production from all sources.

Sections 8.0 Escherichia coli (*E. coli*) TMDL for Skunk Creek Segment 1: Includes:

(a) Development of a Load Duration Curve (LDC)
(b) TMDL Allocations and Margin of Safety
(c) Numeric TMDL and Flow Zones
(d) Seasonal Variation

Section 9.0 Water Quality Improvement Plan and Monitoring Strategy: Discusses water quality restoration objectives, a strategy to meet the identified objectives and TMDLs, and describes a water quality monitoring plan for evaluating the long-term effectiveness of implementation practices.

Section 10.0 Public Participation and Public Comment: Describes other agencies and stakeholders who were involved with the development of this plan, and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 Skunk Creek Segment 1 Background

This section provides a general description of the physical, ecological, and social characteristics of the Skunk Creek Segment 1 watershed. This information provides context for the pollutant source assessment in **Section 7.0** and future implementation strategy in **Section 9.0**.

2.1 Physical Characteristics

The following information describes the physical characteristics of the Skunk Creek Segment 1 watershed. This includes location, climate, topography, hydrology, land use, geology, and soils.

2.1.1 Location

Skunk Creek Segment 1 is located in southeastern South Dakota and expands across several counties. The segment measures approximately 101.7 km and starts at Brandt Lake 1.6 kilometers east of the intersection of 462nd Avenue and 239th Street in Lake County, SD then ends at the converge with the Big Sioux River in Sioux Falls, SD. The segment's watershed is comprised of several HUC 12 watersheds which extend from the southeastern corner of Lake County to the western side of Minnehaha County (**Figure 2-1**). The size of the Skunk Creek Segment 1 watershed is approximately 128,569 hectares (ha). The length of Skunk Creek Segment 1 was obtained in US EPA Attains database and the watershed area was calculated using ArcMap geoprocessing tools.

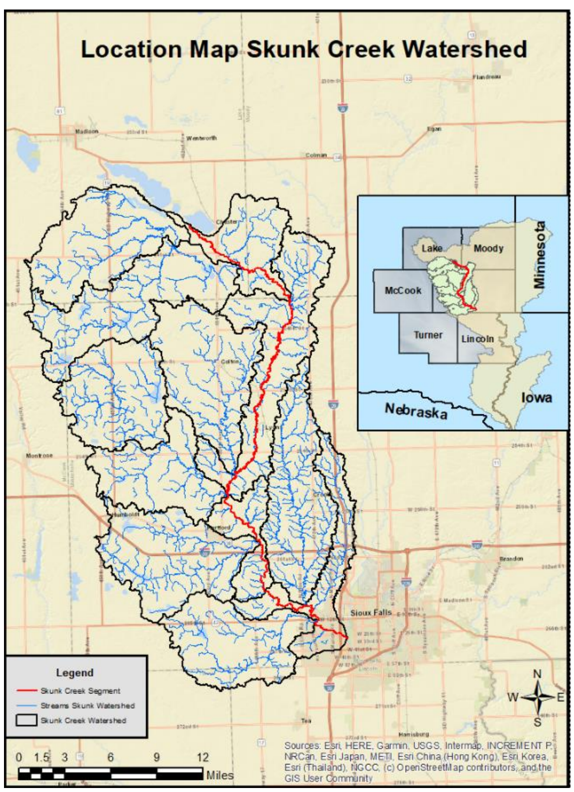

Figure 2-1. Location Map of Skunk Creek Segment 1 TMDL Project Area.

2.1.2 Climate

Skunk Creek Segment 1 climate is influenced by the seasonal cycle and its location in the northern plains. The climate is characterized as a polar continental which means temperatures and precipitation amounts vary greatly throughout the year.

Climate data was retrieved from the NOAA Online Weather Data (NOWData). The data was measured by an Automated Surface Observing System (ASOS) at the Sioux Falls Regional Airport in Sioux Falls, SD. The ASOS is located approximately 6 km northeast of the confluence of Skunk Creek Segment 1 and Big Sioux River. The watershed averages around fourty four inches of snowfall and over twenty six inches of total precipital water annually. Most rainfall occurs in the late spring and summer months (**Figure 2-2**) due to a return of low-level moisture and increasing surface temperatures which aids in convective development. The transition of cold to warm weather in the spring causes the polar and subtropical jet stream(s) to retreat further north and position in a synoptic set-up that brings more active weather to the region (Kuang et al., 2014).

Temperatures fluctuate with the change of seasons. Average low temperatures range from 0°-15°F in late December and January with high temperatures reaching the mid-80°Fs from July through early August. Frostfree days typically occur from early May to the beginning of October.

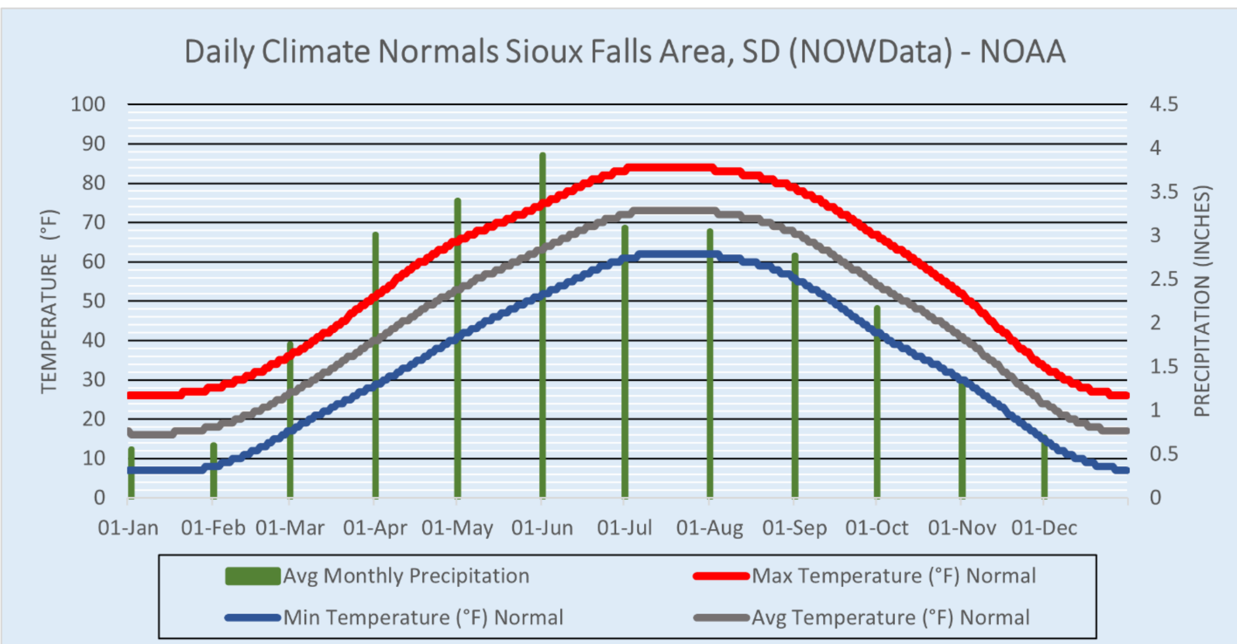

Figure 2-2. Average Annual Precipitation with High and Low Temperatures in Skunk Creek Segment 1 Watershed.

Skunk Creek Segment 1 watershed can also be influenced by other extreme weather phenomena like droughts, floods, and heatwaves. These extreme weather phenomena are an effect of upper level wind patterns and the cycles of the Southern Oscillation (Rauber et al., no date). The combination of extreme weather phenomena, seasonal temperatures, and precipitation can affect the characteristics of Skunk Creek Segment 1.

2.1.3 Hydrology

The drainage network in the Skunk Creek Segment 1 watershed is characterized by the mainstem of the Skunk Creek Segment 1 and several smaller tributaries (**Figure 2-3)**. The watershed is broken into twelve HUC 12 watersheds. Skunk Creek Segment 1 major tributaries (Willow Creek, Colton Creek, Buffalo Creek, Upper and Lower West Branch Skunk Creek Segment 1) are important hydrologically, but are not considered impaired for *E. coli* and do not have TMDLs.

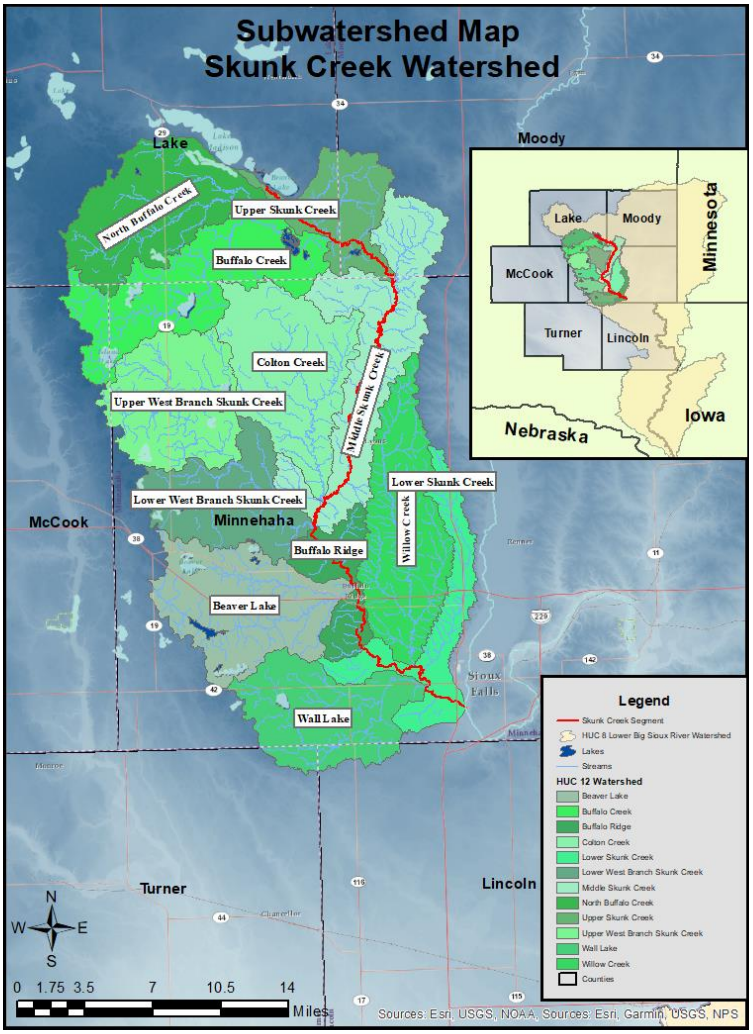

Figure 2-3. Subwatershed of the Skunk Creek Segment 1 TMDL Project Area

Tributary streamflow's generally follow the typical seasonal changes for the region. The highest stream flows occur in the spring (March-May) due to increased runoff from snowmelt and precipitation events. Streamflow begins to decline in June, reaching minimum flow levels in the fall. Streamflow can fluctuate rapidly through the summer months due to thunderstorm activity.

Baseflows are typically reached in the fall months as thunderstorm activity subsides and the weather pattern changes to drier and cooler conditions.

2.1.4 Topography & Soils

The topography is mapped below in **Figure 2-4.** Elevation ranges from 569 meters (1867 feet) to 340 meters (1401 feet) at the confluence with the Big Sioux River. The highest elevation in the Skunk Creek Segment 1 watershed can be found in the western parts of Buffalo Creek and West Branch watersheds. This area consists of gently sloping hills (2-6%) to sporadic low lying flood plains in the Western Branch Skunk Creek Segment 1. Moving towards the lower end of the Skunk Creek Segment 1 watershed the land changes to a flat outwash plain. Moraine type landforms are common in the middle section of Skunk Creek Segment 1 near the waterbody which are more suitable to rangeland.

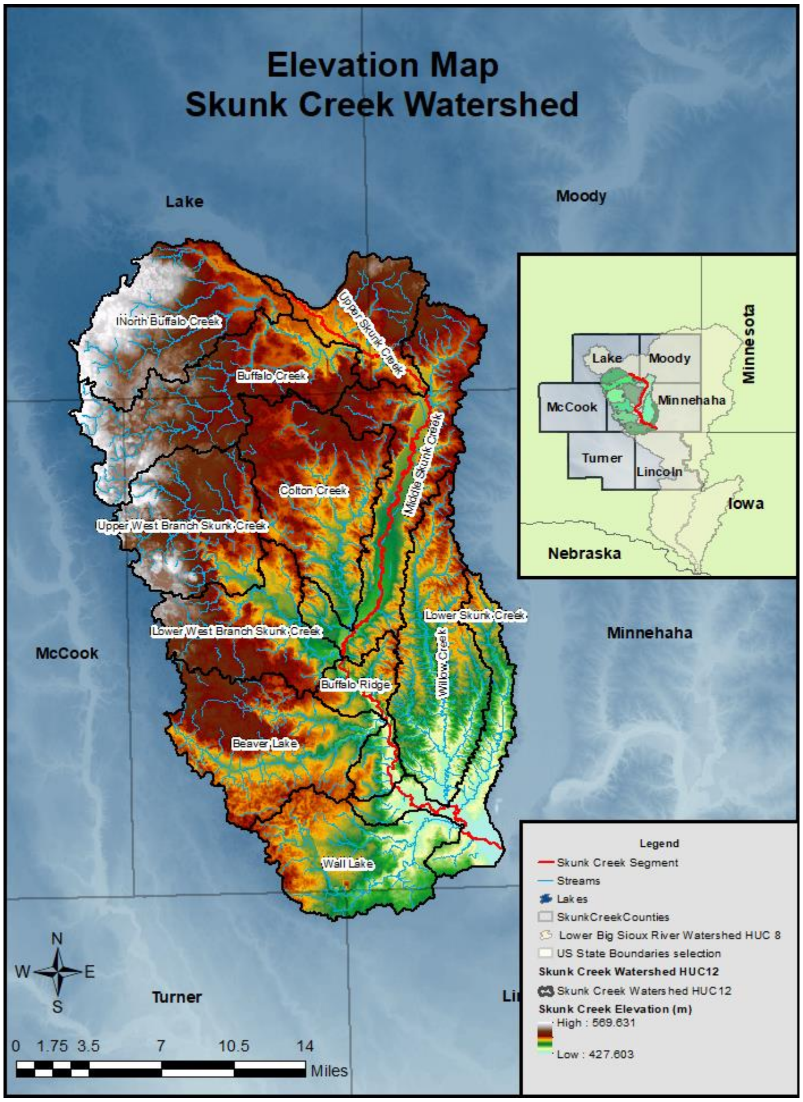

Figure 2-4. Topography of the Skunk Creek Segment 1 TMDL Project Area

A map and classification of soils is provided in **Figure 2-5.** Soil characteristics are correlated to the topography in the Skunk Creek Segment 1 watershed. The most predominate soil classifications in the western and southern part of the watershed are the Flandreau Loam, Egan-Ethan complex, and Wentworth-Trent. These types of soils are well draining with little to no frequent flooding. Main land use for the soils are row crops and small grains. Soils change over to the Moody-Nora and Nora-Crofton Complex closer to the middle section of Skunk Creek Segment 1 and Obert Silty Clay Loam along the eastern side of the watershed. A complete list of soil classifications for the Skunk Creek Segment 1 watershed can be found in **Appendix A**.

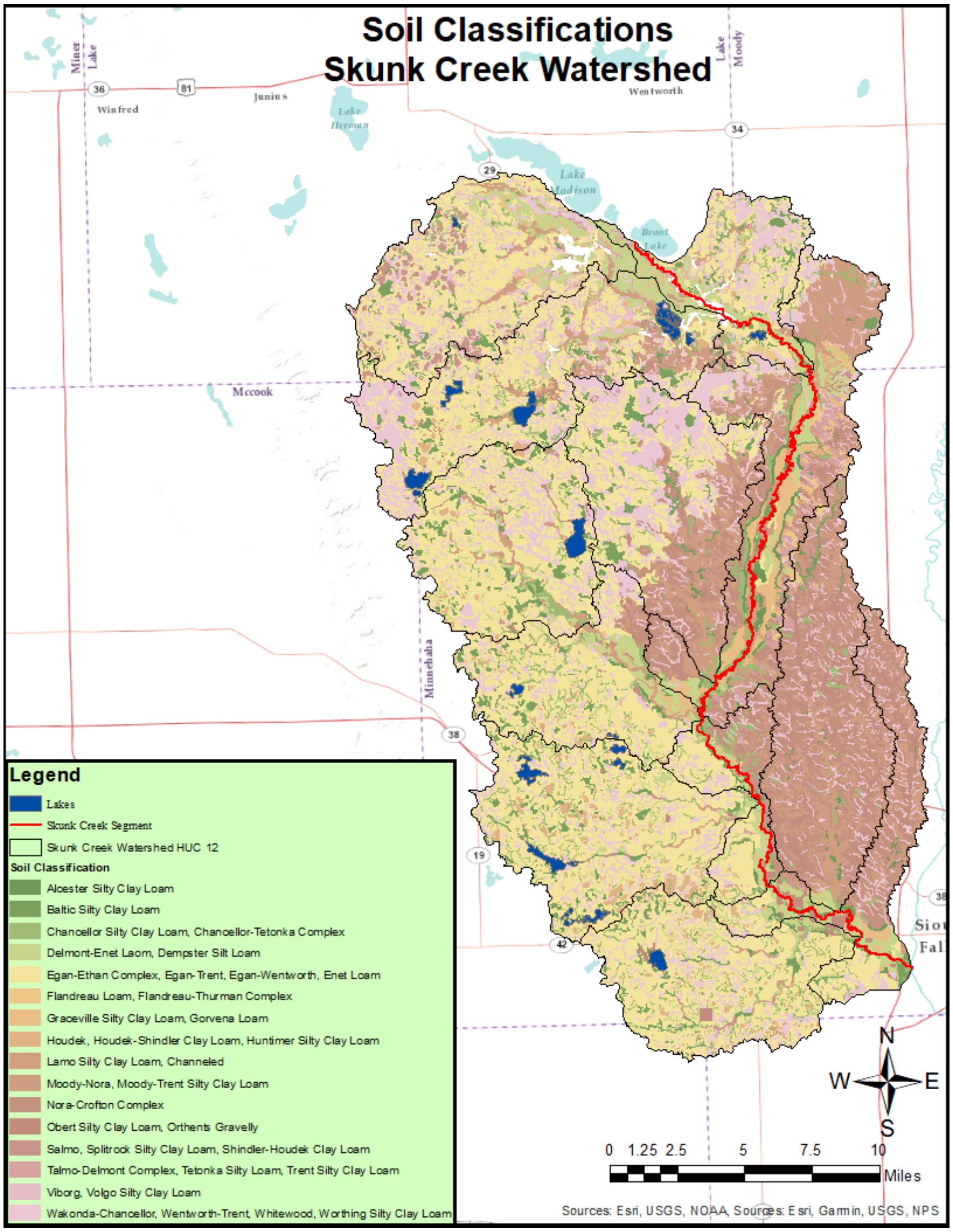

Figure 2-5. Soil Classifications of the Skunk Creek Segment 1 Watershed

2.2 Social Profile

The following section describes the social characteristics of the Skunk Creek Segment 1 watershed. This includes demographics and land use.

2.2.1 Demographics

Most of the population in Skunk Creek Segment 1 watershed is concentrated in municipalities. See **Table 1**. for the population estimates released by the U.S. Census Bureau in 2020. Small towns located in the Skunk Creek Segment 1 watershed that have populations around seven hundred or less are Lyons, Humbolt, Chester, and Colton. Bigger municipalities like Hartford and Crooks have populations in the thousands while Sioux Falls approaches two hundred thousand residents. All the municipalities are in the watershed except Sioux Falls, which has a small portion of the city's municipality area in the Skunk Creek Segment 1 watershed. Locations of all municipalities in the watershed can be found in (**Figure 2-6**).

Table 1. Municipality population in the Skunk Creek Segment 1 TMDL Project Area

Municipality	Population (2020)
Lyons	70
Hartford	3,354
Humboldt	579
Crooks	1,362
Sioux Falls	192,517
Chester	257
Colton	738

Several state and federal highways run though the Skunk Creek watershed. The main transportation corridors are Interstate 90 and Interstate 29 which are located on the south and east side of the watershed. In Sioux Falls, heavy residential and infrastructure can be found in and around the confluence of Skunk Creek. It was calculated that about 3,763 hectares or approximately 3% of the Skunk Creek Segment 1 watershed is inclusive of the city of Sioux Falls. The calculation was performed using ARC geoprocessing tools. The watershed also contains a well-connected web of county and township roads. These roads can be found along a majority of the section lines in the watershed.

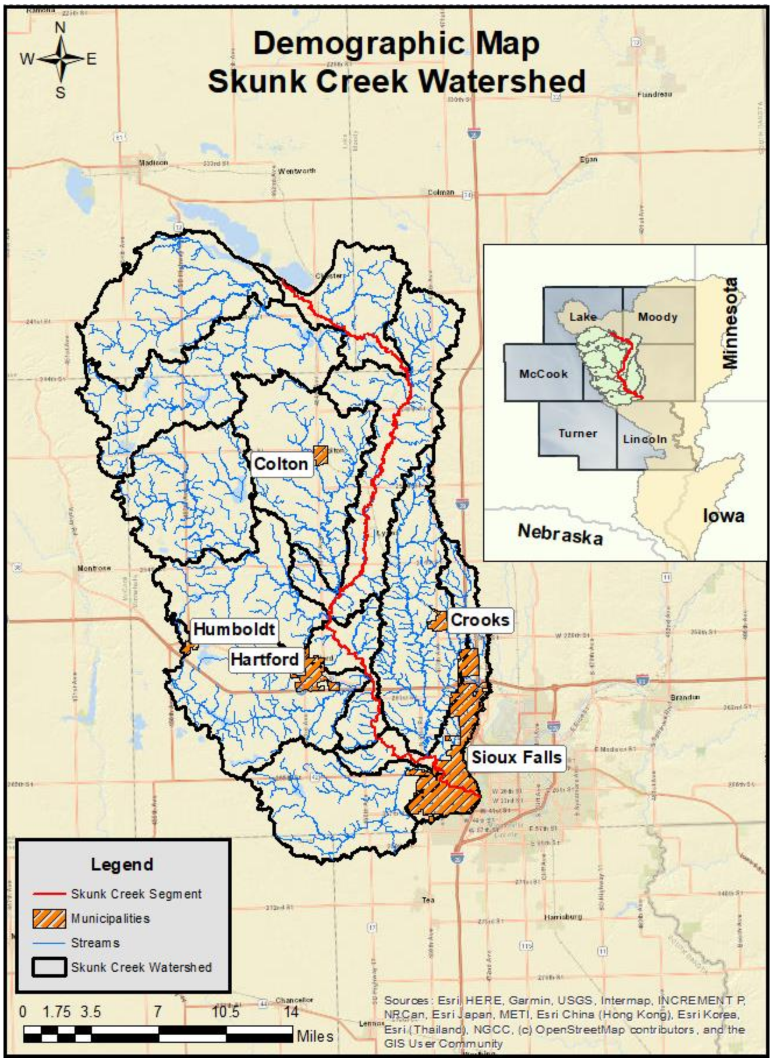

Figure 2-6. Demographic Map of Municipalities in the Skunk Creek Segment 1 TMDL Project Area

2.2.2 Land Use

Land use in the Skunk Creek Segment 1 watershed consists mostly of crop land with some grazing and hay ground. A land use map can be found below in **Figure 2-7.** Corn and soybeans are the dominate crops planted with a mixture of small grains scattered throughout the watershed. Grassland is mainly concentrated along or near waterways or on soils not suitable for cropland.

Cropland in the eastern half of the watershed has soils with better drainage and permeability than the western half due to its soil characteristics and presence of rolling hills. The eastern watershed has deep medium substrate soils that provide moderate permeability with gently to moderately sloping hills. The western half of the watershed contains flat ground to gentle slopes with slow permeability type soils. Low lying areas and sloughs are more common in the western half due to its soil characteristics. Spots prone to flooding or have low permeability may be left fallow during wet years.

Most of the pasture and grasslands are concentrated along Skunk Creek Segment 1, tributaries, and in areas prone to flooding. These areas contain land not suitable for cropland due to the topography and their soil classification. Grasslands in these areas are located close or adjacent to waterways and low-lying drainage areas. There are also several waterfowl production areas located in the western part of the watershed. These production areas are in large sloughs with no drainage outlets.

Forest or woody vegetation is sporadic throughout the watershed and mainly made-up of tree belt establishments. More concentrated woody vegetation can be found along Skunk Creek Segment 1 in the Buffalo Ridge sub watershed and around other waterbodies. Deciduous tree stands are more prevalent near waterbodies while coniferous tree stands are common near the top of slopes in moderate to highly permeable soils.

Urban development is predominant with municipalities found in the Skunk Creek Segment 1 watershed as discussed in **Section 2.2.1**. Other wildlife and state park grounds can be found in the Skunk Creek Segment 1 watershed.

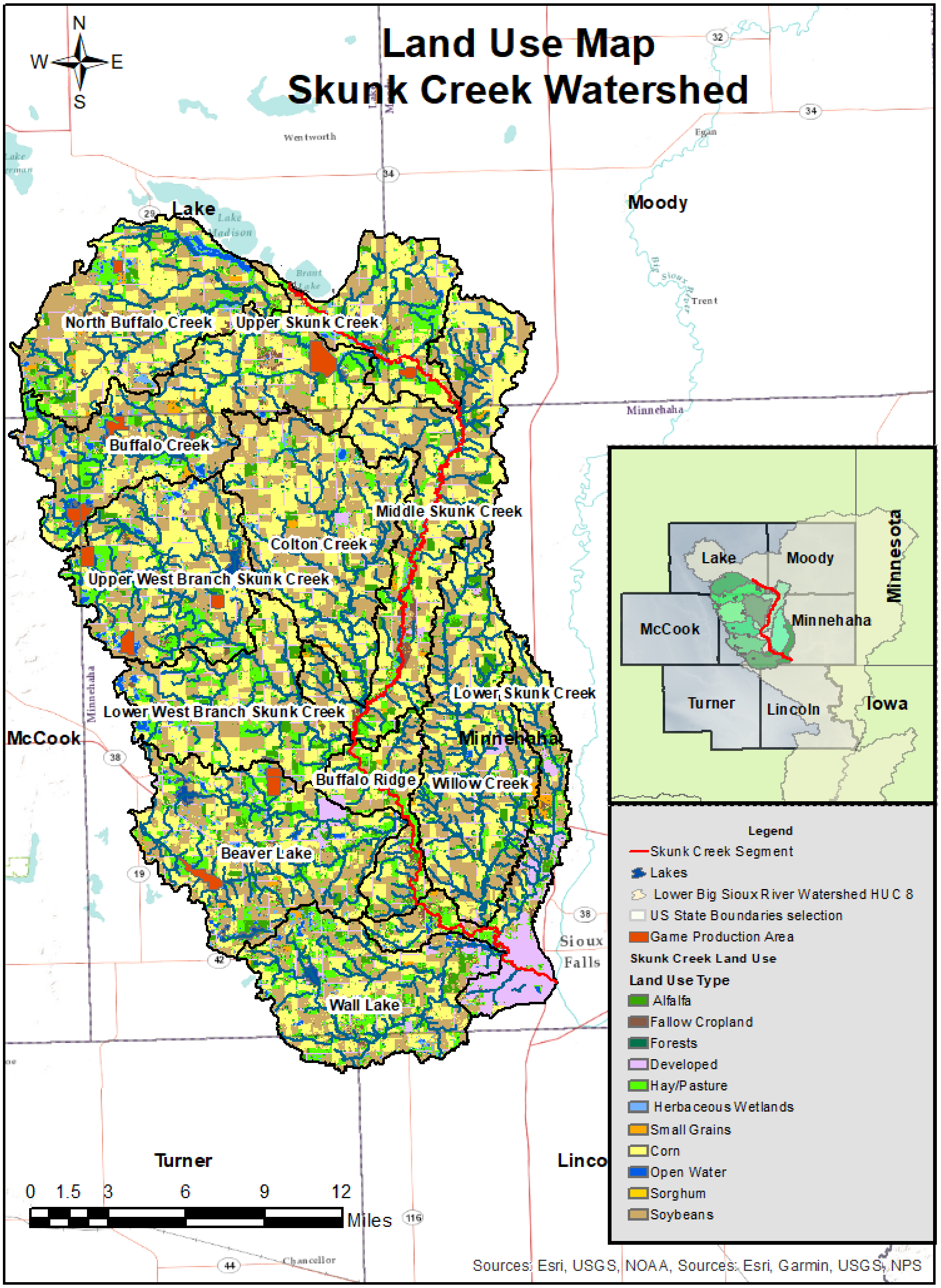

Figure 2-7. Land Use in the Skunk Creek Segment 1 TMDL Project Area

3.0 South Dakota Water Quality Standards

WQS are comprised of three main components as defined in the Federal Clean Water Act (33 U.S.C. §1251 et seq.) and Administrative Rules of South Dakota (ARSD) Chapter 74:51:01:

- Beneficial Uses – Functions or activities that reflect waterbody management goals
- Criteria – Numeric concentrations or narrative statements that represent the level of water quality required to support beneficial uses
- Antidegradation – Additional policies that protect high quality waters

3.1 Beneficial Uses

Waterbodies in South Dakota are designated one or more of the following beneficial uses: A list of South Dakota's beneficial uses can be found here: Beneficial Uses of Waters Established.

(1) Domestic water supply
(2) Coldwater permanent fish life propagation
(3) Coldwater marginal fish life propagation
(4) Warmwater permanent fish life propagation
(5) Warmwater semipermanent fish life propagation
(6) Warmwater marginal fish life propagation
(7) Immersion recreation
(8) Limited contact recreation
(9) Fish and wildlife propagation, recreation, and stock watering
(10) Irrigation waters
(11) Commerce and industry

All waters (both lakes and streams) within South Dakota are designated the use of fish and wildlife propagation, recreation, and stock watering (9). All streams are designated the uses of (9), and (10) irrigation. Additional uses are designated to waterbodies based on a beneficial use attainability assessment.

According to the 2024 Integrated Report, Skunk Creek Segment 1 from the outlet of Brandt Lake to the confluence with the Big Sioux River has been designated the beneficial uses of: (6) Warmwater marginal fish life propagation, (8) Limited contact recreation, (9) Fish and wildlife propagation, recreation, and stock watering and (10) Irrigation waters.

3.2 Water Quality Criteria

A list all the numeric criteria that must be met to support the beneficial uses designated for Skunk Creek Segment 1 can be found in **Table 2**. When multiple uses establish criteria for the same parameter, the most stringent criterion is used as indicated in the table with parentheses.

Table 2. South Dakota surface WQS for Skunk Creek Segment 1 in Minnehaha County, South Dakota.

Parameter	Criteria	Beneficial Use
Alkalinity ($CaCO_3$)	≤ 750[1] mg/L	Fish and wildlife propagation, recreation, and stock watering
	≤ 1313[2] mg/L	
Dissolved oxygen (warmwater semipermanent)	≥ 5.0[3] mg/L	Warmwater marginal fish life propagation
Total ammonia nitrogen as N	Equal to or less than the result from Equations 2[2] or 3[1] in Appendix A of Surface WQS	Warmwater marginal fish life propagation
E. coli (May 1 – September 30) (limited contact recreation)	*E. coli* ≤ 630[4] cfu/100 mL	Limited Contact Recreation
	E. coli ≤ 1,178[2] cfu/100 mL	Limited Contact Recreation
E. coli[6] (May 1 – September 30) (immersion recreation)	*E. coli* ≤ 126[4] cfu/100 mL	Immersion Recreation
	E. coli ≤ 235[2] cfu/100 mL	Immersion Recreation
Conductivity	≤ 2,500[1] micromhos/cm @ 25°C	Irrigation
	≤ 4,375[2] micromhos/cm @ 25°C	
pH (standard units)	≥ 6.5 and ≤ 9.0 units	Fish and wildlife propagation, recreation, and stock watering
Nitrates as N	≤ 88[2] mg/L	Fish and wildlife propagation, recreation, and stock watering
	≤ 50[1] mg/L	
Total suspended solids (warmwater semipermanent)	≤ 90[1] mg/L	Warmwater marginal fish life propagation
	≤ 158[2] mg/L	
Total dissolved solids	≤ 2,500[1] mg/L	Fish and wildlife propagation, recreation, and stock watering
	≤ 4,375[2] mg/L	
Temperature (warmwater semipermanent)	≤ 90 °F	Warmwater marginal fish life propagation
Undissociated hydrogen sulfide	≤ 0.002[2] mg/L	Warmwater marginal fish life propagation
Total petroleum hydrocarbon	≤ 10 mg/L	Fish and wildlife propagation, recreation, and stock watering
Oil and grease	≤ 10 mg/L	Fish and wildlife propagation, recreation, and stock watering
Microcystin (May 1st – Sep 30th)	< 8[5] µg/L	Limited Contact Recreation
Cylindrospermopsin (May 1st – Sep 30th)	< 15[5] µg/L	Limited Contact Recreation
Sodium adsorption ratio	≤ 10 ratio	Irrigation

(1) 30-day average as defined in ARSD 74:51:01:01(60); (2) daily maximum; (3) DO as measured anywhere in the water column of a non-stratified waterbody, or in the epilimnion of a stratified waterbody; (4) Geometric mean as defined in ARSD 74:51:01:01(24) and 74:51:01:50-51; (5) Not to be exceeded in more than three 10 day assessment periods over the course of the recreation season. (6) This use is not associated with Skunk Creek Segment 1, but its downstream waterbody.

Additional "narrative" standards that may apply can be found in ARSD 74:51:01:05; 06; 08; and 09. These rules contain language that generally prohibits the introduction of materials into waterbodies causing pollutants to form, visible pollutants, undesirable odors and nuisance aquatic life which can all interfere with the biological integrity of a waterbody.

3.2.1 *E. coli* Water Quality Criteria

South Dakota has adopted numeric *E. coli* criteria for the protection of (7) Immersion and (8) Limited contact recreation uses. Immersion recreation waters are to be maintained suitable for activities such as swimming, bathing, water skiing and other similar activities with a high degree of water contact that make bodily exposure and ingestion more likely. Limited contact recreation waters are to be maintained suitable for boating, fishing, and other water-related recreation other than immersion recreation.

Through the 1970's and 1980's EPA epidemiological studies identified *E. coli* as a good predictor of gastrointestinal illnesses in fresh waters (US EPA, 1986). *E. coli* is a class of bacteria naturally found in the intestinal tract of humans and warm-blooded animals. The presence and concentration of *E. coli* in surface waters, typically measured in colony forming units (cfu) or counts (#) per 100 ml, is used to identify fecal contamination and as an indicator for the likely presence of other pathogenic microorganisms. In 1986 EPA recommended states adopt *E. coli* criteria for immersion recreation based on a rate of 8 illnesses per 1,000 swimmers (US EPA, 1986). While it is generally understood that limited contact recreation is associated with a reduced illnesses risk and different routes of exposure, it is difficult to directly relate an illness rate to these activities from epidemiological studies based on immersion recreation. Therefore, to protect downstream uses and establish effluent limitations for limited contact recreation waters, EPA has suggested numeric criteria five times the immersion recreation values (US EPA, 2002). Because of the reduced risk, the multiplier was considered protective of the limited contact recreation use through the EPA and DANR WQS review and approval process.

The South Dakota *E. coli* criteria for the immersion recreation beneficial use requires that 1) no single sample maximum (SSM) exceed 235 cfu/100 ml and 2) during a 30-day period, the geometric mean (GM) of a minimum of 5 samples collected during separate 24-hr periods must not exceed 126 cfu/100 ml (ARSD 74:51:01:50). The *E. coli* criteria for the limited contact recreation beneficial use requires that 1) no single sample exceed 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 (ARSD 74:51:01:51). *E. coli* criteria apply from May 1 through September 30, which is considered the recreation season. The numeric *E. coli* criteria applicable to Skunk Creek Segment 1 are values listed in **Table 2**.

TMDLs must also consider downstream WQS. In this case, Skunk Creek Segment 1 flows into Big Sioux River segment 11 (SD-BS-R-BIG_SIOUX_11) which is designated the immersion recreation beneficial use with stricter criteria. Due to this fact, the Skunk Creek Segment 1 TMDL was written to the immersion recreation beneficial use to be protective of downstream WQS.

3.3 Antidegradation

This TMDL document is consistent with South Dakota antidegradation policies (ARSD 74:51:01:34) because it provides recommendations and establishes pollutant limits at water quality levels necessary to meet criteria and fully support existing beneficial uses.

4.0 Impairment Assessment Methods

Assessment methods document the decision-making process used to define whether WQS are met. DANR evaluates monitoring data following these established procedures to determine if: 1) one or more beneficial use is not supported, 2) the waterbody is impaired, and 3) it should be placed on the next 303(d) list. Waterbodies impaired by pollutants require TMDLs and these assessment methods are commonly used again in the process sometime after TMDLs have been established and restoration efforts have been implemented. In select cases, attainment is judged instead by comparing current conditions to TMDL loading limits. For example, when certain characteristics of the pollutant (e.g., bioaccumulative) or waterbody (e.g., a reservoir filling with sediment) prioritize loading concerns.

When determining to list a waterbody for impairment, DANR allows a 10% or less exceedance frequency of both the SSM and GM. As long as the *E. coli* dataset meets other age and size requirements, a waterbody is considered impaired when greater than 10% of samples exceed either the SSM or GM. WQS are considered met if the exceedance frequency of both the SSM and the GM are 10% or less. **Table 3** presents South Dakota's assessment method for *E. coli*, and describes what constitutes a minimum sample size and how an impairment decision is made.

Table 3. Assessment Methods for Determining Support Status for Section 303(d) (DANR 2022).

Description	Required Minimum Sample Size	Impairment Determination Approach
For Conventional Parameters: • TSS • *E. coli* • pH • Temperature • Dissolved Oxygen	STREAMS: • Minimum of 20 samples (collected on separate days) for any one parameter are required within a waterbody reach. • Minimum of 10 chronic (calculated) results are required for chronic criteria (30-day averages and geomeans). LAKES: Reference the lake listing methodology starting on page 31 of the 2022 IR.	STREAMS: >10% exceedance for daily maximum criteria (acute) or >10% exceedance for 30-day average criteria OR when overwhelming evidence suggests nonsupport/support LAKES: Reference the lake listing methodology starting on page 31 of the 2022 IR..

The assessment method mentions chronic and acute criteria. Although these terms do not directly relate to *E. coli* criteria (see **Section 3.2.1)**, the assessment method is organized together with other conventional parameters in the Integrated Report to show that a consistent approach is applied to many pollutants. In this limited definition, chronic refers to the GM and acute refers to the SSM *E. coli* criteria. Different assessment methods have been established for toxic parameters and mercury in fish tissue. **Section 6.0** will apply the assessment method to evaluate the Skunk Creek Segment 1 data collection and monitoring results.

5.0 Developing Numeric Targets for E. *coli*

TMDLs are required to identify a numeric target to measure whether the applicable water quality standard is attained. A maximum allowable load, or TMDL, is ultimately calculated by multiplying this target with a flow value and a unit conversion factor. Generally, the pollutant causing the impairment and the parameter expressed as a numeric water quality criteria are the same. In these cases, selecting a TMDL target is as simple as applying the numeric criteria.

There are two numeric *E. coli* criteria for TMDL target consideration (**Table 2**). When multiple numeric criteria exist for a single parameter, the most stringent criterion is selected as the TMDL target. To judge whether one is more protective of the beneficial use, it is necessary to further elaborate how the criteria was derived (**Appendix B**). Criteria development revealed that the GM and SSM criterion are equally protective of the beneficial use because they are based on the same illness rate and only differ simply from different statistical values and sampling timeframes (USEPA, 2012).

The immersion recreation SSM *E. coli* criterion of 235 cfu/100mL was selected as the numeric TMDL target for the Skunk Creek Segment 1 TMDL because a proper geometric mean could not be calculated from the available monitoring dataset. In addition to the daily load, the geometric mean criteria must be attained on a longer (i.e., monthly) basis. Refer to **Section 6.0** for a review of the Skunk Creek Segment 1 sampling and results.

6.0 Water Quality Data and Discharge Information

E. coli data was obtained from one monitoring station within the impaired segment from 2006 to 2020 during the recreational season (May 1st to September 30th). The associated daily flows were obtained from long-term flow records available from a USGS gage station located within the impaired segment.

All *E. coli* data collection conducted during this project followed methods in accordance with the South Dakota Standard Operating Procedures for Field Samplers developed by the DANR Watershed Protection Program. Water samples were sent to the State Health Laboratory in Pierre, SD for analysis. *E. coli* data collected during the recreation season was exclusively used to develop the TMDL. All water quality data used for TMDL development can be found in **Appendix C**.

6.1 Flow Information and Data

A long-term flow record was obtained from a USGS stream gage station on Skunk Creek Segment 1 in Sioux Falls, SD. USGS monitoring Station ID: 06481500 is located on South Marion Road about 0.8 kilometers northwest of Exit 78 (26th St. Louise Ave) on Interstate 29. This station also contains long-term water quality data and is located near the end of the impaired segment. The station captures the entire drainage area in the Skunk Creek Segment 1 watershed.

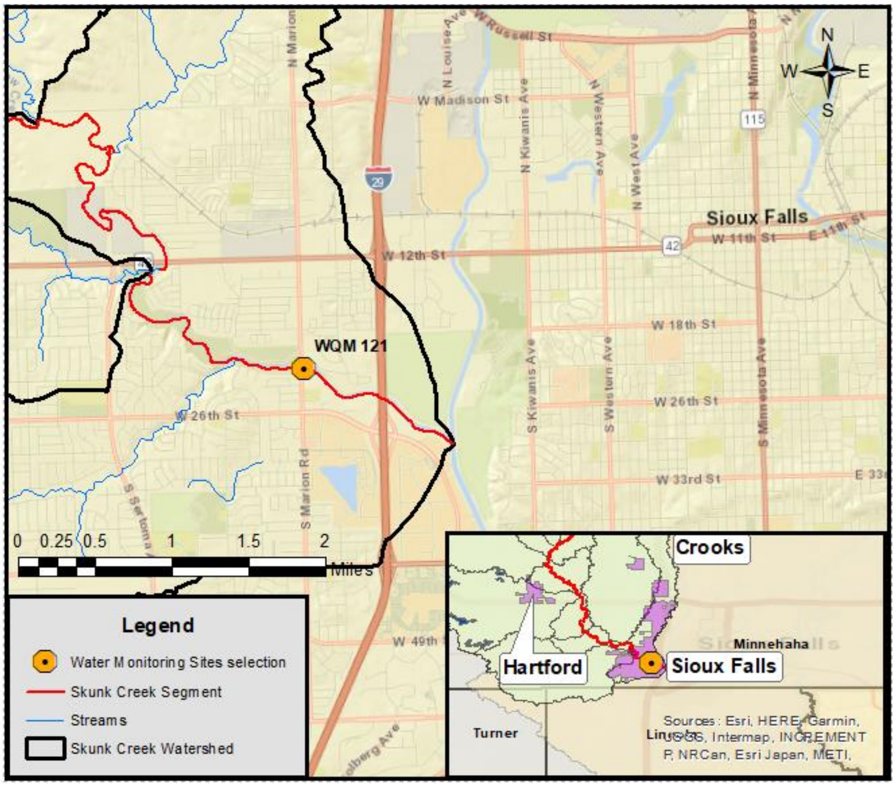

Figure 6-1: WQM 121 Location along Skunk Creek Segment 1

Continuous gage height and periodic discharge measurements were collected from May 2006 to November 2020. Average daily flows from this timeframe were used to develop the Load Duration Curve (LDC) based TMDL in **Section 8.0.**

6.2 *E. coli* Water Quality Data

All applicable *E. coli* data collected during the recreation season within the Skunk Creek Segment 1 watershed was analyzed for TMDL development. Four water quality monitor stations with *E. coli* data were identified in the Skunk Creek watershed. Three are located on tributaries to Skunk Creek. The Station ID: CENTBSRT20 on West Branch Skunk Creek, Station ID: CENTBSRT19 on Colton Creek, and Station ID: EDWQSPT22 on Willow Creek were previous monitoring stations for the Central Big Sioux River implementation project. The project used these station's data for determining BMP effectiveness. These three monitoring stations water quality data will not be used for Skunk Creek Segment 1 *E. coli* TMDL.

E. coli data used for the Skunk Creek Segment 1 *E. coli* TMDL was obtained from a DANR Water Quality Monitoring station (WQM 121). This long-term monitoring site was established as part of SD DANR's ambient water quality monitoring network. WQM 121 is located at the same location as USGS station (06481500). This monitoring station will provide a long-term dataset in the future to evaluate attainment of WQS for Skunk Creek Segment 1.

A total of 91 *E. coli* samples were collected at WQM 121 from 2006-2020 by staff from East Dakota Water Development District (EDWDD) and DANR during the recreation season (May – September). *E. coli* sample collection was not conducted at the frequency required to calculate a monthly GM. As a result, impairment was based solely on the SSM criterion. *E. coli* concentrations ranged from 8 cfu/100mL to 9,210 cfu/100mL. Thirty-seven *E. coli* samples exceeded the SSM criterion for immersion recreation. Eighteen *E. coli* samples exceeded the SSM criterion for limited contact recreation.

7.0 Source Assessment and Allocations

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. The U.S. Environmental Protection Agency (EPA) defines point source pollution as "any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term "point source" also includes concentrated animal feeding operations, which are places where animals are confined and fed. By law, agricultural stormwater discharges and return flows from irrigated agriculture are not "point sources"," (US EPA)[1]. Point sources are often wastewater treatment plants or industrial facilities that discharge effluent directly into waterbodies. Pollutant loading sources that do not meet the definition of a point source are considered nonpoint sources. Nonpoint sources are associated with diffuse pollutant loading to a waterbody and are often linked to runoff from agricultural, urban, or forestry activities, as well as streambank erosion and groundwater seepage that can occur from these activities. Natural background loading and atmospheric deposition are both considered types of nonpoint sources.

7.1 Construction Storm Water Permits

Construction activities have the potential to produce pollutants that may contaminate stormwater runoff. Currently there are several construction permits that are ongoing in the watershed. The status of these construction projects are considered to be active by DANR until the permitted party opts to close the permit. Stormwater construction activities must have coverage and comply with South Dakota's *General Permit Authorizing Stormwater Discharges Associated with*

[1] US EPA (U.S. Environmental Protection Agency). National Pollution Elimination System Permit Basics. https://www.epa.gov/npdes/npdes-permit-basics

Construction Activities ensuring that discharges are minimal. The permits also stipulate that they do not contribute to violations of surface water quality criteria. A Stormwater Pollution Protection Plan (SWPPP) is required for all permitted construction and Industrial stormwater sites. The SWPPP is a written document that outlines how contractors will ensure stormwater runoff leaving the site will not become contaminated with pollutants. A WLA is not assigned since these permits are not expected to be a source of bacteria pollution.

7.2 Non-stormwater Point Sources

This section provides an *E. coli* source assessment for the Skunk Creek Segment 1 watershed. All point sources with a National Pollutant Discharge Elimination System (NPDES) permit are identified.

Town of Humboldt (NPDES Permit# SD824015)

The Town of Humboldt has a no discharge Wastewater Treatment Facility (WWTF) along East 2nd Street on the east side of the municipality. The wastewater treatment facility began operation in 1991 and consists of a gravity flow collection system, with contributions from two area lift stations. Wastewater flows to a two-cell stabilization retention pond system with a total cell area of 5.2 hectares (12.8 acres). This system doesn't contain infrastructure for effluent flow. A mechanical pump is used if there needs to be an emergency discharge. Flow is discharged into a ditch which goes into nearby Beaver Lake. An unnamed tributary serves as the outlet of Beaver Lake and flows approximately 12 kilometers to Skunk Creek.

The facility was inspected in May of 2022 and follow-up corrective actions were needed for monitoring on-site pH analysis and following reporting requirements of emergency discharges. Since the last inspection, nine emergency discharges are on file: October 2017 (not sampled), April 2018 (not reported), May 2018 (not reported), August 2018 (not reported), October 2018, March2019, April 2019 (not sampled), May 2019 (not sampled), and October 2019 (not reported). Emergency discharge forms were not submitted for any of the discharges.

Since this facility is not permitted to discharge, only performs emergency discharges due to significant rainfall events, and does not directly discharge into Skunk Creek, it was not assigned a WLA in the TMDL.

City of Crooks (NPDES Permit# SD0020761)

The City of Crooks has a wastewater treatment facility on the southwest side of the city along 469th Ave. The bi-level pond system was built in 1972 and currently serves a population of 1,269 persons with an average design flow of 0.16 MGD. The facility has six separate cells with a total cell area of 10.2 hectares (25.2 acres). Wastewater flows by gravity, aided by one area lift station, to a main lift station, which pumps wastewater to either Cell 1 or Cell 1B. Cells 1, 2, and 3 are operated in series. Cells 1B, 2B, and 3B are also operated in series. Cell 3B wastewater is routed to Cell 3. Discharges from the facility are from a valve-controlled discharge structure in Cell 3. See **Figure 7-1** for a diagram of the Crooks Wastewater Treatment Facility.

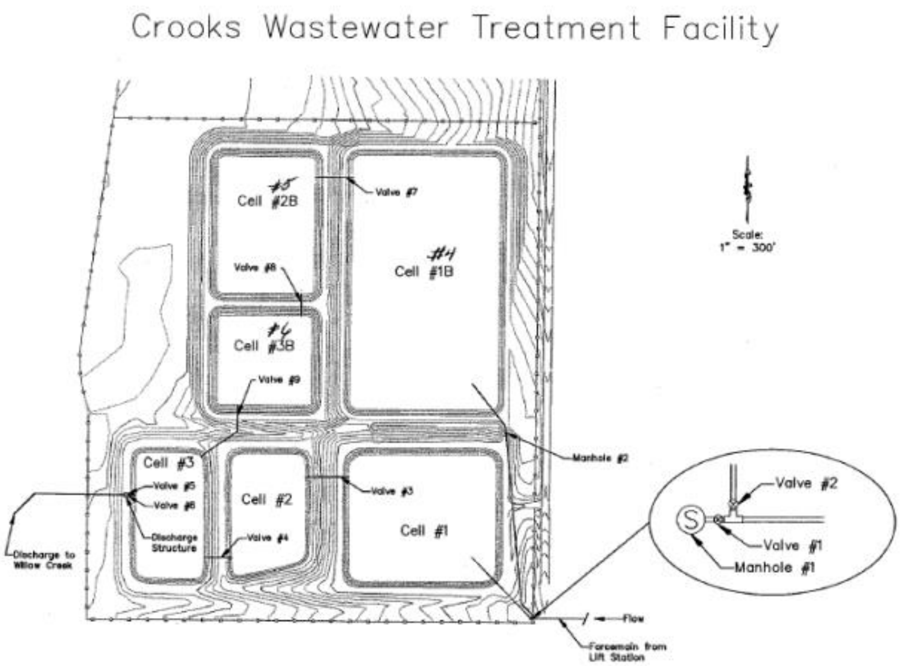

Figure 7-1. City of Crooks Wastewater Treatment Facility's Diagram

Any discharge from this facility will enter Willow Creek which is a tributary of Skunk Creek Segment 1. Wastewater flows over 11 kilometers before the confluence with Skunk Creek.

According to the City of Crooks Statement of Basis, Skunk Creek was identified as being impaired for fecal coliform. A fecal coliform TMDL has been completed and approved by EPA. The fecal coliform TMDL indicated that point sources within the watershed are contributing an insignificant amount to the fecal coliform loading and no wasteload allocation was assigned to the City of Crooks. The limits developed for the draft permit for *E. coli* should ensure that the City of Crooks does not discharge bacteria in levels that will contribute to the impairment.

The facility was inspected in September of 2023 and follow-up corrective actions were needed in reporting effluent limit violations. DMR corrections have been made following the inspection. The facility has reporting DMR data for 14 months in the last 10 years and discharged in the recreation season on two separate occasions (May 2018 and May 2020). Besides the two separate discharge events in the recreation season, the facility typically discharges outside of the recreation period over the last 10 years.

As long as Crook's WWTF adheres to requirements set forth in the NPDES permit any discharge from this facility is expected to have little to no impact on the Skunk Creek Segment 01 TMDL. A WLA will not be assigned to the facility.

City of Crooks Municipal Utilities (NPDES Permit# SDG860048)
The City of Crooks is permitted to discharge overflow water from the drinking water distribution system which could potentially reach Skunk Creek. *E. coli* effluent limits are not included in the permit because *E. coli* is not a pollutant of concern. Potential discharge from this facility is not expected to impact the TMDL. A WLA was not assigned to this facility in the TMDL.

Chester Sanitary District (NPDES Permit# SD0020338)
Chester Sanitary District operates a wastewater treatment facility (WWTF) 1.6 kilometers east of Chester along 465th Ave. The WWTF consists of two area and one main lift stations that pump wastewater to a three-cell stabilization pond system, with an average design flow rate of 0.036 MGD and average reported flow rate of 0.82 MGD. The total size of the three-cell pond system is 5.7 hectares (14 acres). Cell 3 contains a valve-control discharge structure with a Parshall flume for flow measurement. The discharged effluent is piped approximately 1.6 kilometers south to Skunk Creek Segment 1 (Outfall 002). See **Figure 7-2** for a map of the treatment system obtained from Chester Sanitary District Statement of Basis.

Figure 7-2. Chester Sanitary District Treatment System

This WWTF serves a total population of approximately 500 persons: 265 from Chester Sanitary District (permit application), and 235 from Brant Lake Sanitary District (permit file). No known industrial users contribute flow to the system. A WLA was assigned to the TMDL for the Chester Sanitary District.

City of Colton Water Distribution (NPDES Permit# SDG860069)
The City of Colton is permitted to discharge overflow water from the drinking water distribution system which could potentially reach Skunk Creek via Colton Creek. *E. coli* effluent limits are not included in the permit because *E. coli* is not a pollutant of concern. Potential discharge from these facilities is not expected to impact the TMDL. A WLA was not assigned to this facility in the TMDL.

City of Colton (NPDES Permit# SD0022322)
The City of Colton operates a wastewater treatment facility located 0.4 kilometer southwest of the city in Minnehaha County, South Dakota. This wastewater treatment facility serves a population of 738 persons (2020 census), with no known industrial users contributing flow to the system.

The wastewater treatment facility consists of a gravity-flow collection system to a main lift station and three stabilization ponds. Wastewater flows from the primary cell southeast to the second cell about 0.4 km away then into the third cell operating in series. Discharge from the third cell is valve-controlled, and effluent flow rate is measured with a Parshall flume.

Wastewater discharge from Colton's wastewater treatment ponds have generally occurred once to twice annually on a temporary basis (weeks) during the spring and fall with some discharge events occurring outside the peak recreation season (2016-2021). Colton's wastewater treatment ponds also provide a mechanism to reduce *E. coli* bacteria. Bacteria in the ponds are not likely to be viable for long periods due to extended retention time and resultant exposure to the sun's ultraviolet light. Temporary discharge from Colton's WWTF does not occur directly to the impaired segment of Skunk Creek Segment 1, rather discharge occurs directly into Colton Creek (Skunk Creek Segment 1 tributary) approximately 19 kilometers upstream from the Skunk Creek Segment 1 confluence. As long as Colton's WWTF adheres to requirements set forth in the NPDES permit any discharge from this facility is expected to have little to no impact on the Skunk Creek Segment 01 TMDL. As a result, a WLA of zero was assigned to the TMDL.

Tri-Valley School District (NPDES Permit# SDG827278)
The Tri-Valley School District has a wastewater treatment facility on the north side of the school campus which is located 6.4 kilometers south of the City of Colton along 252nd St. The WWTF began operation in 1982 and serves only the school. The facility has a three-cell stabilization pond system with a storage capacity of 0.44 hectare–meters (3.6 acre-feet). No inspection report has been provided for this system. Since the facility is not permitted to discharge to Colton Creek and has no direct impact to Skunk Creek Segment 1, a WLA was not assigned to this facility.

Wall Lake Sanitary District (NPDES Permit# SD0026778)
Wall Lake Sanitary District operates a wastewater treatment facility located approximately 0.3 kilometers south of Wall Lake. A pressure collection system collects wastewater from 43 grinder

pumps that serve 2-3 homes each. Wastewater then flows to the main lift station to a stabilization pond system that consists of three ponds that operate in series. Effluent is discharged through a valve-controlled 90° V-notch weir. This facility serves a population of 200 persons with no known industrial users contributing to flow. The average design flow is 0.02 MGD. With a 0.026 MGD peak design flow. Any discharge from this facility will enter an unnamed tributary which will flow approximately 13 miles to Skunk Creek. Last reported discharge was in 2000.

Although Wall Lake Sanitary District is authorized to discharge, it is not required to monitor for bacteria as part of its permit. The facility may periodically discharge into an unnamed tributary which has no assigned beneficial uses. As long as Wall Lake Sanitary District WWTF adheres to requirements set forth in the NPDES permit any discharge from this facility is not expected to impact the TMDL. A WLA was not assigned to this facility in the TMDL.

City of Hartford (NPDES Permit# SD0021750)

The City of Hartford operates a wastewater treatment facility located on the south side of the municipality next to Interstate 90. The WWTF was built in 2001 and serves a population of 3,354 persons. Wastewater from the city primarily flows via gravity, with two area lift stations (one of which is temporary until a new facility is built), to a main lift station located on Railroad Street in Hartford. Wastewater passes through a mechanical bar screen and six-inch Parshall flume with a flow meter at this lift station. Three available pumps convey wastewater via one of two ten-inch force mains to the WWTF.

The facility consists of two separate processes to treat wastewater. Influent wastewater from the force main enters two aerated cells then through three tertiary cells working in series. Any discharge from the Hartford WWTF will enter an unnamed tributary of Skunk Creek Segment 1 which flows 5.6 kilometers to Skunk Creek Segment 1. See **Figure 7-3** for a map of the facility and its outfall obtained from Hartford's Statement of Basis. A WLA was assigned to the TMDL for the City of Hartford.

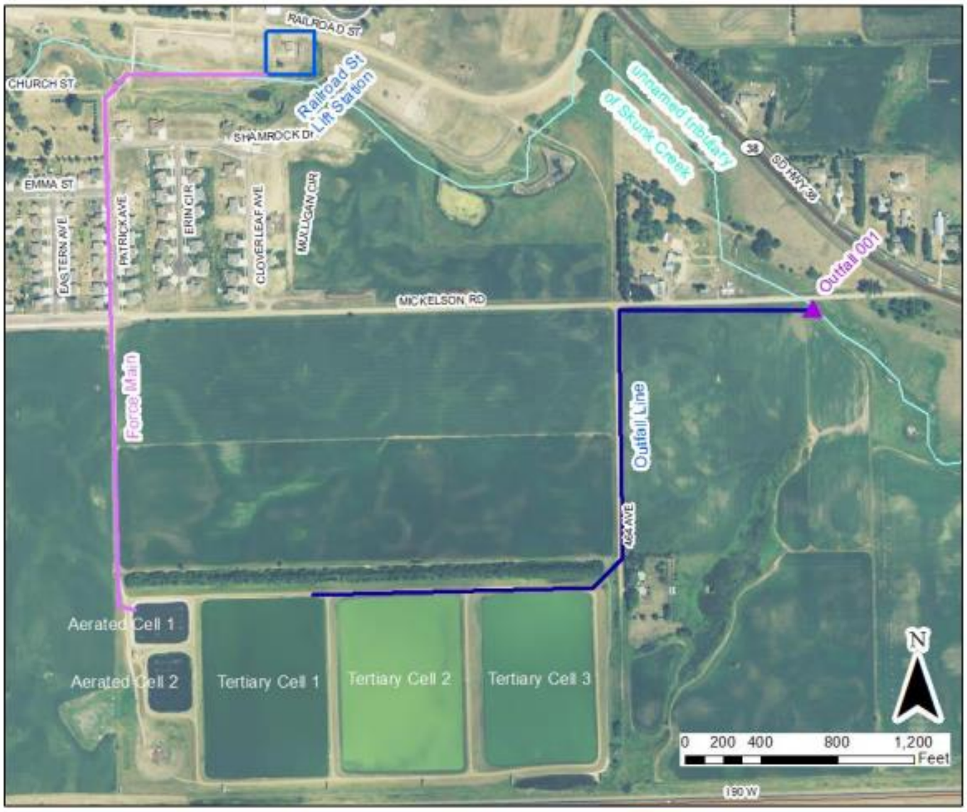

Figure 7-3. City of Hartford Wastewater Treatment Facility

The Hartford WWTF is currently considered to be hydraulically overloaded. The city is, as of the writing of this TMDL, currently in the design phase of constructing a new WWTF to handle increase wastewater loadings. The new system will incorporate a UV unit for disinfection in the treatment process before being discharged. Construction of the new WWTF is expected to start on October 1, 2022 with a completion date of October 1, 2025.

The City of Hartford proposes to install sanitary sewer pipe on Mickelson Road between Patrick Avenue and Highway 38. The city will also install a new lift station, force main, and storm sewers to accommodate the increasing growth in the area. Install approximately 2,347 meters of sanitary sewer and 18 oversized manholes along Western Avenue to add service to the city's industrial park and residences along the new service route.

South Dakota State Penitentiary – West Farm (NPDES Permit# SDG820427)

The South Dakota State Penitentiary has a wastewater treatment facility which was constructed in 1972 and is located on a farm west of the City of Sioux Falls on 264th Street in Minnehaha, South Dakota. The WWTF consists of a gravity flow collection system and two stabilization ponds, 0.6 acres and 2.2 acres, respectively. The first cell was constructed in 1972 and the second cell added in 1990. The facility is designed for total retention. The pond system treats primarily domestic wasted with contributions from on-site kitchen, laundry and shower facilities. The facility serves about 35 adjudicated youth and staff members.

An inspection to the system was conducted in October 2017. Corrective actions were needed to the facilities dike for controlling cattails and planting native grasses or installing rip-rap to protect erosion. The facility has never reported a discharge since constructed. Since facility is not permitted to discharge and has no direct impact to Skunk Creek Segment 1. A WLA was not assigned to this facility.

City of Sioux Falls (NPDES Permit# SD0022128)

The city of Sioux Falls operates a wastewater reclamation facility (WRF) located at the northeastern edge of the city along Sycamore Ave. This wastewater treatment facility serves a population of 178,500 persons (2017 inspection report). The city's collection system consists of approximately 1,426 kilometers of sewer line, with 19 city-owned lift stations and 2 privately-owned lift stations. Other privately-owned collection systems such as trailer parks and apartment complexes also contribute influent wastewater to the facility. The facility and point of discharge is located outside of the Skunk Creek Segment 1 watershed, however approximately 3% of Skunk Creek Segment 1 watershed is urban infrastructure is serviced by this WRF system.

The WRF consists of preliminary, primary, secondary, and tertiary wastewater treatment, with an average design flow of 21 million gallons per day (MGD) and a peak design flow of 35 MGD. An annotated facility site map is included in Sioux Falls Statement of Basis. Effluent flow from this facility discharges directly into the Big Sioux River Segment 12. A WLA from this facility was assigned to the Big Sioux River Segment 12 *E. coli* TMDL and is included in this TMDL discussion because it treats wastewater from the Sioux Falls portion of the Skunk Creek watershed.

7.3 City of Sioux Falls MS4

Under EPA's Stormwater Phase I MS4 Rule, City of Sioux Falls is regulated as a Municipal Separate Stormwater Sewer System (MS4) with having a population over 100,000. In 1999 the City of Sioux Falls and South Dakota Department of Transportation was granted a surface water discharge permit (SDS-000001). The MS4 permit area corresponds to the City of Sioux Falls storm sewer boundary and the interstate highway system operated and maintained by the South Dakota Department of Transportation. The purpose of the MS4 section in this document is to provide a bacteria source assessment of the MS4 area residing in the Skunk Creek Segment 1 watershed and review BMPs the city has taken to mitigate bacteria loadings into Skunk Creek Segment 1.

City of Sioux Falls MS4 Bacteria Source Assessment

The municipal boundary of the City of Sioux Falls makes up approximately 3,763 hectares or 3% of the Skunk Creek Segment 1 watershed. The municipal area incorporates developed and undeveloped urban areas. Not all the municipal area has an installed and operating storm sewer system. The bacteria source assessment will focus on the Sioux Falls area in the Skunk Creek TMDL watershed to identify areas of bacteria production and describe bacteria monitoring.

Potential bacteria sources in the City Sioux Falls are generally located in residential and city parks. These areas have an increased risk for bacteria production from pets and local wildlife. Any run-off from these areas may contribute to bacterial loadings in the cities storm sewer network. Undeveloped areas, commercial zones, and open sport complexes (golf courses, baseball and football fields) are expected to provide minimal to no bacteria contribution to the City of Sioux Falls storm sewer system.

The City of Sioux Falls performs public outreach as part of their MS4 permit compliance. The city has setup a Pet Waste Program to educate pet owners of environmental impacts from improperly disposed pet waste. Clean up stations have been installed in various locations in city parks and along trails.

A "No Mow" program has been implemented on City-owned properties. The program is to keep vegetation growth in riparian areas of Skunk Creek Segment 1 and Big Sioux. The City has partnered with the Big Sioux River Project introducing riparian buffers along Skunk Creek Segment 1.

Bacteria sampling of storm sewer outfalls is not a provision of the MS4 permit. The City of Sioux Falls is required to visually inspect a portion of their storm sewers each year during dry weather to identify non-stormwater flows contributing to their storm sewer system. In 2017, the City of Sioux Falls conducted internal studies to determine BMP removal efficiencies of an extended detention basin and a wetland detention pond. Results showed reductions from both BMPs with a wide range of effectiveness. There has been no long-term monitoring plan for any of the storm sewer outfalls. The only discharge and *E. coli* concentration data which is available is at selected outlets used for BMP studies. The data is limited by number of samples at each outlet and was only sampled for a short period of time.

It is recommended that the city consider setting up a long-term monitoring plan for *E. coli* from storm sewer outfalls as part of their Stormwater Best Management Practice Master Plan. Determining *E. coli* concentrations from the storm sewer outfalls during storm events could provide several benefits. Monitoring results could be used to direct BMP resources to those areas with the greatest concentrations and loading. In addition, monitoring results could determine BMP effectiveness. Achieving *E. coli* concentrations in storm sewer outfalls at or below 235 cfu/100 ml (SSM) would protect the downstream immersion recreation use designated to the Big Sioux River and help meet TMDL goals although numeric *E. coli* effluent limits are not a recommendation of the TMDL.

City of Sioux Falls Storm Water BMP Master Plan and Infrastructure Improvements
In 2003 the City of Sioux Falls developed a Stormwater Best Management Practice (BMP) Master Plan to address the growth areas in the city. The Plan contains two volumes the Master

Plan and Appendixes. The vision statement for the master plan is to develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. Further expansion of BMPs are addressed in Chapter 11 of the city's Engineering and Design Standards.

The chapter dictates any new development over two acres in size or adding an acre or more of new impervious surfacing must install a site-specific privately-owned BMP. See **Appendix D.** for a map that was provided by the City of Sioux Falls which shows locations of all BMPs in the municipal boundary of Sioux Falls within the Skunk Creek Segment 1 Watershed. Most city BMPs installed have water quality capture volume included in their design. While these types of BMPs are effective at removing solids, they also may provide partial bacterial load reduction.

The City of Sioux Falls conducted a BMP study on extended and wetland detention basins in 2010. The study was looking into determining effectiveness of these types of basins on reducing *E. coli* concentrations during wet weather events which used the standard of more than 0.1" rain/ 2 hours. Seven sites were tested for two to three rain events. The sampling provided mixed results though some sites showed a small reduction of *E. coli*. Given how volatile *E. coli* can be and the limited number of samples collected in the study more future sampling may provide a better representation of BMP effectiveness of these basins.

The City of Sioux Falls is proposing upgrades to the storm sewer system in the drainage basin bounded by Interstate I-29 to Marion Road and 41st Street to 47th Street. The purpose of the project is to reduce overland flow on Marion Road and the neighborhood to the east during major storm events. The project will correct undersized storm sewers which do not meet city design standards, prevent overtopping of city owned right-of -way and flows through private property, create adequate storm water detention storage which is not available, and prevent storm water ponding on private property and in the- right-of-way. The loan also includes $429,000 to construct nonpoint source improvements in the Big Sioux River basin. The nonpoint source component of the loan will be used to make improvements which include stream bank stabilization, grazing management, agricultural waste management, and vegetative buffers.

The City of Sioux Falls is proposing to make improvements to three different drainage basins in the southwest portion of the city. All projects include drop inlets, junction boxes, and other necessary appurtenances associated with the construction of stormwater systems. The proposed improvements will reduce overland flows, replace and upsize storm water drainage infrastructure to meet current design standards, and improve conveyance through each basin.

- Improvements to Basin 95 will include construction of two stormwater detention sites and the installation or replacement of approximately 1,036 meters (3,400 feet) of stormwater pipe of various sizes.
- Improvements to Basin 104 include the construction of approximately 305 meters (1,000 feet) of a 12-foot by 5-foot box culvert.

- Improvements to Basin 371 include the construction of a stormwater detention site and the installation of approximately 1,372 meters (4,500 feet) of 18-inch RCP parallel to existing open channel drainageways. Multiple culverts will also be installed to convey stormwater through existing streets.

The City of Sioux Falls has an ordinance (Chapter 55) in-place regarding privately owned BMPs. The city routinely inspects private BMPs to protect life and property, uphold City stormwater standards, and ensure the infrastructure is in compliance. These items are based on the BMP design type that was chosen to treat the site. After the inspection, a letter is sent to the property owner informing them of any necessary maintenance that needs to take place. It is then up to the property owner to ensure that the BMP is in working order per the engineered design plan. (City of Sioux Falls, 2020)

7.4 CAFOs in the Skunk Creek Segment 1 Watershed

There are seven permitted CAFOs within the Skunk Creek Segment 1 watershed. Each of the CAFO's facility name, type of operation, and permit number can be found in **Table 4**. All CAFO's are required to maintain compliance with provisions of the SD Water Pollution Control Act (SDCL 34A-2). SDCL 34A-2-36.2 requires each concentrated animal feeding operation, as defined by Title 40 Codified Federal Regulations Part 122.23 dated January 1, 2007, to operate under a general or individual water pollution control permit issued pursuant to 34A-2-36. The general permit ensures that all CAFO's in SD have permit coverage regardless if they meet conditions for coverage under a NPDES permit.

All facilities with a general permit number that starts with SDG-01* are covered under the 2003 General Water Pollution Control Permit for Concentrated Animal Feeding Operations, which requires housed lots to have no discharge of solid or liquid manure to waters of the state, and allows open lots to only have a discharge of manure or process wastewaters from properly designed, constructed, operated and maintained manure management systems in the event of 25-years, 24-hour or 100-year, 24-hour storm event if they meet the permit conditions. The general permit was reissued and became effective on April 15, 2017. All CAFO's with coverage under the 2003 general permit have a deadline to apply for coverage under the 2017 general permit.

Table 4. CAFOs in the Skunk Creek Segment 1 Watershed

Name of Facility	Type of Operations	SD General Permit #
Boadwine Farms, Inc.	dairy cattle (housed lot)	SDG-100059
JPJ Enterprises, Inc.	beef cattle (housed and open lots)	SDG-0100231
Marcus Steineke Swine Facility	finisher swine (housed lot)	SDG-0100166
N & H Hog Farms	farrow to finish swine (housed lot)	SDG-0100275
Rustic Acres Hutterian Brethren, Inc.	multiple animals (housed lot)	SDG-0109096
Steineke Farms	multiple animals (housed and open lots)	SDG-0100124
Todd Sundal Swine Finishing Barn	finisher swine (housed lot)	SDG-0100413

All facilities with a general permit number that starts with SDG-1* are covered under the 2017 General Water Pollution Control Permit for Concentrated Animal Feeding Operations. The 2017 general permit allows no discharge of manure or process wastewater from operations with state permit coverage or NPDES permit coverage for new source swine, poultry, and veal operations, and other housed lots with covered manure containment systems. Operations also have the option to apply for a state issued NPDES permit. Operations covered by the 2017 general permit or NPDES permit for open or housed lots with uncovered manure containment systems can only discharge manure or process wastewater from properly designed, constructed, operated and maintained manure management systems in the event of 25-year, 24-hour storm event if they meet the permit conditions.

Both the 2003 and 2017 general permits have nutrient management planning requirements based on EPA's regulations and the South Dakota Natural Resources Conservation Services 590 Nutrient Management Technical Standard to ensure the nutrients are applied at agronomic rates with management practices to minimize the runoff of nutrients. Additionally, the general permits include design standards, operation, maintenance, inspection, record keeping, and reporting requirements.

For more information about South Dakota's CAFO requirements and general permits visit: DANR Concentrated Animal Feeding Operations. As long as these facilities comply with the general CAFO permit requirements ensuring their discharges are unlikely and indirect loading events, the TMDL assumes their *E. coli* contribution is minimal, and unless found otherwise, no additional permit conditions are required by this TMDL.

7.5 *E. coli* Nonpoint Sources and Assessment

A comprehensive assessment of the total *E. coli* production from nonpoint sources was conducted for the Skunk Creek Segment 1 watershed. Nonpoint sources of *E. coli* in the Skunk Creek Segment 1 watershed originate primarily from wildlife (i.e., natural background), agriculture and humans. Due to a lack of literature values for *E. coli* production of many livestock and wildlife species, source loading calculations were based on fecal coliform. This is an acceptable surrogate to source characterization because *E. coli* is a bacterium within the fecal coliform group. Further, fecal coliform source contributions are considered synonymous with *E. coli* based on the close statewide paired bacteria data relationship documented in the Bacteria Translation TMDL.

Data from the National Agricultural Statistic Survey (NASS) and the most recent South Dakota Game Fish and Parks County wildlife survey were used to estimate livestock and wildlife densities, respectively (USDA, 2017; SD GF&P, 2019; Huxoll, 2002). Animal density information was used to estimate relative source contributions of bacteria for the Skunk Creek Segment 1 watershed **(Table 5)**. A watershed population for each livestock animal was calculated by the percentage of the watershed in each county multiplied by the county livestock population. Individual county livestock population data were added up then multiplied by the Skunk Creek Segment 1 watershed area to provide a density value. The same procedure was also used for human and wildlife. *E. coli* production estimates for livestock, humans and some wildlife species are referenced from EPA's Bacteria Indicator Tool (USEPA, 2020). Bacteria production in the Skunk Creek Segment 1 watershed was estimated at 3.6E+10 cfu/acre/day

(Table 5). **Table 5. Skunk Creek Segment 1 *E .coli* Nonpoint Source Allocations**

Species	#/acre watershed	Bacteria/Animal/Day	Bacteria/Acre/Day	Percent
Dairy cow[2]	5.6E-02	1.0E+11	5.7E+09	15.6%
Beef[2]	2.0E-01	1.0E+11	2.1E+10	58.6%
Hog[2]	7.7E-01	1.1E+10	8.3E+09	22.9%
Sheep[2]	3.1E-02	1.2E+10	3.8E+08	1.0%
Human[2]	3.2E-01	2.0E+09	6.4E+08	1.8%
All Wildlife	Sum of all wildlife		1.9E+07	0.1%
Turkey (Wild)[1]	3.0E-03	9.3E+07	3.5E+04	
Goose[2]	4.0E-02	4.9E+10	1.6E+07	
Deer[2]	7.0E-03	5.0E+08	6.3E+05	
Beaver[2]	5.0E-03	2.5E+08	4.6E+04	
Raccoon[2]	8.0E-03	1.3E+08	2.3E+05	
Coyote/Fox[3]	3.0E-03	4.1E+09	1.3E+06	
Muskrat[4]	1.1E-02	1.3E+08	5.8E+05	
Opossom[4]	2.0E-03	1.3E+08	4.6E+03	
Mink[4]	4.0E-03	1.3E+08	2.9E+04	
Skunk[4]	5.0E-03	1.3E+08	9.3E+04	
Badger[4]	2.0E-04	1.3E+08	2.0E+04	
Rabbits[4]	2.5E-02	1.3E+08	5.2E+05	
Total			**3.6E+10**	**100%**
(1) USEPA 2001				
(2) Bacteria Indicator Tool Worksheet				
(3) Best Professional Judgment based off of Dogs				
(4) FC/Animal/Day copied from Raccoon to provide a more conservative estimate of background effects of wildlife				

7.5.1 Natural Background Sources

Wildlife within the watershed is a natural background source of bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (2019). The approximate contribution of bacteria from wildlife in the Skunk Creek Segment 1 watershed was 0.1%. The main contributors of bacteria from natural sources were waterfowl. The contribution of bacteria from natural sources is less than livestock and human sources.

7.5.2 Human Sources

A calculation of bacteria from human population in the Skunk Creek Segment 1 watershed was performed by using population estimates from the United States Census Bureau and ArcMap program. Approximately 70,255 people reside in the watershed with most of the population located in the City of Sioux Falls. Residence in City of Sioux Falls is on a sewer system which is a part of the city's water reclamation facility permit. The estimated rural population living in the watershed is approximately 7,293. It is assumed that the rural population are equipped with properly functioning septic systems that contribute no load production. to be the primary disposal source for residents in the rural portion of the watershed. **Table 5** includes all human produced *E. coli* and does not include expected reductions as a result of delivery to a septic system. Human bacteria production per day is estimated at 2.0E+09 (Yagow et al. 2001). The total production from humans in the watershed is 1.8%. No bacteria should be entering the segment if all bacteria are delivered to a properly functioning septic systems.

7.5.3 Agricultural Sources

Manure from livestock is a potential source of *E. coli* to Skunk Creek Segment 1. Livestock may contribute *E. coli* directly by wading in or near waterbodies. Manure on rangelands or in feeding areas can be vulnerable to runoff from precipitation events and end up in the stream channel. Looking at **Figure 2-6**, most of the pasture and grassland in the Skunk Creek Segment 1 watershed are located along Skunk Creek Segment 1 and its tributaries.

A calculation of bacteria produced by livestock in the Skunk Creek Segment 1 watershed was conducted. Livestock numbers were gathered using USDA National Agriculture Statistics database. The most current data for county livestock population were used. These county population numbers included livestock located in CAFO facilities. CAFO operations located in the watershed were identified in Table 4.

Most of the bacteria produced by livestock in the watershed are predominantly beef cattle. Beef cattle produce approximately 58.6% of the bacteria per acre in the Skunk Creek Segment 1 watershed. Total livestock bacteria contribution in the watershed is approximately 98%. Future implementation practices should focus on mitigating bacteria runoff and contributions from livestock sources.

8.0 Escherichia coli (E. *coli*) TMDL for Skunk Creek Segment 1

The Load Duration Curve (LDC) for Skunk Creek Segment 1 was developed using the rating curve and *E. coli* data that was discussed in **Section 6.0.** The LDC approach was deemed an appropriate method for identifying possible sources of bacteria based on the flow zone. For Skunk Creek Segment 1, **Figures 8-1** shows violations occurring within all five flow zones.

When incorporating the water quality criteria, the LDC is a dynamic expression of the allowable load for any given day. 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 (40–70 percent), dry conditions (70–90percent), and low flows (90-100 percent). This flow zone breakout follows the recommendation of EPA's An Approach for Using Load Duration Curves in the Development of TMDLs (USEPA, 2007).

Section 5.1 discussed why the immersion recreation SSM *E. coli* criterion of 235 cfu/100mL was selected as the numeric TMDL target for Skunk Creek Segment 1. The SSM was used in developing an *E. coli* daily load by using the formula below:

$$E.coli\ Load\ \frac{CFU}{Day} = \ Average\ Daily\ Flow\ \left(\frac{ft^3}{sec}\right)\ X\ \ 235\frac{CFU}{mL}\ X\ \frac{86{,}400\ sec}{Day}\ X\ \frac{28316.8\ mL}{ft^3}$$

The *E. coli* allowable loads were then plotted with their paired percentage values to produce the LDC in **Figure 8-1**. The load duration curve represents the TMDL across the entire flow regime.

E. coli observations were also plotted on the LDC graph by using the equation above. The SSM and average daily flow variables were substituted for the *E. coli* observation and corresponding average daily flow value of the *E. coli* observation date. These observations represent an instantaneous single day load. The plotted *E. coli* observations follow a generally parallel slope with the LDC curve.

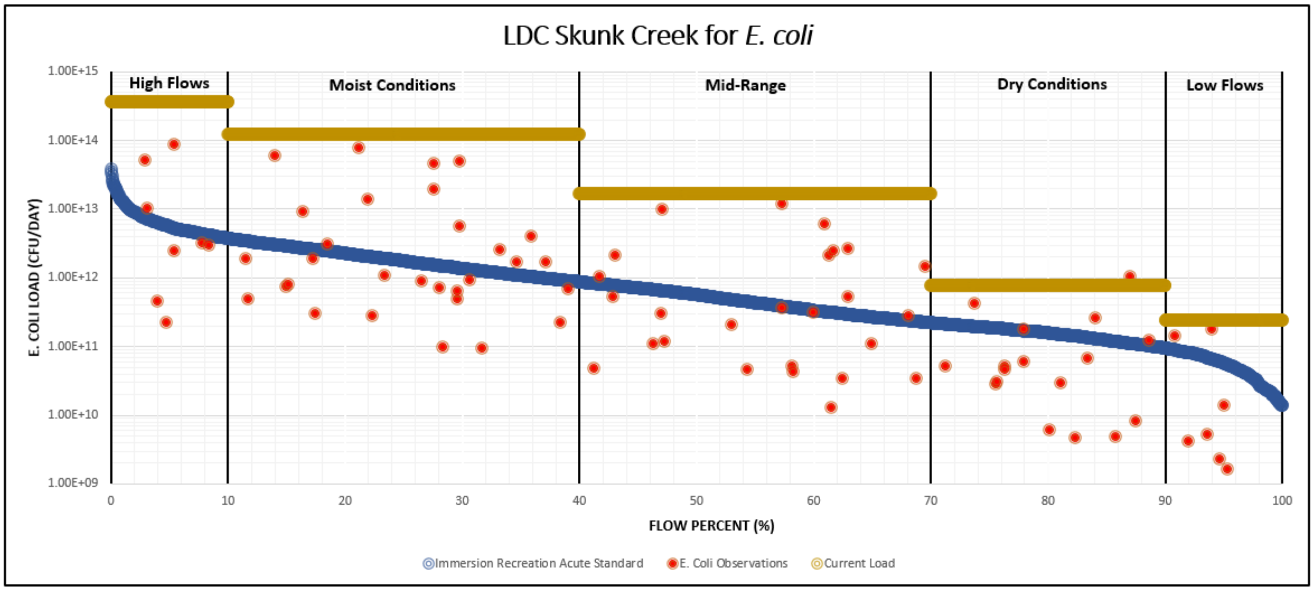

Figure 8-1: *E. coli* Load Duration Curve for Skunk Creek Segment 1

The plotted *E. coli* observations on the LDC show characteristics of water quality impairment. *E. coli* observations that plot above the curve are exceeding the TMDL, while those below the curve are in compliance. As the plot shows, *E. coli* samples collected from Skunk Creek Segment 1 exceed the TMDL in all flow zones. Loads exceeding the criteria in the high flow zones imply storm runoff from nonpoint sources. Exceedances in the low flow zone typically indicate point sources or nonpoint sources in or near the channel.

Current loads were calculated based off the 95th percentile flow and *E. coli* concentrations for all flow zones. These loads provide a representation of *E. coli* loading in each flow zone relative to the LDC. If the current load in a particular flow zone is above the LDC, a reduction is required to meet the TMDL target. When the current load in a particular flow zone is below the LDC it implies TMDL attainment. **Section 8.2** provides more detail about the flow zones and reductions needed to meet the TMDL target.

8.1 TMDL Allocations

Contributing factors of pollution are split between point and nonpoint sources. Wasteload allocations (WLAs) are the allocated loads for point sources including all sources subject to regulation under the NPDES program. Therefore, load allocations (LA) are the allocated loads of nonpoint sources as well as natural background sources. The TMDL (or loading capacity) is the sum of waste load allocations, load allocations, and a margin of safety (MOS).

A TMDL is expressed by the equation: TMDL = ΣWLA + ΣLA + MOS, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)
MOS = margin of safety

8.1.1 Margin of Safety

In accordance with regulations, a margin of safety (MOS) was established to account for uncertainty in the data analyses. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and/or (2) by establishing allocations that in total are lower than the defined loading capacity. This document used the second method to establish a safety margin for the *E. coli* TMDL.

A 10% explicit MOS was calculated within the load duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). This 10% explicit MOS was calculated from the TMDL within each flow zone. The remaining assimilative capacity was attributed to nonpoint sources (LA) or point sources (WLA).

8.1.2 Waste Load Allocations (WLA)

All NPDES permitted point sources within Skunk Creek Segment 1 watershed were identified and reviewed for WLA consideration in **Sections 7.1-7.3**. The Chester Sanitary District and the City of Hartford WWTF were identified as discharges influencing bacteria loading to Skunk Creek Segment 1. As a result, these sources were assigned a WLA in the TMDL. NPDES facilities not receiving a WLA are the Town of Humbolt, City of Crooks, City of Crooks Municipal Utilities, City of Colton Water Distribution, City of Colton, Tri-Valley School District, Wall Lake Sanitary District, South Dakota State Penitentiary West Farm, & City of Sioux Falls.

The WLA calculation was based on the immersion recreation *E. coli* SSM criteria (235 cfu/ 100 mL), multiplied by an effluent flow and a conversion factor. For this TMDL, the determined effluent flow was either the 80th percentile from recorded DMR data or a facility's peak design flow. In this case, the Chester Sanitary District had a sufficient DMR data so the 80th percentile effluent flow of 1.13 MGD was used. The TMDL will use the peak design effluent flow of 3.40 MGD for the new WWTF in Hartford. Using the peak design flow of the new WWTF accounts for the current WWTF while also allowing for future growth within the City of Hartford. During normal operation of these facilities, only a portion of the calculated WLA would be discharged.

***E. coli* Equations** - *K.G. 5/15/2019*

$$Daily\ Maximum\ E.\ Coli\ WLA\ \left(\frac{\#}{day}\right) = \text{"Daily Max E. coli Limit x"}\ \left(\frac{\#}{100\ mL}\right) \times \text{"Effluent Flow y"}\ \left(\frac{MG}{D}\right) \times \left(\frac{10^6\ G}{MG}\right) \times \left(\frac{10^3\ mL}{L}\right) \times \left(\frac{3.785\ L}{G}\right)$$

It is important to note that any facility discharging directly into Skunk Creek Segment 1 must, at a minimum, meet the WQC associated with beneficial uses 6, 8, 9, and 10. All point sources and WLA considerations are documented in **Appendix E.**

The WLA established in this TMDL is not intended to add load limits to the NPDES permits. The permit is deemed consistent with the assumptions and requirements of the WLAs by adhering to permit requirements, primarily by meeting end-of-pipe *E. coli* concentrations consistent with the applicable water quality criteria and concentration-based TMDL target. As long as wastewater discharges from WWTFs do not exceed peak design flows and *E. coli* effluent limits, any variable flow rates from these facilities are not expected to impact the TMDL. The TMDL allocations (i.e., WLAs) would need to be adjusted in the future if a facility increases peak flow capacity (expansion) or a new waste load(s) is added to the stream segment and there is insufficient remaining WLA to assign to the new source.

City of Sioux Falls MS4 Allocation

Discharges from the City of Sioux Fall's storm sewers would be most common with precipitation events in the spring and early summer due to the incidence of snow melt and rain events. A brief climate overview of the Skunk Creek Segment 1 watershed was discussed in **Section 2.1.2.** The area averages about forty-four inches of snow and twenty-six inches of precipitation a year with most of the precipitation occurring in the spring and summer months.

E. coli loading from the City of Sioux Fall's stormwater sewer outfalls (MS4 area) is considered a direct point source to Skunk Creek Segment 1. Insufficient amount of discharge and *E. coli* concentration data was available to develop a quantified *E. coli* load from all the cities storm sewer outfalls that discharge into Skunk Creek. *E. coli* loads are expected to vary significantly daily depending on precipitation. A jurisdictional area approach was used to develop an *E. coli* WLA to account for the MS4 load in the TMDL based on the following equation:

$$MS4\ Allocation = (TMDL - \sum WLA - MOS) \times Percent\ Area\ in\ Skunk\ Creek\ Watershed$$

TMDL = Total Maximum Daily Load (Flow Zone)
WLA = Waste Load Allocation for WWTFs
MOS = Margin of Safety (10% of TMDL Flow Zone)
Percent Area = 3% MS4 area in Skunk Creek Watershed

The MS4 allocation calculation was applied proportionate to each flow zone. The MS4 allocation accounts for a minimal portion of the TMDL in all flow zones, which is reasonable given the MS4 area only accounts for 3% of the entire Skunk Creek Segment 1 watershed. The MS4 allocation (WLA) is applicable to the TMDL based on current area and infrastructure of the storm sewer system in the City of Sioux Falls.

City of Sioux Falls MS4 Future Growth Allocation

The City of Sioux Falls is planning for continued growth into the future. In 2016, the City of Sioux Falls adopted Shape of Sioux Falls 2040 Comprehensive Plan to help manage future growth, plan neighborhood land use, and improve the sustainability of the community. The plan outlines areas where future growth is expected which will, likely result in their annexation to the city. Portions of the Skunk Creek watershed are included in these projected development areas. As a result, these newly developed areas will need to be added to the City of Sioux Falls MS4 permit. To address this expected increase in the MS4 area, a separate MS4 future growth allocation is included as part of the Skunk Creek Segment 1 *E. coli* TMDL.

Future 2040 area growth in the Skunk Creek Segment 1 watershed was calculated with geoprocessing tools based on the projected development areas presented in the Sioux Falls 2040 Comprehensive Plan. By 2040, approximately 6% of the Skunk Creek watershed will be developed and fall under the City of Sioux Falls MS4 permit. This results in an additional 3% *E. coli* allocation to the MS4 allowing for this future growth. Similar to the current MS4 allocation, the jurisdictional area method was used in this calculation process. The MS4 future growth allocation was applied proportionate to each flow zone. The MS4 future growth allocation (as part of the overall WLA) is a necessary component of the TMDL due to the expected developed areas outlined in the Shape of Sioux Falls 2040 Comprehensive Plan.

8.1.3 Load Allocations (LA)

EPA regulations require that a TMDL include LAs, which identify the loading capacity from nonpoint sources and sources of natural background. Most of the bacteria produced in the Skunk Creek Segment 1 watershed is from agriculture nonpoint sources. A list of bacteria producers and their daily bacteria production per acre can be found in **Table 5.** The LA was calculated by subtracting the 10 percent explicit MOS, MS4 allocation and the sum of the WLA from the TMDL for each flow zone (seen in the equation below).

$$\mathrm{LA} = \mathrm{TMDL} - \mathrm{MOS} - \mathrm{MS4} - \sum \mathrm{WLA}$$

Reducing bacteria concentrations below the SSM standard in each flow zone provides assurance that both the SSM and GM standards will be met. To achieve the specified reductions, primary focus should be placed on reducing bacteria inputs from livestock grazing and feeding areas. Implementation practices to achieve this task are discussed in **Section 9.0.**

8.2 Numeric TMDL and Flow Zones

The TMDL and allocations for each flow zone are presented in **Table 6.** Direct point sources exist in the impaired segment but make up a small portion of the TMDL. Assuming the WLAs are attained, all reductions are associated with nonpoint sources.

Table 6. *E. coli* TMDL and Flow Zone Allocations for Skunk Creek Segment 1

Immersion Recreation E. Coli TMDL Component	Skunk Creek Flow Zones Expressed as (CFU/day)				
	High Flows	Moist Conditions	Mid-Range Conditions	Dry Conditions	Low Flows
LA	1.50E+13	2.91E+12	6.60E+11	1.45E+11	3.95E+10
MS4 - City of Sioux Falls	4.78E+11	9.30E+10	2.11E+10	4.61E+09	1.26E+09
MS4 - Sioux Falls Future Growth	4.78E+11	9.30E+10	2.11E+10	4.61E+09	1.26E+09
WLA - City of Hartford	3.02E+10	3.02E+10	3.02E+10	3.02E+10	3.02E+10
WLA - Chester	1.01E+10	1.01E+10	1.01E+10	1.01E+10	1.01E+10
10% Explicit MOS	1.77E+12	3.49E+11	8.25E+10	2.16E+10	9.14E+09
TMDL @ 235 CFU/100mL*	1.77E+13	3.49E+12	8.25E+11	2.16E+11	9.14E+10
Current Load	3.65E+14	1.24E+14	1.68E+13	7.66E+11	2.45E+11
Load Reduction	95%	97%	95%	72%	63%

* Skunk Creek is assigned limited contact recreation use, however the TMDL is written to protect downstream uses

8.2.1 High Flows (0-10%)

The high flow zone represents moderate to significant flooding events in the Skunk Creek Segment 1 watershed. The rate of flow for this zone is categorized with flows greater than 658 cfs. This flow magnitude occurs on an infrequent basis and is characteristic of significant run-off events typical during the spring and summer. High flows are commonly the product of a rapid spring snowmelt but may also be generated by intense rainfall events. Bacteria sources across the watershed have the potential to be conveyed into the stream channel during high flow conditions. The 95th percentile bacteria concentration and flow was calculated at 4,840 counts/100 ml and 3,086 cfs, respectively. An *E. coli* load reduction of 95% is required to achieve compliance with the single sample maximum threshold of the immersion recreation beneficial use. In addition to the daily load, the geometric mean criterion must be attained on a monthly basis.

8.2.2 Moist Conditions (10-40%)

The moist condition flows represent above average flow to moderate flooding events. This portion of the flow regime occurs following snow melt and moderate rainfall events. Flows in this zone range from 657cfs to 153 cfs. The flows in this zone occur in the spring and possibly through the summer months. Bacteria sources from this zone are expected to be from runoff events and sources near the stream. The 95th percentile bacteria concentration and flow was calculated at 8,337 counts/100ml and 606 cfs, respectively. An *E. coli* load reduction of 97% is required to achieve compliance with the single sample maximum threshold of the immersion recreation beneficial use. In addition to the daily load, the geometric mean criterion must be attained on a monthly basis.

8.2.3 Mid-Range Conditions (40-70%)

Mid-range conditions represent flow rates between 152 cfs and 38 cfs. Mid-range flows are best characterized as base flow conditions which is streamflow that is sustained between precipitation events. Bacteria sources from this zone likely originate from in or near the stream channel with occasional runoff events. The 95th percentile bacteria concentration and flow was calculated at 4,783 counts/100ml and 38 cfs, respectively. An *E. coli* load reduction of 95% is required to achieve compliance with the single sample maximum threshold of the immersion recreation beneficial use. In addition to the daily load, the geometric mean criterion must be attained on a monthly basis.

8.2.4 Dry Conditions (70-90%)

The dry flow zone represents flow rates that are between 37 and 17 cfs. This zone is best characterized as below average base flow conditions. Flows from this zone occur during periods of abnormal dryness. Bacteria sources from this zone likely originate from in or near stream sources. The 95th percentile bacteria concentration and flow was calculated at 835 counts/100ml and 36 cfs, respectively. An *E. coli* load reduction of 72% is required to achieve compliance with the single sample maximum threshold of the immersion recreation beneficial use. In addition to the daily load, the geometric mean criterion must be attained on a monthly basis.

8.2.5 Low Flows (90-100%)

The low flow zone represents flow rates that are less than 17 cfs. This zone represents shallow water levels resulting in very below normal flow conditions. Flows from this zone occur during the winter months and drought conditions. Bacteria sources from this zone likely originate from in or near stream sources. The 95th percentile bacteria concentration and flow was calculated at 629 counts/100ml and 16 cfs, respectively. An *E. coli* load reduction of 63% is required to achieve compliance with the single sample maximum threshold of the immersion recreation beneficial use. In addition to the daily load, the geometric mean criterion must be attained on a monthly basis.

8.3 Seasonal Variation

Seasonality is important when considering bacteria contamination as pathogen transmission may be greatly influenced by fluctuating environmental factors. For example, it has been reported that the growth and survival of *E. coli* in water and cattle manure depends on temperature while the effects of climate on hydrology may include earlier snowmelt, change in streamflow timing, altered spring maximum flows, and intensified summer droughts (Kibria et al. 2016).

Seasonal variation is a component of the load duration curve framework that examines the seasonal exceedance pattern of individual *E. coli* bacteria loads. Sample data was collected May through September when the recreational standards apply for the immersion recreation beneficial use.

Daily bacteria loads exceed the single sample maximum TMDL threshold consistently through all flow regimes. The implications of this pattern suggest bacteria sources are consistently located near Skunk Creek Segment 1 year-round. Identifying bacteria sources close to Skunk Creek Segment 1 is warranted to achieve TMDL attainment goals of the immersion recreation beneficial use.

8.4 Critical Conditions

The critical condition can be thought of as the "worst case" scenario of environmental conditions (e.g., stream flow, temperature, loads) in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet WQC. During critical condition periods, if water quality criteria were met under those conditions, it would be likely that the water quality criteria would be met overall (U.S. EPA, 2007).

E. coli concentrations and loadings are greatest during runoff events and periods of direct livestock access. Implementing watershed-scale best management practices designed to reduce manure transport during runoff events is essential to meet reduction goals. Other priority implementation practices would be to reduce livestock access to the stream corridor and channel. Developing alternative water sources away from stream riparian areas would decrease risk of direct bacteria loadings.

9.0 Water Quality Improvement Plan and Monitoring Strategy

This section describes an overall strategy designed to achieve beneficial use support and *E. coli* standards attainment for Skunk Creek Segment 1.

9.1 Improvement and Monitoring Strategy Overview

The monitor strategy includes general measures for reducing loads from identified nonpoint sources of *E. coli* as well as approaches to further evaluate *E. coli* conditions in the Skunk Creek Segment 1 watershed. Effective monitoring is integral for evaluating conservation practices and provides a basis for an adaptive management approach. Having a successful monitoring strategy in place allows for feedback on:

- The effectiveness of restoration activities
- Pollutant load reductions
- The status of TMDL target attainment
- Identifying all significant sources of *E. coli*
- Providing technical justification to modify restoration strategies, targets, or allocations if appropriate

9.2 Role of DANR and Stakeholders

DANR administers the 319 nonpoint source grant for South Dakota. Funds from the grant are primarily awarded to projects that focus on implementing watershed-scale BMPs to improve and protect water quality. Nonpoint source implementation projects generally focus on impaired waterbodies and are designed to address TMDL goals. Successful implementation of TMDL pollutant-reduction projects often requires collaboration among private landowners, land management agencies, and other stakeholders. More information on DANR's Section 319 Nonpoint Source Management Program will be discussed in **Section 9.9.1**.

DANR works with interested participants to use TMDLs as a basis for developing locally driven projects that aim at improving or protecting waterbodies. Because most nonpoint source pollution reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers work collaboratively with local and state agencies to achieve water quality restoration goals and meet TMDL targets.

9.3 Adaptive Management Process

DANR is entrusted to assess the waters for which TMDLs have been completed and restoration measures or BMPs have been applied to determine whether compliance with WQS has been attained, water quality is improving, or if revisions to current goals are necessary. This aligns with an adaptive management approach.

Adaptive management is a systematic approach for improving resource management by learning from management outcomes and allows for flexible decision making. There is an inherent amount of uncertainty involved in the TMDL process, such as quantifying source contributions (e.g., determining natural background) and characterizing spatial and seasonal loading conditions. Use of an adaptive management approach based on continued monitoring of project implementation helps manage resource commitments and achieve success in meeting the WQS and supporting water quality beneficial uses. This approach further allows for adjustments to restoration goals and/or allocations, as necessary. **Figure 9-1** below is a visual explanation of the iterative process of adaptive management (Williams et al., 2009).

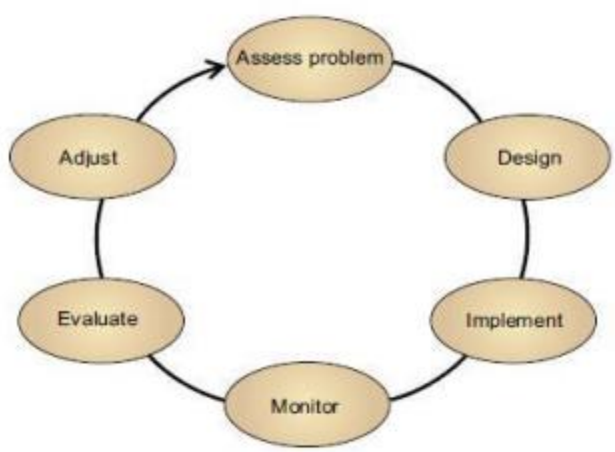

Figure 9-1. Diagram of the Adaptive Management Process

9.4 Water Quality Restoration Objectives

The water quality restoration objective is to reduce *E. coli* loads to meet the WQS (TMDL targets) for recovery of beneficial uses for Skunk Creek Segment 1. Based on the assessment provided in this document, the TMDL can be achieved through implementation of appropriate nonpoint sources BMPs.

Specific objectives for watershed restoration activities could be identified by local stakeholders through the development of a watershed restoration plan (WRP) or similar approach. A WRP can provide a strategy for water quality restoration and monitoring in the Skunk Creek Segment 1 watershed, focusing on how to achieve the TMDL, as well as other water quality issues of interest to the local community and stakeholders. A WRP serves as a locally organized "road map" for watershed activities, prioritizing projects, and identifying funding and technical resources for achieving local watershed goals, including water quality improvements by implementation. The WRP can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities.

The EPA requires nine minimum elements for a WRP. A complete description can be found here: Handbook for Developing Watershed Plans to Restore and Protect our Waters

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

The Clean Water Act Section 319 (nonpoint source management programs) provides authority for congressional funding to South Dakota. 319 funds for nonpoint source projects may be used to implement WRPs.

In 2013, a Water Quality Master Plan was created for the Central Big Sioux watershed which includes Skunk Creek Segment 1. The master plan was developed in the Central Big Sioux River Watershed project area which was an assessment project sponsored by the East Dakota Water Development District. Stakeholders in the watershed at the local, state, and federal level collaborated to develop the master plan to guide implementation efforts. Due to the complexity of implementation options in the watershed, a watershed-scale, decision-support model was developed to be used to facilitate prioritization and placement of BMPs. This model can be used in future watershed projects to assist in coordinating watershed-scale investments in the Central Big Sioux watershed.

The Big Sioux River Watershed Strategic Plan was developed in 2016 for the Big Sioux River watershed in South Dakota. The plan focused on identifying sources of impairments for 303(d) water bodies in the Big Sioux Watershed. Point and nonpoint sources of fecal coliform were discussed for the Skunk Creek Segment 1 watershed. Load reductions for Willow Creek, Colton

Creek, and West Branch Skunk Creek were deemed critical and would greatly reduce fecal coliform bacteria loading for Skunk Creek Segment 1.

9.5 Reasonable Assurance

Skunk Creek Segment 1 receives *E. coli* loadings from both point and non-point sources. When a TMDL is developed for impaired waters that receive pollutant loadings from both point and nonpoint sources and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. Reasonable assurance ensures that a TMDL's WLA and load allocations are properly calibrated to meet the applicable WQS.

Reasonable assurance of the TMDL established for Skunk Creek Segment 1 will require a comprehensive approach that addresses:

- Wastewater discharges under NPDES permits.
- Storm Sewer Discharges under MS4 SWMP
- Non-point source pollution.
- Existing and potential future sources
- Regulatory and voluntary approaches.

There is reasonable assurance that the goals of the TMDL established for Skunk Creek Segment 1 can be met with proper planning between state and local regulatory agencies, stakeholders, BMP implementation, and access to adequate financial resources. The waste load allocations used in the TMDL were obtained from regulations defined in the NPDES permits administratively assigned to the different communities within the watershed. **Sections 9.6** to **Section 9.9** provide specific projects and efforts that, when fully implemented, provide reasonable assurance that bacteria loading from both point and nonpoint sources will be reduced and monitored.

9.6 *E. coli* Restoration Approach

Cattle grazing in riparian areas and manure runoff are identified as the most likely causes of elevated *E. coli* loading to Skunk Creek Segment 1. General recommendations for the management of livestock grazing, septic system, and other sources of human caused *E. coli* loading to Skunk Creek Segment 1 are outlined below.

A WRP developed by local stakeholders would contain more detailed information on restoration priorities, milestones and specific BMP recommendations to address key pollutant sources. Monitoring is an important part of the restoration process and for evaluating BMP effectiveness. Specific monitoring recommendations are outlined in **Section 9.7** and **Section 9.8.**

9.6.1 Grazing and Manure Management

In watersheds that contain livestock, the goal of the *E. coli* restoration strategy is to reduce source input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, limiting the transport of *E. coli* (from manure on rangeland and cropland) to waterbodies. Specific BMPs include grazing management to improve riparian health by reducing livestock direct access to waterbodies and installing buffer strips. Grazing management that intends to increase vegetative post-grazing ground cover should be considered when the goal is to decrease *E. coli* loading from rangelands.

9.6.2 Residential Sources

It is imperative that all facilities with a water treatment facility operate in compliance with their NPDES permits and WLAs set forth in the TMDL. Below are some recommendations for the facilities to consider ensuring high operational effectiveness of wastewater treatment and storm sewers.

City of Hartford WTF

- Continue scheduled sanitary sewer lines and storm sewer replacement and repairs.
- Continue upgrading treatment system as new technologies become available.
- Continued maintenance of the existing facility and new WTF.
- Continue *E. coli* monitoring to assure compliance with WQS.
- Encourage WTF personnel to attend annual wastewater training courses sponsored by the state.

City of Crooks WTF, Chester Sanitary District, & City of Colton WTF

- Continue scheduled replacement of sanitary pumps, replacing riprap, and repairing inter-pond valves.
- Continue scheduled sanitary sewer lines and storm sewer replacement and repairs.
- Continued maintenance of the existing facility.
- Continue upgrading treatment system as new technologies become available.
- Encourage WTF personnel to attend annual wastewater training courses sponsored by the state.

Town of Humbolt, Wall Lake Sanitary District, South Dakota State Penitentiary -West Farm & Tri-Valley School District

- Continue scheduled replacement of sanitary pumps, replacing riprap, and repairing inter-pond valves.
- Continue scheduled sanitary sewer lines and storm sewer replacement and repairs.
- Encourage WTF personnel to attend annual wastewater training courses sponsored by the state.

City of Sioux Falls Storm Sewers

- Continue following permit requirements.
- Continue inspecting and updating storm sewer infrastructure.

- Continue current BMP implementation and programs.
- Develop a monitoring strategy of storm sewer outfalls.

9.7 Strengthening Source Assessment and Available Data

In order to better understand conditions contributing to *E. coli* loading, it is recommended that *E. coli* sampling be continued in areas where elevated *E. coli* concentrations were observed, and to note specific land uses and conditions at the time of sampling that could be contributing to elevated instream concentrations. *E. coli* sampling should primarily be done in the recreation season when water quality is most susceptible to impacts from *E. coli* contributions.

More frequent sampling will need to take place along tributaries in the Skunk Creek Segment 1 watershed. This TMDL identified potential areas for *E. coli* nonpoint sources in the Willow Creek and Colton Creek watersheds. Additional monitoring sites and prolonged sampling in these watersheds is recommended to get a better representation of *E. coli* loadings from these locations. Water quality data from these sites would also benefit future implementation projects in this area to quantify any changes in *E. coli* concentrations. The following monitoring would help improve the understanding of *E. coli* loading in the Skunk Creek Segment 1:

- Additional monitoring of *E. coli* of West Branch Skunk Creek Segment 1 at Station ID: CENTBSRT20 to span multiple field seasons. Any monitoring will yield a better understanding of sources located throughout the watershed.
- Additional monitoring of *E. coli* of Colton Creek at Station ID: CENTBSRT19 for multiple seasons. Sampling from 2014-2018 have recorded elevated *E. coli* levels.
- Continue monitoring program at WQM 121.
- Continue monthly sampling on Willow Creek at Station ID: EDWQSPT22. Previous sampling from 2014-2021 have recorded elevated *E. coli* levels.

Below is information that could help strengthen the source assessment and help guide monitoring activities.

- Thorough analysis of the number of septic systems in the watershed, their proximity to surface water and their state of repair.
- A more detailed understanding and location of grazing and manure management practices within the watershed.

9.8 Consistent Data Collection and Methodologies

DANR uses water quality data from several stakeholders to conduct beneficial use support and impairment assessments as part of the IR process. Water quality data collected by other stakeholders can be used to evaluate overall progress of restoration efforts.

It is recommended that future water quality monitoring efforts conducted by local stakeholders follow quality assurance plans and standard operating procedures developed by the DANR

Watershed Protection Program. These plans and procedures maintain consistency with data collection and analysis used to develop this TMDL.

DANR Watershed Protection Program and the South Dakota Discovery Center jointly operate the South Dakota Volunteer Water Quality Monitoring Program. The goal of the program is to increase public interest and engagement for water quality in South Dakota. The Watershed Protection Program trains volunteer monitors on water quality sampling techniques and procedures. Further expansion of volunteer monitors in the Skunk Creek Segment 1 watershed would benefit the monitoring portion of the adaptive management process. Consistent additional data collection can allow DANR to evaluate overall implementation effectiveness and make recommended adjustments to local implementation.

9.9 Implementation Strategy

Funding support and technical assistance for implementing watershed-scale nonpoint source projects can be obtained through DANR. Funding programs provided by DANR administer financial support for projects that protect and improve water quality in South Dakota. These programs are the Consolidated Water Facilities Construction program, Clean Water State Revolving Fund (CWSRF) program, and the Section 319 Nonpoint Source Management Program.

9.9.1 Section 319 Nonpoint Source Management Program

The Section 319 Nonpoint Source Management Program provides the means for states, tribes and territories to receive federal funds to address nonpoint source pollution. Applications for Section 319 grant funds are submitted to DANR to be presented at the annual Non-Point Source Task Force Meeting. The task force then reviews and submits a grant funding recommendation to the Board of Water & Natural Resources for grant approval. Watershed projects awarded 319 funds are the primary channel for reducing nonpoint source pollution in South Dakota by implementing water-quality BMPs.

The Big Sioux Implementation Project is a 319-funded project that is targeting bacteria pollutant sources within the Big Sioux Basin. The project's objectives are to restore and protect the water quality of impaired watersheds.

Multiple types of BMPs have been considered in the development of a water quality management implementation plan for the impaired segments of the Big Sioux Basin including Skunk Creek Segment 1. **Section 8.2** provides the LDC and indicate the greatest reductions are required in three flow zones. With majority of bacteria production in the Skunk Creek Segment 1 watershed comes from livestock, implementation measures should focus on the following:

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.
- Riparian buffer strips should be installed along streams bordering cropland and pastureland.

- Animal confinement facilities should implement proper animal waste management systems.
- An assessment of progress will be part of every Section 319 implementation segment, and revisions to the plan will be made as appropriate in cooperation with basin stakeholders.

10.0 Public Participation

SD DANRs Watershed Protection Program (WPP) partnered with East Dakota Water Development District (EDWDD) to assess beneficial use support and acquire data and information necessary to develop the *E. coli* TMDL for Skunk Creek Segment 1. *E. coli* data collected during the project was supplemented with *E. coli* data available from SD DANR's ambient surface water quality monitoring program (i.e., WQM 121).

Field staff from WPP and EDWDD communicated with interested landowners and residents in the watershed during the field collection process to gain information about potential sources of *E. coli*. This also provided a pathway to inform interested parties of the project scope and activities being conducted to assess the impairment and address concerns. A public meeting was held at the City of Sioux Falls Environmental Office on November 26, 2018, to discuss outcomes of the revised Big Sioux River (segments 8, 10, 11 and 12) *E. coli*-TSS TMDLs. Attendees were assured that a future *E. coli* TMDL for Skunk Creek Segment 1 would use immersion recreation criteria as the TMDL target to protect the downstream use on the Big Sioux River (Segment 11).

Staff from the City of Sioux Falls Environmental Division assisted SD DANR in providing City of Sioux Falls MS4 and BMP information.

A 30-day public comment period was issued for the draft Skunk Creek Segment 1 *E. coli* TMDL. A public notice letter was published in the Argus Leader, Minnehaha Messenger and Madison Daily Leader. The draft TMDL document and ability to comment was made available on DANRs One-Stop Public Notice Page at: https://danr.sd.gov/public/default.aspx. The public comment period began February 6, 2025 and ended March 9, 2025.

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Appendix A – Soil Classifications of the Skunk Creek Segment 1 TMDL Project Area

Soil Classification	Landform	Slope (%)	Drainage class	Frequency of Flooding	Permeability	Water Capacity	Surface Runoff	Main Land Use
Baltic Silty Clay Loam (Ba)	Tilll/Flood Plains	0 - 1	Very Poorly Drained	Frequent for Long Periods	Slow	High	Negligible	Wildlife Habitat
BenClare-Corson Complex (BcA)	Terraces	0 - 2	Moderately Well Drained	None	Slow	High	Low	Row Crops & Small Grain
Bon Loam (Bo)	High Flood Plains	0 - 2	Moderately Well Drained	Occasional for Brief Periods	Moderate	High	Low	Row Crops & Small Grain
Chancellor Silty Clay Loam (Cb)	Till Plains	0 - 1	Poor to Moderate	Frequent for Brief Periods	Slow	High	Very Low	Row Crops & Small Grain
Chancellor-Tetonka Complex (Cc)	Till Plains	0 - 1	Poorly Drained	Frequent for Brief Periods	Slow	High	Very Low	Row Crops & Small Grain
Delmont-Enet Loam (DeA)	Outwash Plains	0 - 2	Well Drained to Excessive	None	Moderate - Rapid	Low - Moderate	Low	Row Crops & Small Grain
Dempster Silt Loam (DmA)	Well Drained	0 - 2	Well Drained	None	Moderate - Rapid	Moderate	Low	Row Crops & Small Grain
Egan-Ethan Complex (EaB)	Till Plains	2 - 6	Well Drained	None	Moderately Slow	High	Medium	Row Crops & Small Grain
Egan-Trent Silty Clay Loam (EfA)	Till Plains	0 - 2	Moderate - Well Drained	None	Moderately Slow	High	Low	Row Crops & Small Grain
Egan-Wentworth-Trent (EgB)	Till Plains	1 - 6	Well Drained	None	Moderate	High	Low - Moderate	Row Crops & Small Grain
Enet Loam (EnA)	High Flood Plains	0 - 2	Well Drained	Rare	Moderate - Rapid	Moderate	Low	Row Crops & Small Grain
Flandreau Loam (FaA)	Till Plains	0 - 6	Well Drained	None	Moderate - Rapid	Moderate	Low	Row Crops & Small Grain
Flandreau-Thurman Complex (FtB)	Till Plains	2 - 6	Well Drained to Excessive	None	Moderate - Rapid	Low - Moderate	Very Low - Medium	Row Crops & Small Grain
Graceville Silty Clay Loam (GrA)	Outwash Plains	0 - 2	Well Drained	None	Moderate - Rapid	High	Low	Row Crops & Small Grain
Groveau Loam (GsB)	Till Plains	2 - 6	Well Drained	None	Moderate	High	Medium	Row Crops & Small Grain
Houdek (HoB)	Till Plains	2 - 6	Well Drained	None	Moderately Slow	High	Medium	Row Crops & Small Grain
Houdek-Shindler Clay Loam (HsC)	Moraines	6 - 15	Well Drained	None	Moderately Slow	High	Medium - Very High	Crops & Rangeland
Huntimer Silty Clay Loam (HuA)	Ice-walled Lake Plains	0 - 2	Well Drained	None	Slow	High	Medium	Row Crops & Small Grain
Lamo Silty Clay Loam (La)	Low Flood Plains	0 - 2	Poorly Drained	Occasional for Brief Periods	Moderately Slow	High	Low	Row Crops & Small Grain
Lamo Silty Clay, Channeled (Lb)	Low Flood Plains	0 - 1	Poorly Drained	Frequent for Brief Periods	Moderately Slow	High	Low	Rangeland & Wildlife
Moody-Nora Silty Clay Loam (MnB)	Plains	2 - 9	Well Drained	None	Moderately	High	Medium	Crops & Rangeland
Moody-Trent Silty Clay Loam (MtA)	Plains	0 - 2	Moderate to Well Drained	None	Moderate	High	Low	Row Crops & Small Grain
Nora-Croft Complex (NcC)	Dissecting Plains	6 - 9	Well Drained	None	Moderate	High	Medium	Row Crops & Small Grain
Obert Silty Clay Loam (Ob)	Low Flood Plains	0 - 1	Very Poorly Drained	Frequent for Brief Periods	Moderately Slow	High	Very Low	Rangeland
Orthents Gravelly (Og)	Outwash Plains	0 - 60	Excessively Drained	None	Moderate - Rapid	Very Low	Very Low - Low	Rangland - Wildlife
Salmo (Sa)	Low Flood Plains	0 - 1	Poorly Drained	Frequent for Brief Periods	Moderate	Moderate	Very Low	Crops & Rangeland
Splitrock Silty Clay Loam (SpA)	Till Plains	0 - 2	Well Drained	None	Moderately Slow	High	Low	Row Crops & Small Grain
Shindler-Houdek Clay Loam (SdE)	Moraines	15 - 40	Well Drained	None	Moderately Slow	High	Very High	Rangeland
Talmo-Delmont Complex (TdE)	Moraines	15 - 40	Excessively Drained	None	Moderate - Rapid	Very Low - Low	Medium - High	Wildlife Habitat
Tetonka Silt Loam (Te)	Till Plains	0 - 1	Poorly Drained	Frequent Long Periods	Slow	High	Negligible	Row Crops & Wildlife
Trent Silty Clay Loam (Tr)	Plains	0 - 2	Moderately Well Drained	None	Moderate	High	Low	Row Crops & Small Grain
Viborg Silty Clay Loam (Vi)	Till Plains	0 - 6	Well Drained	None	Moderate	High	Low	Row Crops & Small Grain
Wakonda-Chancellor (Wa)	Till Plains	0 - 2	Moderate	Occasional for Brief Periods	Slow - Moderate	High	Very Low - Low	Row Crops & Small Grain
Wentworth-Trent (WhA)	Till Plains	0 - 2	Moderate to Well Drained	None	Moderate	High	Low	Row Crops & Small Grain
Whitewood (Wk)	Till Plains & Plains	0 - 2	Poorly Drained	Frequent for Very Brief Periods	Moderately Slow	High	Low	Row Crops & Small Grain
Worthing Silty Clay Loam (Wo)	Till Plains	0 - 1	Very Poorly Drained	Frequent Ponding for Long Periods	Slow	High	Negligible	Rangeland & Wildlife

Appendix B – TMDL Numeric Target Selection Rationale

South Dakota's *E. coli* criteria are based on EPA recommendations originally published in 1986 (USEPA, 1986). EPA issued slightly modified recommendations in 2012 that did not substantially change the underlying analysis or criteria values in South Dakota (USEPA, 2012). As recommended, SDDANR adopted *E. coli* criteria that contains two components: a geometric mean (GM) and a single sample maximum (SSM). The GM was established from epidemiological studies by comparing average summer exposure to an illness rate of 8:1,000. The SSM component was computed using the GM value and the corresponding variance observed in the epidemiological study dataset (i.e., log-standard deviation of 0.4). EPA provided four different SSM values corresponding to the 75th, 82nd, 90th, and 95th percentiles of the expected water quality sampling distribution around the GM to account for different recreational use intensities in **Figure 5-1** below. South Dakota adopted the most stringent recommendation, the 75th percentile, into state water quality standard regulations as the SSM protective of designated beaches.

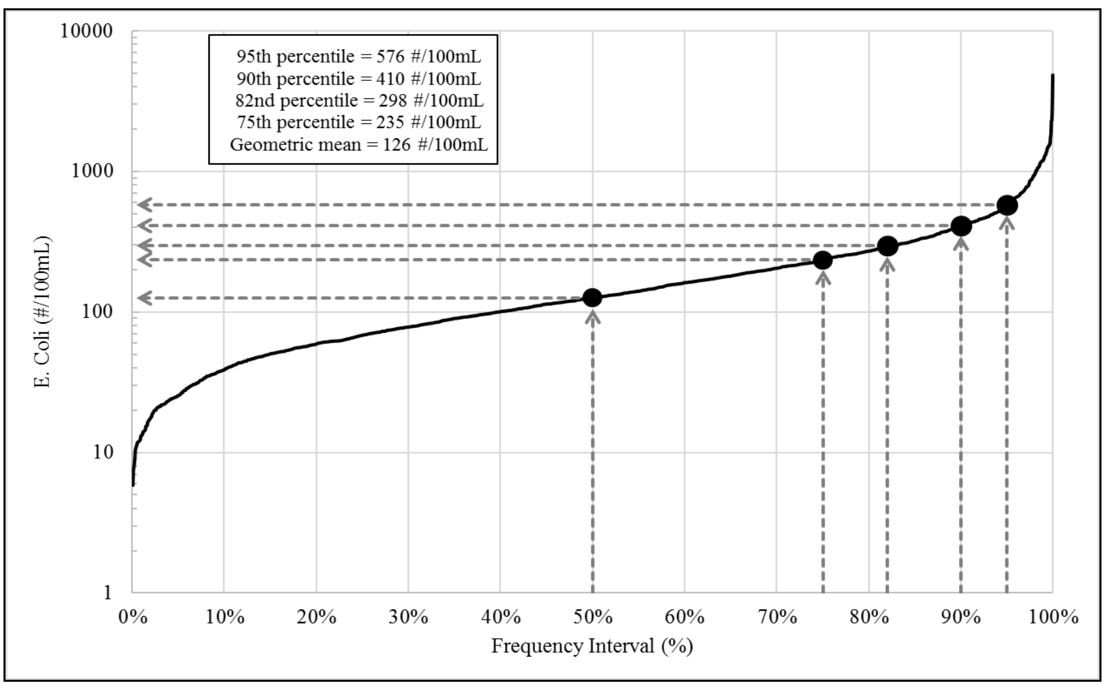


Figure 5-1. Log-Normal Frequency Distribution Used to Establish South Dakota's Immersion Recreation *E. coli* Criteria of 126 (GM) and 235 (SSM) #/100mL (EPA, 1986).

Dual criteria were established to balance the inherent variability of bacteria data and provide flexibility for handling different sampling routines. Together, the GM and SSM describe a water quality distribution expected to be protective of immersion contact recreation. The GM and SSM are equally protective of the beneficial use because they are based on the same illness rate and differ simply representing different statistical values and sampling timeframes. While this investigation has revealed the GM and SSM *E. coli* criteria to be equally protective of the immersion recreation use, a likewise conclusion can be made for the GM and SSM criteria associated with the limited contact recreation use since those values were simply derived as five times the immersion values.

As described in EPA's Protocol for Developing Pathogen TMDLs, the availability of data may dictate which criterion should be used as the TMDL target (USEPA, 2001). When a geometric mean of the sampling dataset can be calculated as defined by South Dakota Administrative Rules (i.e., at least five samples separated by a minimum of 24-hours over a 30-day period) and compared to the GM criterion, DANR uses the GM criterion as the TMDL target. This establishes a smaller overall loading capacity and is considered a conservative approach to setting the TMDL.

When a proper GM cannot be calculated, as in this case for Skunk Creek Segment 1 (SD-BS-R-SKUNK_01), DANR uses the SSM as the TMDL target. This is permissible because the SSM is equally protective of the beneficial use as discussed above. Although this target selection leads to the establishment of a larger allowable load, in some respects it is more appropriate because timeframes align better (i.e., the SSM is associated with a single day and TMDLs establish daily loads, versus the 30-day GM). Additionally, certain aspects of DANR's *E. coli* assessment method, when combined with a SSM TMDL target, result in an expected dataset GM more protective than the GM criterion. DANR uses assessment methods to define how to interpret and apply WQS to 303(d) impairment decisions.

Returning to the original distribution used to establish South Dakota's Immersion Recreation *E. coli* criteria in **Figure 5-1** remember that SDDANR chose to adopt a SSM concentration based on the most stringent recommendation (75th percentile). According to assessment methods in South Dakota, however, the SSM concentration is treated as a 90th percentile (i.e., 10% exceedance frequency). Step #1 in **Figure 5-2** shows how doing so effectively moves the SSM point to the right. If the original log-normal frequency distribution with a log-standard deviation of 0.4 is subsequently re-fitted to this new 90th percentile point at 235 #/100mL (red dotted line), the corresponding 50th percentile (GM) is 72 #/100mL as shown in Step #2 of **Figure 5-2**.

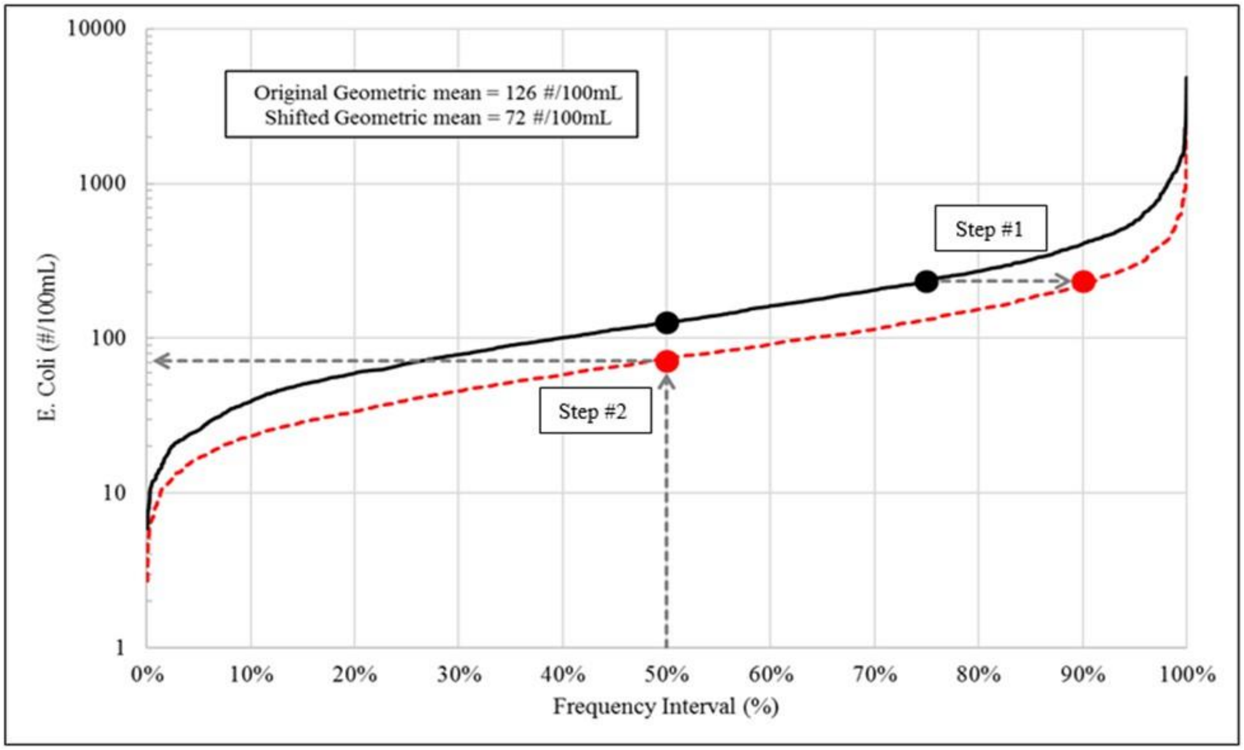


Figure 5-2. **The Effective Impact of South Dakota's *E. coli* Assessment Method on the Criteria's Original LogNormal Frequency Distribution (Black line = original; red dotted line = shifted)**

The GM associated with this shifted distribution is more stringent than the GM of the original distribution (126 #/100mL), thus this demonstrates that attaining a maximum daily SSM target in a TMDL will also achieve the 30-day GM criterion when following South Dakota's assessment method. A similar conclusion was determined by EPA in *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2007) using Michigan criteria as an example.

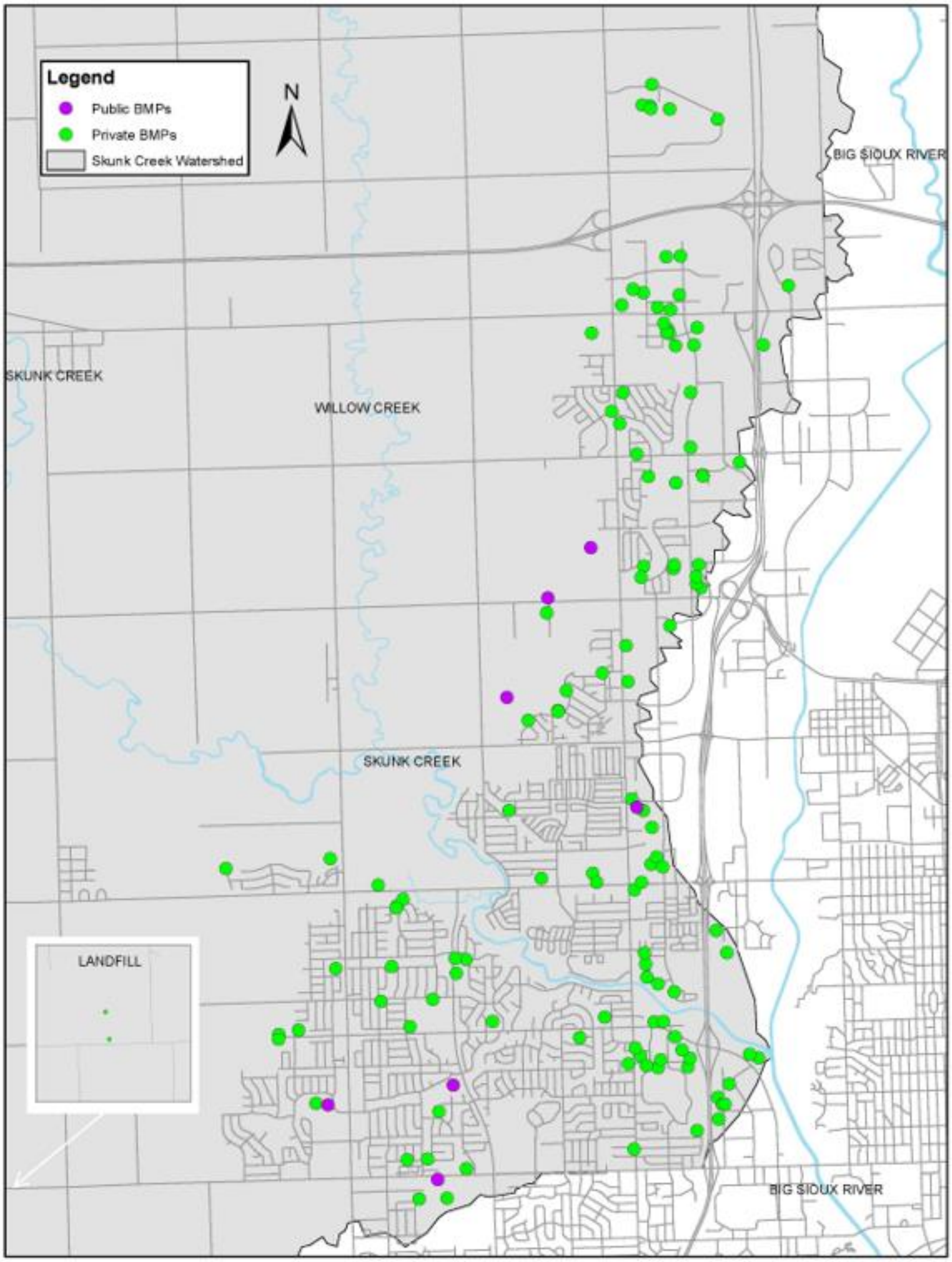
Finally, while the SSM is associated with a single day of sampling and the GM is associated with 30 days of sampling, it is not technically appropriate to refer to them as "acute" and "chronic" criteria. Those terms distinguish timeframes over which harm-to-use impacts develop, not the sampling or averaging timeframe as with the SSM and GM. Acute refers to an effect that comes about rapidly over short periods of time. Chronic refers to an effect that can build up over longer periods, sometimes the lifetime of a subject. In the case of *E. coli*, gastrointestinal illness develops within a matter of hours to days. Both the SSM and GM are derived from this same timeframe and based on the same underlying illness rate, thus treating the SSM as an acute criterion and assuming it to be less stringent is incorrect. EPA recommends states use the GM and SSM together, rather than just the GM or just the SSM, to judge whether water quality is protective of recreational uses. DANR follows these guidelines and only relies on one criterion when forced by data availability.

Appendix C – Measured E. coli WQM 121 Data 2006 – 2020

Station	Date	Time (CST)	*E. coli* (#/100mL)	USGS Discharge (cfs)	Percent Flow (%)
WQM 121	05/22/2019	14:15	4350	1308.84	2.92
WQM 121	07/27/2011	11:00	4840	1257.31	3.07
WQM 121	07/18/2019	13:30	1900	1122.65	3.93
WQM 121	09/30/2019	14:35	411	1023.00	4.71
WQM 121	05/14/2019	16:00	20	928.96	5.38
WQM 121	05/14/2019	11:25	10	928.96	5.38
WQM 121	06/05/2019	14:00	134	760.85	7.73
WQM 121	08/08/2018	17:05	4840	732.82	8.35
WQM 121	05/14/2012	17:20	218	606.33	11.54
WQM 121	07/08/2019	13:10	203	600.71	11.69
WQM 121	05/16/2012	12:30	147	530.49	14.02
WQM 121	05/16/2011	17:40	39.3	508.05	14.95
WQM 121	06/14/2011	13:00	4830	502.35	15.17
WQM 121	05/16/2018	17:30	63.8	472.10	16.38
WQM 121	07/31/2019	15:05	73	454.05	17.24
WQM 121	05/27/2020	13:55	839	450.30	17.41
WQM 121	05/03/2006	13:15	184	429.85	18.51
WQM 121	08/17/2010	18:00	34	372.49	21.19
WQM 121	05/06/2020	17:25	350	359.70	21.90
WQM 121	07/07/2020	14:20	9210	351.63	22.32
WQM 121	05/29/2013	14:00	1730	333.68	23.32
WQM 121	08/21/2019	18:05	41	284.29	26.54
WQM 121	05/16/2016	11:00	167	269.58	27.55
WQM 121	05/16/2016	11:00	137	269.58	27.55
WQM 121	06/25/2009	1:56	3076	264.44	27.99
WQM 121	07/08/2009	0:20	7270	258.62	28.36
WQM 121	05/17/2016	13:10	120	243.95	29.51
WQM 121	08/09/2011	18:30	16.8	243.78	29.56
WQM 121	08/14/2019	13:30	84	240.02	29.78
WQM 121	08/14/2019	13:31	109	240.02	29.78
WQM 121	07/16/2009	7:25	988	232.13	30.64
WQM 121	06/10/2020	15:05	9210	220.97	31.67
WQM 121	09/04/2019	14:20	191	204.14	33.19
WQM 121	05/24/2010	19:30	20.6	191.29	34.62
WQM 121	07/01/2009	12:00	583	181.60	35.89
WQM 121	05/05/2009	14:52	411	172.21	37.15
WQM 121	06/26/2013	13:00	1010	163.60	38.33
WQM 121	06/13/2016	11:00	443	159.07	38.99
WQM 121	05/10/2017	16:20	63	145.26	41.22
WQM 121	05/08/2009	11:20	201.4	142.26	41.66
WQM 121	08/22/2011	14:45	14.4	135.63	42.84
WQM 121	06/25/2020	9:20	326	134.32	43.06
WQM 121	07/22/2009	11:50	185	118.08	46.30
WQM 121	08/08/2006	13:40	770	114.03	46.92

Station	Date	Time (CST)	*E. coli* (#/100mL)	USGS Discharge (cfs)	Percent Flow (%)
WQM 121	06/19/2012	14:15	39.4	113.83	47.02
WQM 121	05/14/2009	12:00	111.2	113.03	47.21
WQM 121	08/17/2015	18:10	4840	84.24	52.96
WQM 121	07/22/2020	14:10	63	78.83	54.33
WQM 121	06/08/2006	12:45	125	67.69	57.23
WQM 121	09/12/2011	14:00	28.4	67.43	57.30
WQM 121	08/11/2009	11:38	228	64.85	58.14
WQM 121	08/25/2009	9:30	7701	64.71	58.19
WQM 121	05/20/2009	18:00	36.8	58.42	59.96
WQM 121	05/20/2013	18:45	31.8	56.14	60.91
WQM 121	05/21/2009	5:25	236	55.19	61.26
WQM 121	08/19/2009	7:05	4610	54.62	61.50
WQM 121	07/29/2009	18:56	1610	54.27	61.67
WQM 121	07/18/2016	13:20	10	52.66	62.39
WQM 121	06/15/2009	15:10	1960	51.41	62.88
WQM 121	08/12/2009	18:00	28	51.24	62.95
WQM 121	06/11/2009	10:55	2280	47.31	64.89
WQM 121	08/12/2013	18:45	533	41.79	68.06
WQM 121	08/05/2009	11:10	110	40.57	68.75
WQM 121	05/29/2009	11:45	291	39.58	69.46
WQM 121	08/18/2014	18:00	38.8	37.13	71.25
WQM 121	06/08/2009	0:37	1730	34.24	73.73
WQM 121	08/13/2013	14:00	65.7	32.56	75.52
WQM 121	05/14/2015	10:50	537	32.49	75.64
WQM 121	08/12/2020	14:30	36.8	31.91	76.26
WQM 121	08/12/2020	14:32	39.1	31.91	76.26
WQM 121	09/13/2006	13:15	71	29.63	77.95
WQM 121	09/13/2006	13:15	64.1	29.63	77.95
WQM 121	06/03/2009	11:05	272	27.46	80.11
WQM 121	08/15/2016	13:00	95	26.10	81.05
WQM 121	05/07/2014	17:50	10.2	25.08	82.30
WQM 121	08/16/2016	17:05	52	23.61	83.38
WQM 121	08/18/2020	17:30	8.4	22.65	84.04
WQM 121	09/12/2016	11:50	134	20.66	85.76
WQM 121	08/09/2017	17:50	433	25.25	86.96
WQM 121	08/24/2020	14:30	10.7	19.03	87.43
WQM 121	07/13/2006	13:35	2420	17.95	88.61
WQM 121	09/02/2020	14:15	21.6	15.69	90.79
WQM 121	09/09/2009	11:30	360	14.23	92.00
WQM 121	09/15/2009	11:25	496	11.95	93.62
WQM 121	09/23/2020	15:15	15.2	11.53	93.98
WQM 121	07/30/2013	14:30	20	10.68	94.67
WQM 121	09/21/2009	10:55	738	10.08	94.99
WQM 121	07/26/2012	15:15	10	9.65	95.26
WQM 121	08/20/2012	18:20	63	9.13	95.61
WQM 121	09/18/2013	14:30	14.8	4.57	98.18
WQM 121	09/26/2012	14:30	14.8	2.48	99.95

Appendix D – City of Sioux Falls BMPs in Skunk Creek Segment 1 Watershed



Appendix E – Skunk Creek Segment 1 *E. coli* Point Source WLA Calculations

Skunk Creek *E. Coli* Point Source WLA Calculations (Immersion Recreation)								
Facility	**Permit Number**	**Receiving Waters**	**Design Flow (MGD)**	**80th Percentile DMR Daily Max Flow (MGD)**	**Effluent Flow for WLA (MGD)**	**Daily Max *E. coli* Permit Limit (#/100mL)**	**Daily Max *E. coli* WLA (#/day)**	**Notes**
Town of Humbolt	SD824015	Beaver Lake	N/A	N/A	N/A	N/A	**N/A**	Facility is not permitted to discharge.
City of Crooks	SD0020761	Willow Creek	0.16	N/A	N/A	1,178	**N/A**	Discharge about 11 km from Skunk Creek. As long as Facility adheres to NPDES permit any discharge have little to no impact on TMDL
City of Crooks Municipal Utilities	SDG860048	Willow Creek	N/A	N/A	N/A	N/A	**N/A**	E. coli effluent limits are not included in permit because it is not a pollutant of concern. Not expected to impact TMDL
Chester Sanitary District	SD0020338	Skunk Creek	0.82	1.13	**1.13**	***235**	**1.01E+10**	Direct discharge into Skunk Creek.
City of Colton Water Distribution	SDG860069	Colton Creek	N/A	N/A	N/A	N/A	**N/A**	E. coli effluent limits are not included in permit because it is not a pollutant of concern. Not expected to impact TMDL
City of Colton	SD0022322	Colton Creek	N/A	N/A	N/A	1,178	**N/A**	As long as Facility adheres to NPDES permit any discharge have little to no impact on TMDL. Not expected to impact TMDL
Tri-Valley School District	SDG827278	N/A	N/A	N/A	N/A	N/A	**N/A**	Facility is not permitted to discharge. Not expected to impact TMDL
Wall Lake Sanitary District	SD0026778	Unnamed Tributary	0.02	N/A	N/A	N/A	**N/A**	As long as Facility adheres to NPDES permit any discharge have little to no impact on TMDL. Not expected to impact TMDL
City of Hartford (Future WWTF)	SD0021750	Unnamed Tributary	3.40	N/A	**3.40**	***235**	**3.02E+10**	Discharge 3.5 miles from Skunk Creek. Facility peak design flow is 3.4 MGD.
South Dakota State Penitentiary West Farm	SDG820427	N/A	N/A	N/A	N/A	N/A	**N/A**	Facility is not permitted to discharge.
City of Sioux Falls	SD0022128	Big Sioux River	21.00	N/A	N/A	235	**N/A**	WLA was assigned to the Big Sioux River Segment 12 *E. coli* TMDL
City of Sioux Falls MS4	SDS-000001	Skunk Creek	Unknown	Unknown	**Unknown**	235	**Variable**	City of Sioux Falls MS4 WLAs are a function of Skunk Creek's flow zones.
*Concentration used in the WLA calculation								

Appendix F – EPA Approval Letter and Decisions Document