HUC 07140101 – Cahokia-Joachim Subbasin
Water bodies: 3825 and 3826
Pollutant(s): Pathogens as indicated by *Escherichia coli*

MISSOURI NATURAL RESOURCES

WATER PROTECTION PROGRAM

Total Maximum Daily Load (TMDL)
for
Black Creek and Deer Creek
St. Louis County and St. Louis City

Pollutants of concern: Pathogens

Submitted: July 11, 2017
Approved: June 26, 2019

Prepared by: Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Load (TMDL) for Black Creek and Deer Creek
Pollutant: Pathogens as indicated by *E. coli*

Name: Black Creek
Location: St. Louis County

Name: Deer Creek
Location: St. Louis County and St. Louis City

State map showing location of watershed

12-digit Hydrologic Unit Code (HUC) and Name:[1]
071401010504 – Deer Creek

Water Body Identification Number and Hydrologic Class:[2]
Black Creek: Water body ID No. 3825 – Class P
Deer Creek: Water body ID No. 3826 – Class P

Designated uses:[3]
Livestock and wildlife protection
Irrigation
Protection and propagation of fish, shellfish and wildlife – warm water habitat
Human health protection
Secondary contact recreation
Whole body contact recreation category A – *Deer Creek only*
Whole body contact recreation category B – *Black Creek only*

Uses that are Impaired:
Whole body contact recreation categories A and B

Length and locations of impaired segments:
Black Creek: 2.6 km (1.6 mi), from mouth to Section 21, Township 45N, Range 6E
Deer Creek: 2.6 km (1.6 mi), from mouth to Section 1930, Township 45N, Range 6E

Universal Transverse Mercator [Zone 15 north] coordinates:
Black Creek: From E: 732023, N: 4276834 to E: 731266, N: 4278180
Deer Creek: From E: 733741, N: 4275807 to E: 732023, N: 4276834

Pollutant on 2016 303(d) List:
Escherichia coli, or *E. coli*, bacteria

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[1] A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[2] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class P streams maintain flow during drought conditions.

[3] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

The Missouri Department of Natural Resources in accordance with Section 303(d) of the federal Clean Water Act is establishing this Black Creek and Deer Creek total maximum daily load, or TMDL. These water quality-limited segments in St. Louis County and city are included on Missouri's 2016 303(d) List of impaired waters. The listing of Black Creek and Deer Creek as impaired by pathogens, as indicated by *Escherichia coli*, or *E. coli*, bacteria, was approved by the U.S. Environmental Protection Agency on July 12, 2016. The department's 303(d) submittal to EPA cited urban runoff and storm sewers as likely sources of the impairment. This report addresses the Black Creek and Deer Creek pathogen impairments by establishing TMDLs for *E. coli*. Data analyses conducted to support this listing and TMDL development indicate that *E. coli* are present at concentrations that result in exceedances of Missouri's water quality criteria for the protection of whole body contact recreational uses.

Section 303(d) of the federal Clean Water Act and Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to develop TMDLs for waters not meeting designated uses. The TMDL process quantitatively assesses the impairment factors so that states can establish water quality-based controls to reduce pollution and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding state water quality standards. Missouri's Water Quality Standards at 10 CSR 20-7.031 consist of three major components: designated uses, water quality criteria to protect those uses and an antidegradation policy. The TMDL establishes the pollutant loading capacity necessary to meet the water quality standards established for each water body based on the relationship between pollutant sources and instream water quality conditions. A TMDL consists of a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation is the fraction of the total pollutant load apportioned to point sources. The load allocation is the fraction of the total pollutant load apportioned to nonpoint sources. The margin of safety is a percentage of the TMDL that accounts for any uncertainty associated with the model assumptions as well as any data inadequacies.

Both Black Creek and Deer Creek were first listed as impaired by pathogens in 2012 due to elevated *E. coli* concentrations. Missouri's 2016 listing methodology determines a water to be impaired by bacteria if the geometric mean of measured *E. coli* in a given recreational season exceeds the water quality criteria during any of the last three years in which there are at least five samples. Missouri's recreational season extends from April 1 through October 31. Data meeting these listing methodology specifications were collected and do show these streams to be impaired by *E. coli*.

In addition to *E. coli*, both Black Creek and Deer Creek are also included on the 2016 303(d) List as impaired by chloride. A separate TMDL report will be developed in the future to address this pollutant. The department's TMDL development schedule is available online at dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm.

2. Watershed Description

Deer Creek is an urban stream in St. Louis County and western St. Louis and is a tributary to River des Peres. Deer Creek is identified in the Missouri Use Designation Dataset as water body identification number, or WBID, 3826.[4] Black Creek is identified as WBID 3825 and is a tributary to Deer Creek. Deer Creek originates in north central Creve Coeur south of State Highway 340 and flows southeast for approximately 17.3 km (10.75 mi) before enter the River des Peres in St. Louis. Black Creek originates in north Ladue and flows south for 9.0 km (5.6 mi) until it joins Deer Creek forming the municipal boundary between the cities of Brentwood and Maplewood (Figure 1). The Deer Creek watershed drains approximately 95.3 km^2 (36.8 mi^2). Summary statistics have been developed for the Deer Creek watershed, of which Black Creek is a subwatershed, and are presented in this report.

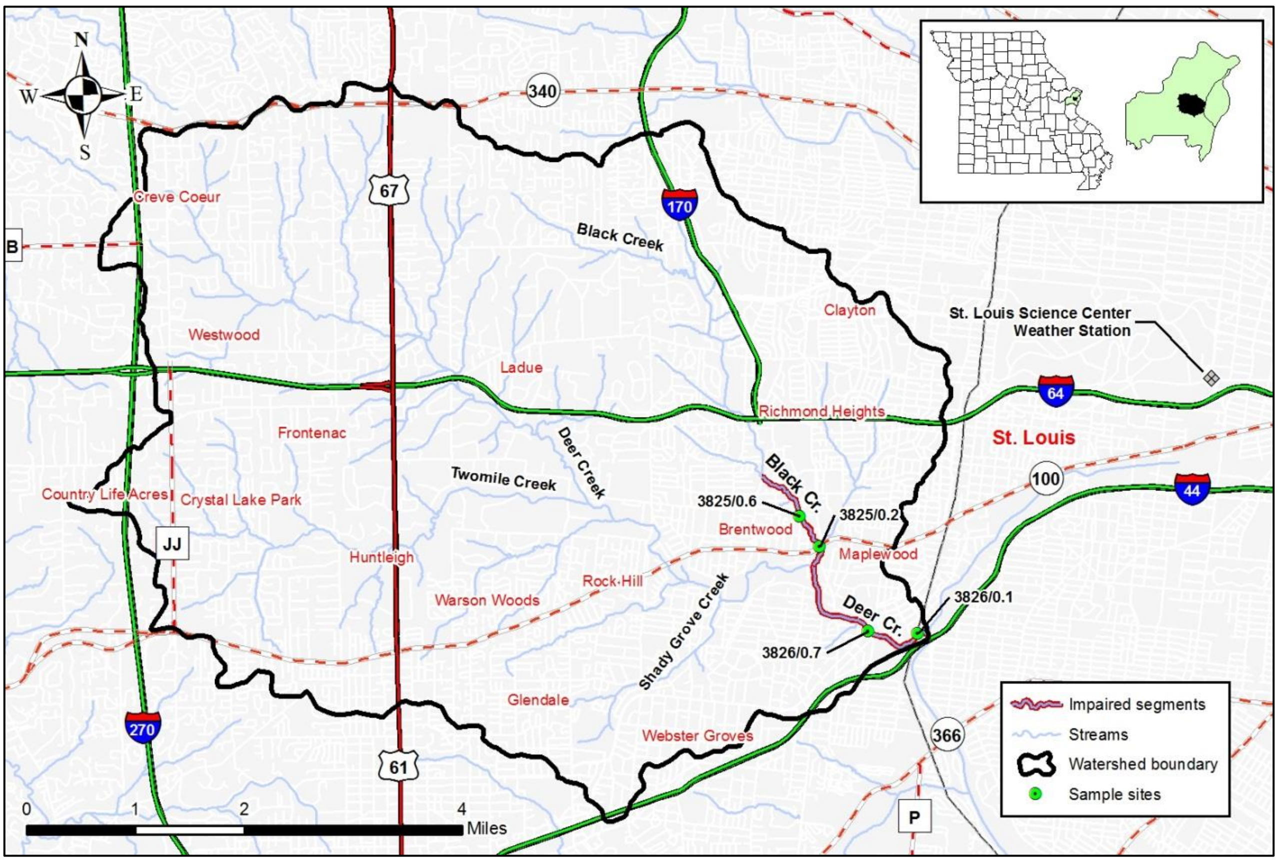

Figure 1. The Deer Creek watershed in St. Louis County[5]

[4] The Missouri Use Designation Dataset documents the names and locations of the state's rivers, streams, lakes and reservoirs, which have been assigned designated uses. See 10 CSR 20-7031 (1)(P).

[5] Bacteria monitoring sites from downstream to upstream (east to west): 3826/0.1 – Deer Creek near Drury Lane, 3826/0.7 – Deer Creek at Maplewood, 3825/0.2 – Black Creek at Manchester Road, and 3825/0.6 – Black Creek near Brentwood.

2.1 Geology, Physiography and Soils

The Deer Creek watershed is a portion of the larger Cahokia-Joachim subbasin, identified by the 8-digit hydrologic unit code, or HUC, 07140101, which in addition to Missouri, lies within portions of Illinois.[6] The Missouri portion of the Cahokia-Joachim subbasin is located within the Apple/Joachim ecological drainage unit (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography and climate characteristics (USGS 2009). The characteristics of an ecological drainage unit are varied and are partially based on the ecoregions that are contained within the drainage unit. Ecoregions are areas with similar ecosystems and environmental resources.[7] A level I ecoregion is a coarse, broad category, while a level IV is a more defined grouping. The Deer Creek watershed is contained entirely within the River Hills ecoregion. This area is a transition zone between the Central Irregular Plains and the Ozark Highlands. Key characteristic features of the River Hills are loess-covered hills and numerous karst features (Chapman et al. 2002). Karst features in the Deer Creek watershed include 147 sinkholes (MoDNR 2014).

Soils in the Deer Creek watershed are varied, but can be grouped based on similar characteristics. Table 1 provides a summary of hydrologic soil groups in the Deer Creek watershed. Hydrologic soil groups categorize soils by their runoff potential. A soil's hydrologic soil group relates to the rate at which water enters the soil profile under thoroughly wetted, bare soil surface conditions. Group A represents soils with the highest rate of infiltration and the lowest runoff potential under these conditions and Group D represents the group with the lowest rate of infiltration and highest potential for runoff (NRCS 2007). The dominant soil group in the Deer Creek watershed is Group C. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils consist chiefly of soils with a layer that impedes downward movement of water. In some cases, soils are placed in dual soil groups based on both the depth to the water table and the soils ability to drain. In the Deer Creek watershed, more than 12 percent of the watershed area is categorized as having soils in the dual group C/D and has characteristics of Group C and a high water table that is typically found in Group D soils. Similarly, a small portion of the watershed is categorized as being in the dual group B/D indicating the soils have characteristics of Group B soils, but maintain a high water table like Group D soils. Group B soils include silt loam and loam, which have moderate infiltration rates. These soils typically consist of well-drained soils with moderately fine to moderately coarse textures. Approximately 6.6 percent of the watershed area could not be rated in a hydrologic soil group. Typically, areas that are not rated are composed of open water, quarries or landfills. In the Deer Creek watershed, areas that are not rated also include areas with soil types described as being greater than 90 percent urban and thus have a very high potential for runoff. Figure 2 shows the distribution of these hydrologic soil groups throughout the Deer Creek watershed.

[6] Watersheds are delineated by the USGS using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS and NRCS 2013).

[7] Ecoregion is defined in Missouri's Water Quality Standards at 10 CSR 20-7.031 (1)(I).

Table 1. Hydrologic soil groups in the Deer Creek watershed (NRCS 2011)

Soil Group:	***Dual Group B/D***	***Group C***	***Dual Group C/D***	***Not Rated***	***Total***
Area: km^2 (mi^2)	1.11 (0.43)	75.99 (29.34)	11.89 (4.59)	6.29 (2.43)	95.28 (36.79)
Percentage: (%)	1.2	79.7	12.5	6.6	100.0

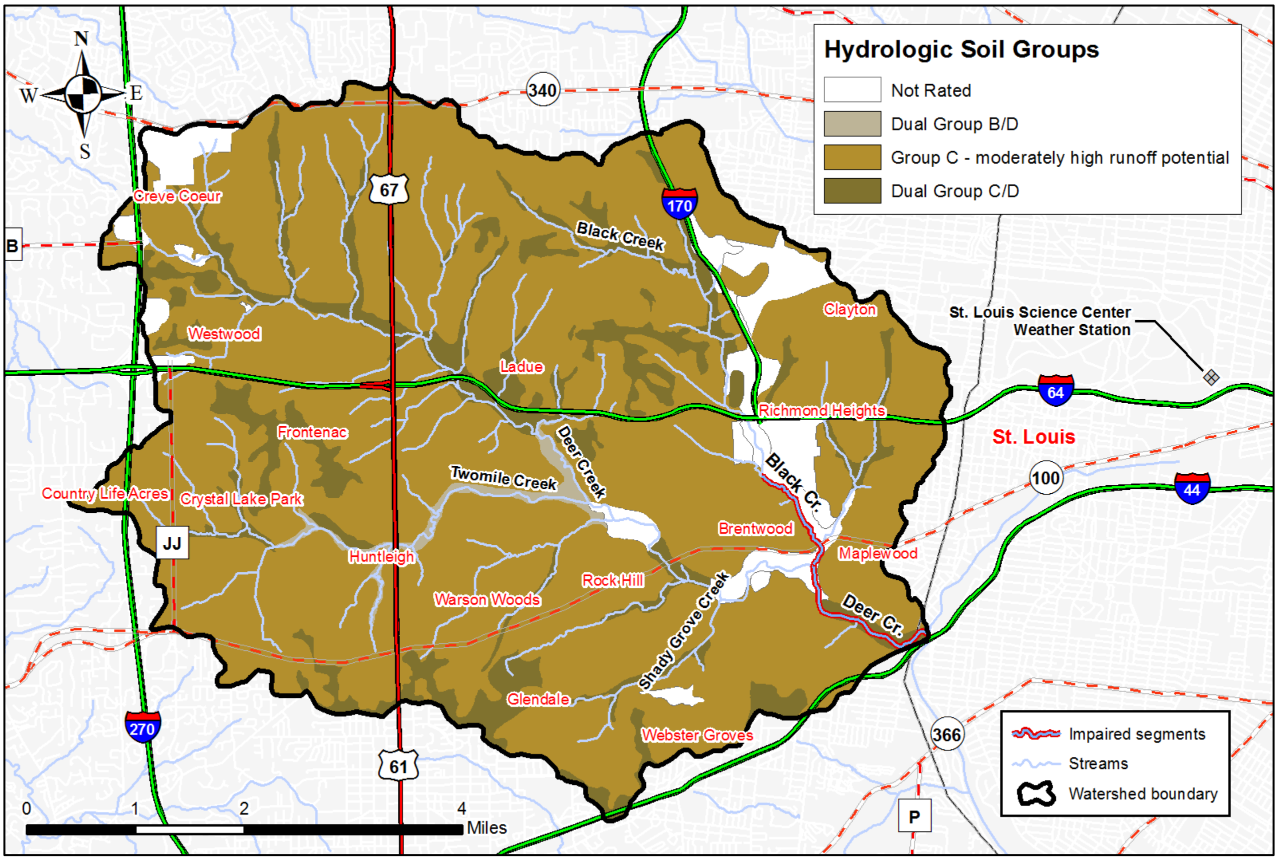

Figure 2. Hydrologic soil groups in the Deer Creek watershed (NRCS 2011)

2.2 Rainfall and Climate

Weather stations provide useful information for developing a general understanding of climatic conditions in a watershed. The St. Louis Science Center weather station is the closest source to the Deer Creek watershed with recent and available weather and climate data (Figure 1). This station records daily precipitation, and maximum and minimum temperature data, which are expected to be representative of conditions in the Deer Creek watershed. Precipitation is an important factor for stream flow and runoff events that can influence certain pollutant sources that may contribute bacteria loads. Figure 3 and Table 2 provide the annual average precipitation and annual average minimum and maximum temperatures from 1981 through 2010.

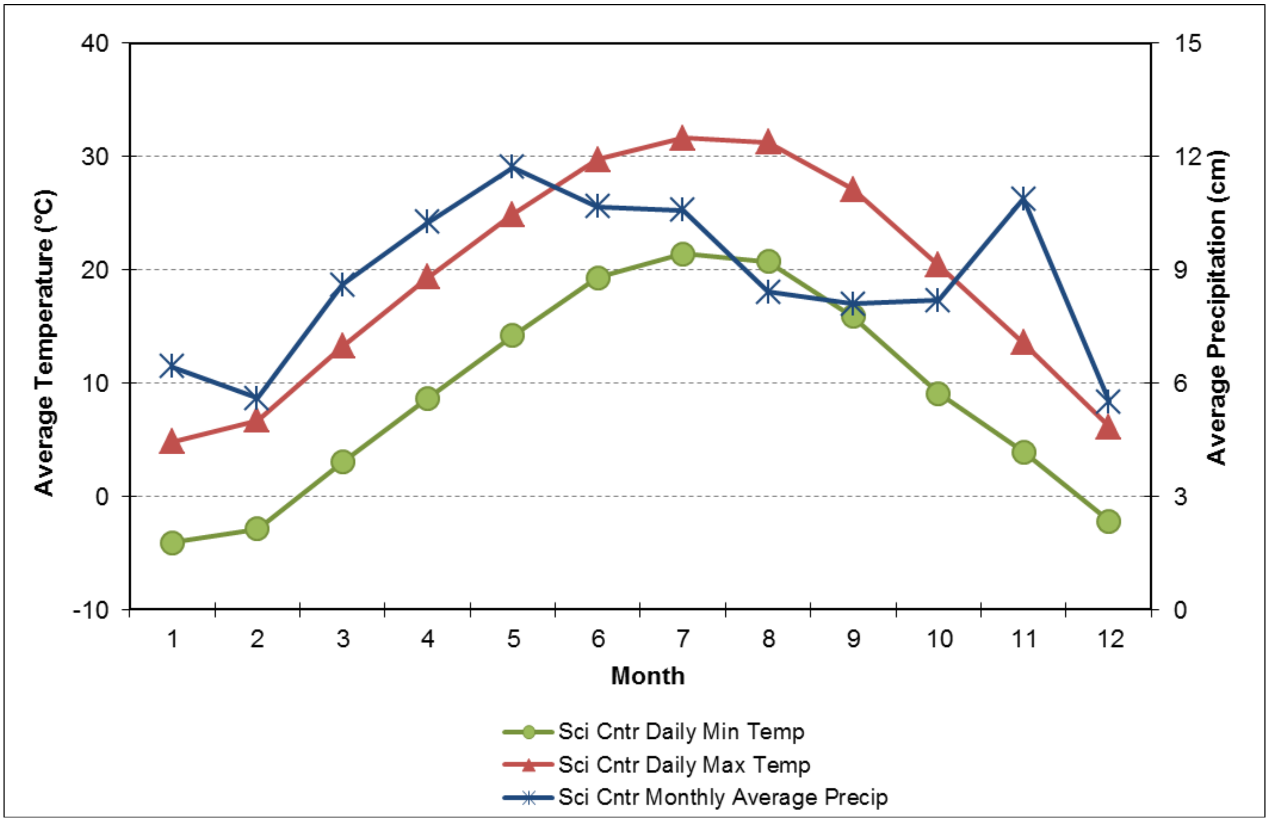

Figure 3. 30-year climate data from the St. Louis Science Center weather station (NOAA 2011)

Table 2. 30-year climate data from the St. Louis Science Center weather station (NOAA 2011)

Weather Station	*Annual Average Precipitation cm (inches)*	*Annual Average Minimum Temperature °C (°F)*	*Annual Average Maximum Temperature °C (°F)*
St. Louis Science Center	104.9 (41.29)	8.9 (48.0)	19.1 (66.3)

2.3 Population

St. Louis County covers an area of 1,355 km^2 (523 mi^2) and, according to 2010 census data, has a population of 999,021 people (U.S. Census Bureau 2010). The population of the Deer Creek watershed is not directly available; however, using U.S. Census Bureau census block data from 2010, the population of the Deer Creek watershed is estimated to be approximately 91,007. This estimation was completed by using Geographic Information System, or GIS, software and superimposing the watershed boundary over a map of census blocks. Where the centroid of a census block fell within the watershed boundary, its total population was included in the total. If the centroid of the census block was outside the watershed boundary, then the population was excluded. This densely populated watershed is entirely contained within a U.S. Census Bureau defined urban area.[8] EPA defines urban areas as entities requiring stormwater regulations through municipal separate storm sewer permits (EPA 2014a).

EPA completed a separate population analysis for purposes unrelated to this TMDL. They used demographic and census block data and a web-based tool called EJSCREEN to determine areas of the state having potential Environmental Justice concerns. EPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies (EPA 2014b). Environmental Justice communities may qualify for financial and strategic assistance for addressing environmental and public health issues (EPA 2011a). From this analysis, EPA determined that the Deer Creek watershed has potential Environmental Justice concerns for up to five percent of its area.

2.4 Land Cover

Land cover characterization was made using the 2011 National Land Cover Database published by the U.S. Geological Survey, or USGS (Homer et al. 2015). Land cover calculations are presented in Table 3 and a map showing the distribution of the various land coverages in the watershed is shown in Figure 4. As can be seen from this information, the watershed is approximately 99 percent developed. More than 58 percent of the watershed area is categorized as low intensity development. Areas of low intensity development have from 20 to 49 percent impervious cover and are composed primarily of single-family housing units. Areas of medium intensity development are also composed of single-family housing units, but contain from 50 to 79 percent impervious cover. Approximately 8 percent of the watershed area is in the medium intensity development category. About 6 percent of the watershed area is in high intensity development where impervious cover is 80 to 100 percent. According to the Metropolitan St. Louis Sewer District, actual imperviousness of the watershed is approximately 33 percent. This amount of imperviousness in the Deer Creek watershed is significant, because stream degradation associated with imperviousness has been shown to first occur at about 10 percent imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994).

Areas of less imperviousness are also found in the watershed, but much of these areas are still associated with some degree of development. Approximately 26 percent of the watershed area is developed open space, which is composed primarily of lawn grasses such as those found in parks,

[8] An urban area is delineated by the U.S. Census Bureau to represent densely populated areas (https://www.census.gov/geo/reference/ua/urban-rural-2010.html)

yards, and golf courses, or planted for erosion control and aesthetic purposes. Impervious surfaces in these area are still common, but account for less than 20 percent of the cover. Vegetated areas that are less susceptible to runoff and are typically more permeable than developed areas, in this case forest and wetlands, account for only 0.1 percent of the watershed's land cover.

Table 3. Land cover in the Deer Creek watershed

Land Cover	***Watershed Area***		
	hectare (acres)	***Km^2 (mi^2)***	***Percentage***
Developed, High Intensity	594.1 (1,468)	5.93 (2.29)	6.24
Developed, Medium Intensity	824.3 (2,037)	8.24 (3.18)	8.65
Developed, Low Intensity	5,596.8 (13,830)	55.97 (21.61)	58.74
Developed, Open Space	2,494.9 (6,165)	24.94 (9.63)	26.18
Forest	6.9 (17)	0.08 (0.03)	0.07
Wetland	2.8 (7)	0.03 (0.01)	0.03
Open Water	8.5 (21)	0.08 (0.03)	0.09
Total:	9,528.3 (23,545)	95.26 (36.78)	100.00

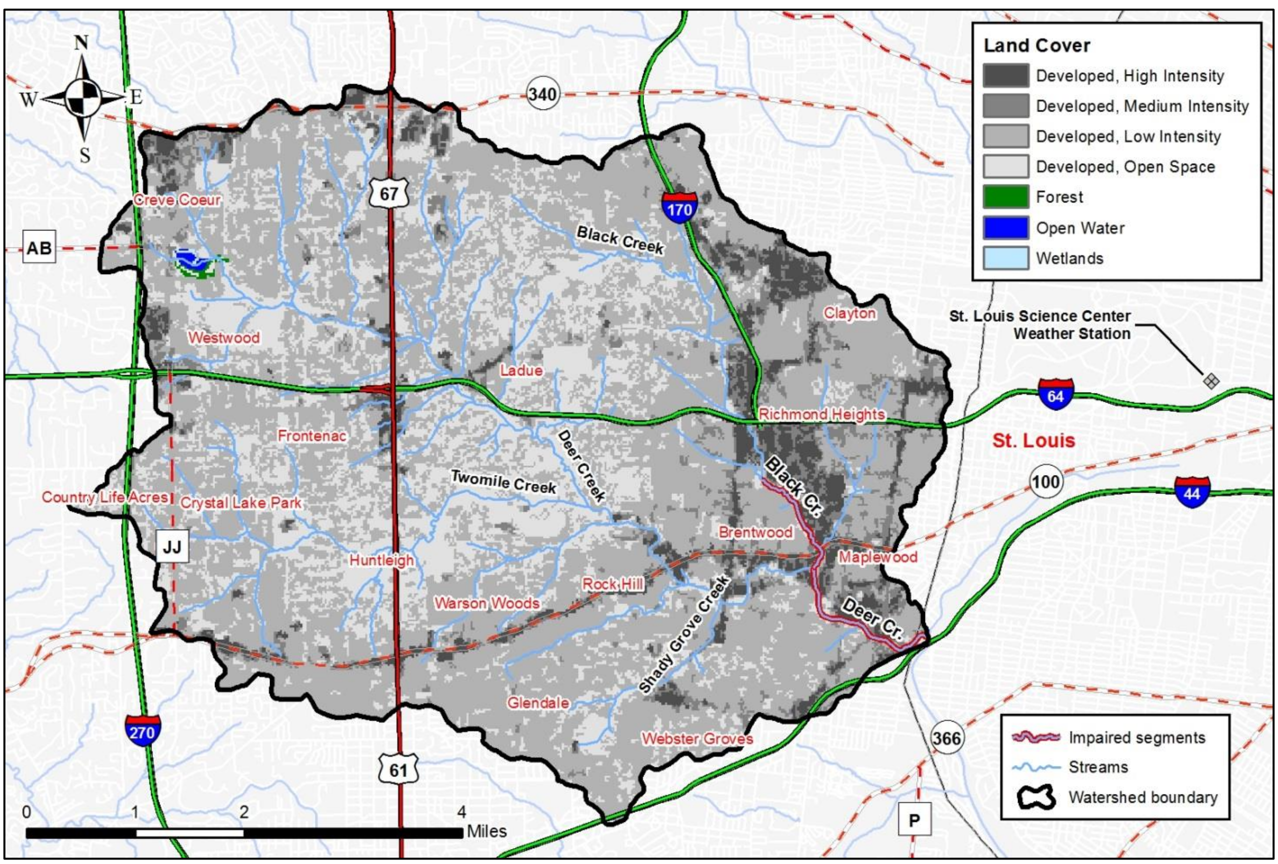

Figure 4. Land cover in the Deer Creek watershed

3. Applicable Water Quality Standards

The purpose of developing a TMDL is to identify the pollutant loading that a water body can assimilate and still attain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy.

3.1 Designated Uses

Designated uses are the uses for a water body defined in the state Water Quality Standards at 10 CSR 20-7.031(1)(C) and assigned per 10 CSR 20-7.031(2) and Table H.[9] These uses must be maintained in accordance with the federal Clean Water Act. The following designated uses have been assigned to Black Creek and Deer Creek and are reflected in the Missouri Use Designation Dataset as described in 10 CSR 20-7.031(2)(E):

- Livestock and wildlife protection
- Irrigation
- Protection and propagation of fish, shellfish and wildlife – warm water habitat
- Human health protection
- Secondary contact recreation
- Whole body contact recreation category A – *Deer Creek only*
- Whole body contact recreation category B – *Black Creek only*

The uses impaired by bacteria are the protection of whole body contact recreation category A and B. Whole body contact recreation includes activities in which there is direct human contact with surface water that results in complete body submergence, thereby allowing accidental ingestion of the water as well as direct contact to sensitive body organs, such as the eyes, ears and nose. Category A waters include water bodies that have been established as public swimming areas and waters with documented existing whole body contact recreational uses by the public. Category B applies to waters designated for whole body contact recreation, but are not contained within category A.

3.2 Water Quality Criteria

Water quality criteria are limits on certain chemicals or conditions in a water body to protect particular designated uses. Water quality criteria can be expressed as specific numeric criteria or as general narrative statements.

In Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A, specific numeric criteria are given for the protection of whole body contact recreational uses. For category A waters, *E. coli* counts, measured as a geometric mean, shall not exceed 126 counts/100mL of water during the recreational season. For category B waters, the geometric mean *E. coli* count shall not exceed 206 counts/100 mL of water during the recreational season. The state's recreational season is defined in this section of the rule as being from April 1 to October 31.

[9] The terminology used for naming designated uses varies from what is presented in the text of 10 CSR 20-7.031 and what is presented in Table H. The terminology utilized in the text of the water quality standards rule is presented here.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects existing uses and a level of water quality necessary to maintain and protect those uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after Nov. 28, 1975, the date of EPA's first Water Quality Standards Regulation.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for Black Creek and Deer Creek are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

Missouri's Water Quality Standards use *E. coli*, bacteria found in the intestines of humans and warm-blooded animals, as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. The department judges a stream to be impaired if the water quality criteria are exceeded in any of the last three years for which there is a minimum of five samples collected during the recreational season. This approach is detailed in the department's 2016 Listing Methodology Document, which is available online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

Per federal regulations at 40 CFR§130.7(c)(1), TMDLs are needed for Black Creek and Deer Creek, because the department has determined that these streams are not meeting applicable water quality standards. Recreational season *E. coli* bacteria data collected from Black Creek and Deer Creek from 2010 – 2016 are summarized in Table 4. Individual bacteria measurements collected during this period are presented in Appendix A. It should be noted that many of the high *E. coli* values measured in these streams, particularly annual maximum values, result from sanitary sewer overflow events as described in Section 5.1.1 of this report.

Table 4. Recreational season *E. coli* data for Black Creek and Deer Creek (2010 – 2016)[10]

Water Body ID #	*Year*	*Number of Samples*	*Geometric Mean (count/100mL)*	*Minimum (count/100mL)*	*Maximum (count/100mL)*
Deer Cr. 3826	2010	7	518	50	3,650
	2011	6	309	41	860
	2012	3	Insufficient data	230	24,000
	2013	9	1,516	150	> 24,196
	2014	15	7,013	150	> 24,196
	2015	15	1,799	240	17,000
	2016	15	1,849	300	17,000
Black Cr. 3825	2010	7	718	173	2,910
	2011	6	645	145	2,380
	2012	3	Insufficient data	430	20,000
	2013	9	4,569	160	> 24,196
	2014	16	5,524	310	> 24,196
	2015	15	11,361	1,000	> 24,196
	2016	15	2,183	320	24,196

5. Source Inventory and Assessment

Source inventory and assessment characterizes known, suspected and potential sources of pollutant loading to a water body. Pollutant sources identified within the watershed are categorized and quantified to the extent that information is available. Sources of pollutants may be point (regulated) or nonpoint (unregulated) in nature.

5.1 Point Sources

Point sources are defined under Section 502(14) of the federal Clean Water Act and are typically regulated through the Missouri State Operating Permit program.[11] Point sources include any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a water body. Under this definition, permitted point sources include permitted municipal and domestic wastewater dischargers, site-specific permitted industrial and non-domestic wastewater dischargers, and general and stormwater permitted entites, which include concentrated animal feeding operations, no-discharge domestic wastewater facilities, and stormwater discharges from municipal separate storm sewer systems. In addition to

[10] Numerous high values, including the maximum values measured in 2014 – 2016, are associated with discharges from sanitary sewer overflows as described in Section 5.1.1 of this report. For calculating geometric means, values reported as greater-than (>) were doubled. This is consistent with the department's assessment procedures described in the 2016 Listing Methodology Document. These observed data collected from Deer Creek and Black Creek were not used in the calculation of the TMDL loading capacity or allocations.

[11] The Missouri State Operating Permit system is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit.

these permitted sources, illicit straight pipe discharges, which are illegal and therefore unpermitted, are also considered point sources.

At the time of this writing, the Deer Creek watershed contains 57 permitted facilities, five of which have general wastewater permits and the remaining 52 have stormwater permits. There are no facilities with site-specific permits in the Deer Creek watershed, nor are there any permitted concentrated animal feeding operations, or CAFOs. Figure 5 shows the location of point source outfalls within the watershed.

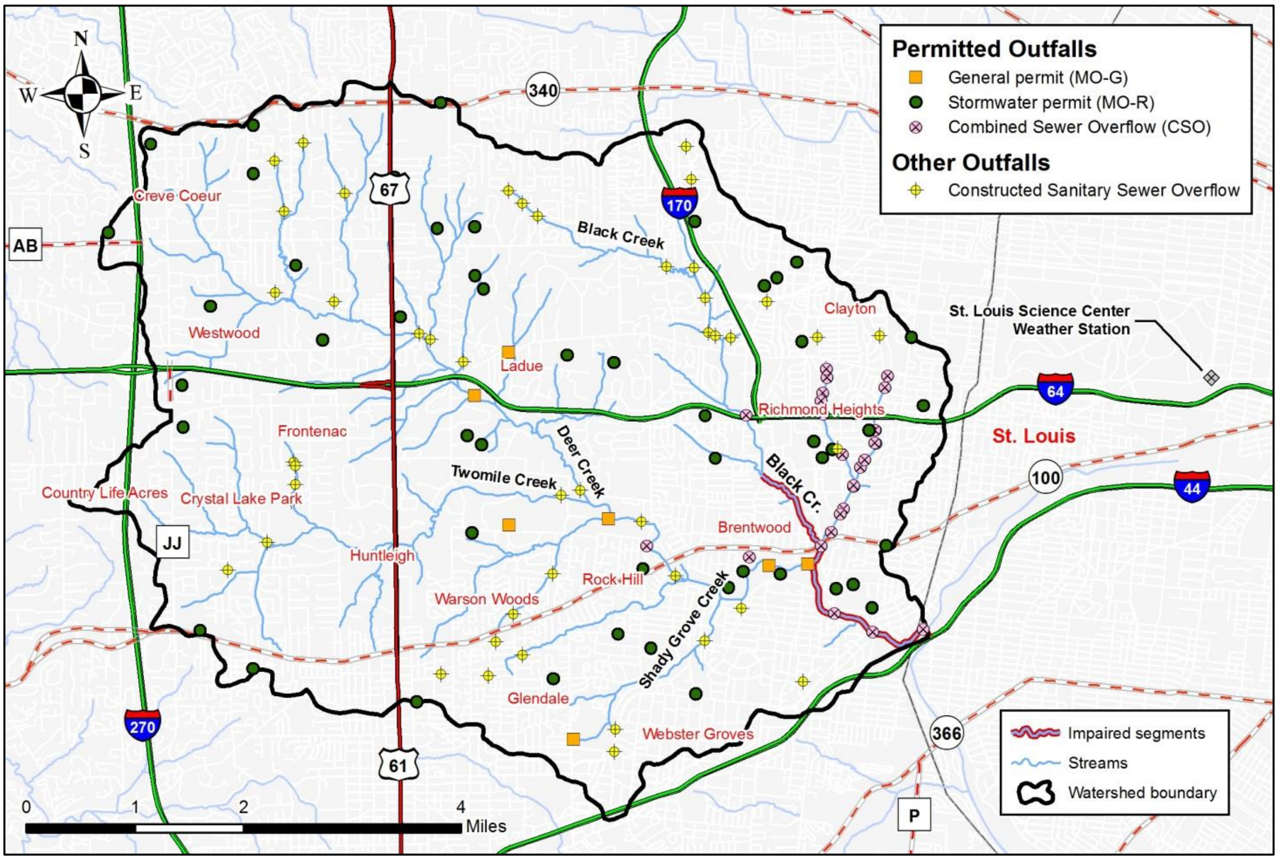

Figure 5. Point source outfall locations in the Deer Creek watershed[12]

5.1.1 Municipal and Domestic Wastewater Permits

Domestic wastewater dischargers include both municipal and non-municipal wastewater treatment facilities. Domestic wastewater is primarily household waste, which includes graywater and sewage. Untreated or inadequately treated discharges of domestic wastewater can be significant sources of bacteria to receiving waters (EPA 1986). However, there are no municipal or other domestic wastewater permitted discharges in the Deer Creek watershed. The Metropolitan St.

[12] Two MS4 permits regulate discharges of stormwater runoff in areas of the watershed not serviced by a combined sewer system. However, it is expected that following the sewer separations and CSO outfall eliminations required by a consent decree, stormwater discharges within the entire watershed area will be regulated by MS4 permits. Permit no. MO-0137910 regulates stormwater discharges from Missouri Department of Transportation right-of-ways and permit no. MO-R040005 regulates MS4 stormwater discharges from all other areas within the watershed.

Louis Sewer District operates and maintains a sanitary sewer system throughout the watershed. The collected domestic wastewater is delivered to the Lemay wastewater treatment facility (permit no. MO-0025151) located outside of the watershed. The sewage collection and transport system infrastructure within the Deer Creek watershed is a potential source of bacteria due to possible breakage or overflows.

Sanitary sewer overflows are untreated or partially treated sewage releases from a sanitary sewer system. Overflows could occur for a variety of reasons including blockages, line breaks, sewer defects, power failures and vandalism. Sanitary sewer overflows can occur during either dry or wet weather and at any point in the collection system, including manholes. Such overflows are unauthorized by the federal Clean Water Act. Occurrences of sanitary sewer overflows can result in elevated bacteria concentrations (EPA 1996). During the period of January 2012 through December 2015, 48 sanitary sewer overflows were reported to the department (Table 5). Thirty of these overflows occurred during the recreational season; however, some overflows discharged to dry land or were otherwise contained and did not reach a water body in the Deer Creek watershed.

Table 5. Reported sanitary sewer overflows in the Deer Creek watershed (2012 – 2015)[13]

Date	***Weather Conditions***	***Cause***
Jan. 3, 2012	Dry	Broken sewer pipe
Jan. 3, 2012	Dry	Broken sewer pipe
Jan. 26, 2012	Dry	Plugged sewer
Feb. 7, 2012	Dry	Plugged sewer
March 19, 2012	Dry	Plugged sewer
April 16, 2012	Dry	Plugged sewer
May 3, 2012	Dry	Plugged sewer
Oct. 12, 2012	Dry	Plugged sewer
March 27, 2013	Dry	Plugged sewer/pipe break
June 10, 2013	Dry	Plugged sewer
July 8, 2013	Dry	Plugged sewer
July 8, 2013	Dry	Plugged sewer
Aug. 14, 2013	Dry	Broken sewer pipe
Aug. 16, 2013	Dry	Plugged sewer
Aug. 21, 2013	Dry	Broken sewer pipe
Aug. 26, 2013	Dry	Broken sewer pipe
Sept. 12, 2013	Dry	Plugged sewer
Oct. 2, 2013	Dry	Plugged sewer
Dec. 19, 2013	Dry	Plugged sewer
March 12, 2014	Dry	Plugged sewer
April 4, 2014	Dry	Plugged sewer
April 29, 2014	Dry	Plugged sewer
May 8, 2014	Dry	Plugged sewer

[13] Overflow information retrieved from the Department of Natural Resources' Missouri Clean Water Information System.

May 9, 2014	Dry	Vandalism
May 15, 2014	Dry	Plugged sewer
May 23, 2014	Dry	Plugged sewer
July 7, 2014	Dry	Broken sewer pipe
July 29, 2014	Dry	Plugged sewer
Aug. 28, 2014	Dry	Vandalism
Oct. 15, 2014	Dry	Plugged sewer
Dec. 3, 2014	Dry	Plugged sewer
Dec. 29, 2014	Dry	Plugged sewer
March 19, 2015	Dry	Plugged sewer
March 25, 2015	Dry	Plugged sewer
March 31, 2015	Dry	Plugged sewer
April 22, 2015	Dry	Plugged sewer
May 22, 2015	Dry	Plugged sewer
June 22, 2015	Dry	Broken sewer pipe
Aug. 4, 2015	Dry	Broken sewer pipe
Aug. 29, 2015	Dry	Plugged sewer
Sept. 6, 2015	Dry	Plugged sewer
Sept. 28, 2015	Dry	Plugged sewer
Oct. 27, 2015	Dry	Broken sewer pipe
Nov. 2, 2015	Dry	Broken sewer pipe
Nov. 19, 2015	Dry	Plugged sewer
Nov. 23, 2015	Dry	Plugged sewer
Dec. 3, 2015	Dry	Plugged sewer
Dec. 14, 2015	Dry	Plugged sewer

Constructed sanitary sewer overflows, designed to relieve the sanitary sewer system during heavy rainstorms, are also present in the Black Creek and Deer Creek watersheds (MSD 2015). According to the Metropolitan St. Louis Sewer District, there are 45 constructed sanitary sewer overflows in the Deer Creek watershed. Of these 45 constructed sanitary sewer overflows, 15 are also located within the Black Creek watershed. In addition to sanitary sewer overflows, combined sewer overflows, or CSOs, are also present within some of the district's service areas. A combined sewer system collects both stormwater runoff and wastewater, including domestic sewage. These systems are designed to transport wastewater to treatment facilities and to discharge directly to a water body if its capacity is exceeded due to stormwater inputs. Combined sewer systems were an early sewer design and are found in approximately 772 cities in the U.S. (EPA 2014c). As with sanitary sewer overflows, CSOs can result in periods of elevated bacteria concentrations in a water body due in large part to the discharge of domestic sewage as well as the runoff component from roofs, parking lots and residential yards and driveways. In the Deer Creek watershed, there are 28 CSO outfalls, 21 of which are also within the drainage area of Black Creek (Figure 7). CSO discharges are managed through the Metropolitan St. Louis Sewer District's long-term control plan, which includes nine minimum controls as required by EPA's CSO policy dated April 19, 1994 (59 FR 18688) and Missouri's effluent regulations at 10 CSR 20-7.015(10). These nine minimum controls as described in the operating permit for the Lemay wastewater treatment facility are:

- Proper operation and maintenance programs;
- Maximum use of the collection system for storage;
- Review and modification of pretreatment requirements;
- Maximization of flow to the publicly operated treatment works for treatment;
- Dry weather flows from CSOs are prohibited;
- Control of solid and floatable material in CSOs;
- Pollution prevention;
- Public notification; and,
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

In addition to these nine minimum controls, the district's long-term control plan states that some CSO outfalls will be eliminated by sewer separation and the remaining outfalls will eventually convey all flows to a storage tunnel underneath the River des Peres and will then be pumped to the Lemay wastewater treatment plant (MSD 2011). Controls specified in the long-term control plan are referenced in the consent decree established as part of the *United States of America and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District*, No. 4:07-CV-1120.

A USGS study about the sources of *E. coli* in metropolitan St. Louis area streams estimated that during the study, at least one-third of the measured in-stream *E. coli* in St. Louis area streams originated from humans.[14] The study also indicated that there is a correlation between *E. coli* densities and the number of upstream CSOs and sanitary sewer overflows (USGS 2010). For these reasons, both CSOs and sanitary sewer overflows are considered potential contributors of *E. coli* to Black Creek and Deer Creek. For this TMDL report, constructed sanitary sewer overflows and combined sewer overflows are considered the primary bacteria contributors to Black Creek and Deer Creek. Initial TMDL implementation efforts should focus primarily on these sources. After contributions from these sources are sufficiently minimized, existing loading should be reevaluated to determine the extent of implementation necessary to address other suspected sources described in this TMDL report. Implementation of actions required to address constructed sanitary sewer overflows and combined sewer overflows should be conducted in accordance with the Metropolitan St. Louis Sewer District consent decree.

5.1.2 Site-Specific Industrial and Non-Domestic Wastewater Permits

Site-specific industrial and non-domestic wastewater permits differ from general wastewater permits by having conditions specific to a facility's site and operation. Industrial and non-domestic facilities discharge wastewater resulting from non-sewage generating activities and are typically not expected to cause or contribute to bacteria impairments. There are no industrial or non-domestic wastewater facilities with site-specific permits in the Deer Creek watershed.

[14] This USGS study categorized samples as either human, dog, or geese when 80 percent of the genetic markers were similar. Those with a less than 80 percent match were categorized as unknown. However, those categorized as unknown may include some percentage of human, dog or geese as well as other urban wildlife (USGS 2010).

5.1.3 Municipal Separate Storm Sewer System (MS4) Permits

There are two municipal separate storm sewer system permits, or MS4 permits, in the Deer Creek watershed. One is a site-specific permit issued to the Missouri Department of Transportation, permit number MO-0137910, and regulates stormwater discharges from highway right-of-ways and other MoDOT owned properties. This permit is more commonly referred to as a transportation separate storm sewer system permit, or TS4 permit. The second MS4 permit in the watershed, permit number MO-R040005, is a general small MS4 permit issued to the Metropolitan St. Louis Sewer District and its co-permittees. Co-permittees in the Deer Creek watershed include St. Louis County and the municipalities of Brentwood, Clayton, Creve Coeur, Des Peres, Frontenac, Glendale, Kirkwood, Ladue, Olivette, Richmond Heights, Rock Hill, Shrewsbury, Town and Country, Warson Woods, and Webster Groves.

MS4 permits authorize the discharge of urban stormwater runoff. In general, urban runoff carries high levels of bacteria and may result in exceedances of water quality criteria during and immediately after storm events in most streams throughout the country (EPA 1983). *E. coli* contaminated runoff can come from both heavily paved areas and from open areas where soil erosion is common (Burton and Pitt 2002). For these reasons, urban runoff is a potential contributor of bacteria to Deer Creek and Black Creek.

Bacterial loading to streams from urban runoff can be caused by sanitary sewer overflows as discussed in Section 5.1.1 of this document, but also commonly results from residential and green space runoff carrying domestic and wild animal waste. Birds, dogs, cats, and rodents have been documented as common sources of *E. coli* in urban stormwater (Burton and Pitt 2002). The USGS study specific to the sources of *E. coli* in metropolitan St. Louis streams discussed in Section 5.1.1 of this document estimated that in addition to one third of the bacteria originating from human sources, 10 percent of the sampled *E. coli* was attributed to dogs and 20 percent to geese (USGS 2010). Another component of urban stormwater is runoff originating from highway corridors. The Federal Highway Administration published research showing that runoff from highway corridors may also contain bacteria. Sources of *E. coli* within highway areas identified in the study include bird droppings, soil, and vehicles carrying livestock and stockyard wastes, which may periodically "seed" a roadway with pathogens. The study further notes that the magnitude and contributions from highway systems are site-specific and can be affected by numerous factors, such as traffic, design, maintenance, land use, climate and accidental spills (FHWA 1984). For these reasons, the significance of any highway contributions of bacteria in the Deer Creek watershed cannot be quantified in this TMDL report. Due to the intermittent and potentially sporadic nature of highway bacterial contributions described in the federal study, and due to the urban nature of the watershed, which makes contributions from the transport of livestock and stockyard wastes less likely, highway systems are not expected to be a significant contributor to the bacteria impairments in the Deer Creek watershed. Highway systems, however, do remain a potentially significant source of heavy metals, inorganic salts, aromatic hydrocarbons and suspended solids (FHWA 1998).

Stormwater discharges of urban runoff within the entire Deer Creek watershed are regulated through the before mentioned MS4 permits and for this reason urban runoff is considered a point source in this TMDL report. Although stormwater discharges are often untreated, MS4 permit holders must develop, implement, and enforce stormwater management plans to reduce the contamination of stormwater runoff and prohibit illicit discharges. These plans must include measurable goals, be reported on annually, and meet six minimum control measures. These six minimum control measures are public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention.

5.1.4 General Wastewater and Non-MS4 Stormwater Permits

General and stormwater permits are issued based on the type of activity occurring and are meant to be flexible enough to allow for ease and speed of issuance, while providing the required protection of water quality. General and stormwater permits are issued to activities similar enough to be covered by a single set of requirements, and are designated with permit numbers beginning with "MO-G" or "MO-R" respectively. A summary of the general and stormwater permits in the Deer Creek watershed, as of April 8, 2015, is presented in Table 6. Permits associated with land disturbance activities are temporary and the number of effective permits of this type in the watershed may vary in any given year. Despite this variability, TMDL calculations and targets will not change as a result of any changes in the numbers of these types of permits.

The department assumes activities authorized under these general and stormwater permits will be conducted in compliance with all permit conditions, including monitoring and discharge limitations. It is expected that compliance with these permits will be protective of the designated recreation use within the watershed. For these reasons, these facilities are not expected to cause or contribute to the bacterial impairments of Deer Creek and Black Creek. If at any time the department determines that the water quality of streams in the watershed is not being adequately protected, the department may require the owner or operator of the permitted site to obtain a site-specific operating permit, per 10 CSR 20-6.010(13)(C).

Table 6. General (MO-G) and non-MS4 stormwater (MO-R) permits

Permit No.	*Facility Name*	*Discharge Type*	*Permit Type*	*Permit Expires*[15]
MO-G760031	Old Warson Country Club	Non-domestic process water	Swimming pool	4/9/2014
MO-G760063	Algonquin Golf Club	Non-domestic process water	Swimming pool	7/31/2019
MO-G490185	Rock Hill Quarries Company	Stormwater/incidental non-domes process	Limestone quarry	10/5/2016
MO-G490324	Breckenridge Main Plant #1	Stormwater/incidental non-domes process	Limestone quarry	10/5/2016
MO-G970006	Edie's Mulch Site	Stormwater	Yard waste	11/29/2017
MO-R100008	St. Louis County Government	Stormwater	Land disturbance by city or county	5/30/2017
MO-R100086	City Of Clayton Parks And Recreation	Stormwater	Land disturbance by city or county	5/30/2017
MO-R203285	Essex Industries Inc.	Stormwater	Metal fabrication	8/31/2019
MO-R203468	O'Hare Foundry Corporation	Stormwater	Metal fabrication	8/31/2019

[15] If a permit has expired, then a facility remains bound by the conditions of that expired permit until either the permit is terminated or a new permit is issued.

Permit No.	Facility Name	Discharge Type	Permit Type	Permit Expires[15]
MO-R23A070	Lee Biosolutions, Inc.	Stormwater	Chemical manufacturing	3/11/2015
MO-RA00163	CVS Pharmacy Store #6282	Stormwater	Land disturbance	2/7/2017
MO-RA00270	St. John's Mercy Medical Center Campus	Stormwater	Land disturbance	2/7/2017
MO-RA00296	Glenview Plat 3	Stormwater	Land disturbance	2/7/2017
MO-RA00299	Brentwood I-64 Gateway Implementation	Stormwater	Land disturbance	2/7/2017
MO-RA00315	Provision Living At Webster Groves	Stormwater	Land disturbance	2/7/2017
MO-RA00329	Sunnen Business Park Phase 2	Stormwater	Land disturbance	2/7/2017
MO-RA01140	Old Chatham Road Subdivision - Lot 4	Stormwater	Land disturbance	2/7/2017
MO-RA01141	Centennial Greenway Shaw Park To Olive	Stormwater	Land disturbance	2/7/2017
MO-RA01292	Shaw Park Tennis Center	Stormwater	Land disturbance	2/7/2017
MO-RA01549	Mary Institute And St. Louis Country Day	Stormwater	Land disturbance	2/7/2017
MO-RA01625	Brentwood Bus Facility	Stormwater	Land disturbance	2/7/2017
MO-RA01713	Ladue Early Childhood Center	Stormwater	Land disturbance	2/7/2017
MO-RA02337	Austin Missouri Real Estate Trust	Stormwater	Land disturbance	2/7/2017
MO-RA02684	2106 S. Warson Road	Stormwater	Land disturbance	2/7/2017
MO-RA02704	Raising Cane's	Stormwater	Land disturbance	2/7/2017
MO-RA02890	CVS Store #10153	Stormwater	Land disturbance	2/7/2017
MO-RA02935	Central Presbyterian Church of St. Louis	Stormwater	Land disturbance	2/7/2017
MO-RA03312	City of Richmond Heights	Stormwater	Land disturbance	2/7/2017
MO-RA03317	City of Glendale	Stormwater	Land disturbance	2/7/2017
MO-RA03349	Villas on Mosley	Stormwater	Land disturbance	2/7/2017
MO-RA03623	Spectrum Retirement Communities	Stormwater	Land disturbance	2/7/2017
MO-RA03674	Bogey Golf Club	Stormwater	Land disturbance	2/7/2017
MO-RA03851	Dale Avenue	Stormwater	Land disturbance	2/7/2017
MO-RA03927	Hanley Retail	Stormwater	Land disturbance	2/7/2017
MO-RA04009	North Taylor Glen	Stormwater	Land disturbance	2/7/2017
MO-RA04188	Menards	Stormwater	Land disturbance	2/7/2017
MO-RA04190	Public Works Facility	Stormwater	Land disturbance	2/7/2017
MO-RA04376	Hiram Neuwoehner High School	Stormwater	Land disturbance	2/7/2017
MO-RA04601	Belle Maison	Stormwater	Land disturbance	2/7/2017
MO-RA04615	Donald Danforth Plant Science Center	Stormwater	Land disturbance	2/7/2017
MO-RA04697	Bogey Golf Club	Stormwater	Land disturbance	2/7/2017
MO-RA04818	Little Sunshine's Playhouse	Stormwater	Land disturbance	2/7/2017
MO-RA04947	Visitation Academy	Stormwater	Land disturbance	2/7/2017
MO-RA05027	City of Rock Hill	Stormwater	Land disturbance	2/7/2017
MO-RA05100	Mosley Grove	Stormwater	Land disturbance	2/7/2017
MO-RA05107	The Grove	Stormwater	Land disturbance	2/7/2017

Permit No.	Facility Name	Discharge Type	Permit Type	Permit Expires[15]
MO-RA05189	Edgewood Children's Center	Stormwater	Land disturbance	2/7/2017
MO-RA05462	Woods at Ladue	Stormwater	Land disturbance	2/7/2017
MO-RA05714	Fontbonne University - Parking	Stormwater	Land disturbance	2/7/2017
MO-RA05719	9942 Old Warson Road	Stormwater	Land disturbance	2/7/2017
MO-RA05726	The Heights At Manhassett	Stormwater	Land disturbance	2/7/2017
MO-RA05728	Pioneer Pak	Stormwater	Land disturbance	2/7/2017
MO-RA05924	Waldrand Trust IV Residence	Stormwater	Land disturbance	2/7/2017
MO-RA05969	ICL Performance Products	Stormwater	Land disturbance	2/7/2017
MO-RA06053	Villa Duchesne and Oak Hill School	Stormwater	Land disturbance	2/7/2017

5.1.5 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential point sources of bacteria. These types of sewage discharges bypass treatment systems, such as a septic tank or a sanitary sewer, and instead discharge directly to a stream or an adjacent land area (Brown et al. 2004). Illicit straight pipe discharges are illegal and are not authorized under the Clean Water Act. At present, there are no data about the presence or number of illicit straight pipe discharges in the Deer Creek watershed. As noted in Section 5.1.3, illicit discharge detection and elimination is one of the six minimum control measures required by an MS4 permit. Such sources are therefore expected to be detected and eliminated in accordance with permitted conditions.

5.2 Nonpoint Sources

Nonpoint source pollution refers to pollution coming from diffuse, non-permitted sources that typically cannot be identified as entering a water body at a single location. They include all other categories of pollution not classified as being from a point source, and are exempt from department permit regulations as per state rules at 10 CSR 20-6.010(1)(B)1. These sources involve stormwater runoff and are minor or negligible under low-flow conditions. Typical nonpoint sources of pollution that have the potential to influence water quality include various sources associated with runoff from agricultural and non-MS4 permitted urban areas, onsite wastewater treatment systems, and riparian corridor conditions.

5.2.1 Agricultural Runoff

Stormwater runoff from lands used for agricultural purposes is often a source of bacterial loading to water bodies. Activities associated with agricultural land uses that may contribute bacteria to a water body include manure fertilization of croplands or pastures, and livestock grazing. However, as noted in Section 2.4, no agricultural land coverages were identified in the Deer Creek watershed.

Although bacterial inputs from livestock are less likely to contribute to water body impairment in urban environment as opposed to a more rural one, stabled horses are present in some residential areas of the watershed, such as in the City of Huntleigh (City of Huntleigh 2008). Such backyard livestock could potentially contribute some bacteria loads if manure is not adequately managed

(EPA 1994). Other green spaces within urban watersheds may contribute bacteria loads as a component of urban stormwater runoff as described in Section 3.1.3.

5.2.2 Urban Runoff (non-MS4 permitted areas)

Stormwater runoff from municipalities not required to have an MS4 permit is considered a nonpoint source. In the Deer Creek watershed, stormwater runoff falls within the jurisdiction of two MS4 permits. Therefore, for purposes of this TMDL, urban runoff within the Deer Creek watershed is considered a potential point source contributor of *E. coli*. For this reason, no nonpoint urban runoff sources have been identified that are likely to be contributing to the bacteria impairment of either Deer Creek or Black Creek. See Section 5.1.3 of this document for a more detailed discussion of potential urban runoff contributions and MS4 permitting.

5.2.3 Onsite Wastewater Treatment Systems

When properly designed and maintained, onsite wastewater treatment systems (e.g., home septic systems) should not contaminate surface waters; however, onsite wastewater treatment systems do fail for a variety of reasons. When these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley & Witten 1996). Failing onsite wastewater treatment systems are known to be sources of bacteria, which can reach nearby streams through both surface runoff and groundwater flows, thereby contributing bacteria loads under either wet or dry weather conditions. Onsite wastewater treatment systems may contribute bacteria to Black Creek and Deer Creek either directly or as a component of MS4-permitted stormwater.

The exact number of onsite wastewater treatment systems in the Deer Creek watershed is unknown; however, such systems are known to exist in some areas of St. Louis County that were developed prior to the sewerage systems serviced by the Metropolitan St. Louis Sewer District (Jack Fischer, St. Louis County Public Works, personal communication, June 6, 2011). Since the district maintains parcel and billing information, an estimate of the number of parcels in the watershed without a sewer connection and potentially having an onsite system can be made. From information provided by the Metropolitan St. Louis Sewer District, it is estimated that there are approximately 30 parcels that have neither a sewer connection nor a water connection.

As stated in Section 5.1.1 of this document, the Deer Creek watershed is serviced by the Lemay wastewater treatment facility. Due to the availability of this sewer system and a St. Louis County ordinance requiring that a sewer connection to a building be made when a sanitary sewer line is within 200 feet of the property, many onsite wastewater treatment system eliminations have been made.

A study conducted by the Electric Power Research Institute suggests that up to 50 percent of onsite wastewater treatment systems in Missouri may be failing (EPRI 2000). Despite the lack of specific data showing that onsite wastewater treatment systems are a significant problem in the Deer Creek watershed, the available failure rate data suggests that any onsite wastewater treatment systems in the watershed are a potential contributor of bacteria to Black Creek and Deer Creek either directly or as a component of MS4 stormwater. However, due to the overall urban nature of the watershed, the number of onsite wastewater treatment systems present in the watershed is expected to be low.

5.2.4 Riparian Corridor Conditions

Riparian corridor conditions can have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of pollutants from runoff. Therefore, a stream with good riparian cover is better able to moderate the impacts of high pollutant loads than a stream with poor or no riparian cover. Table 7 presents land cover calculations for the riparian corridors within the Deer Creek watershed.

For this analysis, the same land cover data calculated in Section 2.4 of this document was used and the riparian corridor was defined as including a 30-meter area on each side of all streams in the watershed that are included in the 1:24,000-scale National Hydrography Dataset.[16] As is the case with the watershed as a whole, the dominant land cover types in the riparian corridor are those associated with varying degrees of development and imperviousness. More than 52 percent of the riparian corridor in the Deer Creek watershed is categorized as having low to high intensity development and greater than 20 percent impervious coverage. Open space development, which contains less than 20 percent impervious cover, makes up more than 47 percent of the riparian corridor. In total, developed land cover types account for more than 99 percent of the total coverage in the riparian corridor. Runoff from these areas that has come in contact with pet or wildlife wastes or from which sanitary sewer overflows have occurred can contribute bacteria loads to the MS4 or directly to an adjacent water body. For this reason, the riparian corridor condition within the watershed is a potential contributing source of bacteria to Black Creek and Deer Creek. For purposes of this TMDL report, bacterial contributions from riparian areas are incorporated into the MS4 wasteload allocation.

Table 7. Land cover in the riparian areas of the Deer Creek watershed

	Area		
Land Cover Type	***hectares (acres)***	***km^2 (mi^2)***	***Percent***
Developed, High Intensity	19.8 (49)	0.20 (0.08)	2.85
Developed, Medium Intensity	50.2 (124)	0.50 (0.19)	7.18
Developed, Low Intensity	295.4 (730)	2.95 (1.14)	42.32
Developed, Open Space	328.2 (811)	3.28 (1.27)	47.04
Forest	0.8 (2)	0.01 (0.00)	0.09
Wetland	0.8 (2)	0.01 (0.00)	0.09
Open Water	2.8 (7)	0.03 (0.01)	0.43
Total:	698 (1,725)	6.98 (2.69)	100.00

[16] The National Hydrography Dataset is digital surface water data for geographic information systems (GIS) for use in general mapping and in the analysis of surface-water systems. Available URL: http://nhd.usgs.gov

6. Numeric TMDL Target and Modeling Approach

As noted in Section 3.2 of this document, Missouri's Water Quality Standards include specific numeric *E. coli* water quality criteria for waters designated for whole body contact recreation category A and B. The *E. coli* concentration of 126 counts/100 mL, which is protective of the category A recreational use, will serve as the numeric target for TMDL development for Deer Creek. The *E. coli* concentration of 206 counts/100mL, which is protective of the category B recreational use, will serve as the numeric target for TMDL development for Black Creek. These targeted concentrations will be expressed as daily loads that vary by flow using load duration curves. Achieving these targeted loads will also result in attainment of whole body contact recreation designated uses. Because the whole body contact recreation category A and B criteria are geometric means, fluctuations in instantaneous bacteria concentrations are expected, and individual bacteria measurements greater than the TMDL targets do not in and of themselves indicate a violation of water quality standards.

The load duration curve approach identifies the maximum allowable daily pollutant load for any given day as a function of the flow occurring that day, which is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA*, No 05-5010, April 25, 2006) and EPA guidance in response to this ruling (EPA 2006; EPA 2007a). EPA guidance recommends that all TMDLs and associated pollutant allocations be expressed in terms of daily time increments, and suggests that there is flexibility in how these daily increments may be expressed. EPA guidance indicates that where pollutant loads or water body flows are highly dynamic, it may be appropriate to use a load duration curve approach, provided that such an approach "identifies the allowable daily pollutant load for any given day as a function of the flow occurring on that day." In addition, for targets that are expressed as a concentration of a pollutant, it may be appropriate to use a table or graph to express individual daily loads over a range of flows as a product of a water quality criterion, stream flow and a conversion factor (EPA 2006).

The load duration curve is also useful in identifying and differentiating between storm-driven and steady-input sources. The load duration curve approach may be used to provide a visual representation of stream flow conditions under which pollutant criteria exceedances have occurred. Additionally, the approach may be used to assess critical conditions and to estimate the level of pollutant load reduction necessary to meet the surface water quality targets for bacteria in a stream (Cleland 2002; Cleland 2003).

To develop the load duration curve for Deer Creek, average daily flow data collected from March 23, 2004 to Dec. 28, 2016, from the USGS gaging station 07010086 at Maplewood was used. For Black Creek, average daily flow data from May 19, 2004 to Dec. 28, 2016 from USGS gaging station 07010082 near Brentwood was used. Flow data from these gages were adjusted to each stream based on the ratio of the impaired drainage areas to the gages' drainage areas. A detailed discussion of the methods and calculations used to develop the bacteria load duration curves in this TMDL report is presented in Appendix B.

7. Calculating Loading Capacity

A TMDL calculates the loading capacity of a water body and allocates that load among the various pollutant sources in the watershed. The loading capacity is the maximum pollutant load that a water body can assimilate and still meet water quality standards. It is equal to the sum of the wasteload allocation, load allocation and the margin of safety:

$$\text{TMDL} = \text{LC} = \sum\text{WLA} + \sum\text{LA} + \text{MOS}$$

Where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

According to 40 CFR §130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity or other appropriate measures. For Black Creek and Deer Creek, bacteria TMDLs are expressed as *E. coli* counts per day using a load duration curve. To develop a load duration curve, the numeric TMDL target is multiplied by flow to generate the maximum daily load at different flows.[17] Figures 6 and 7 are the *E. coli* TMDL load duration curves calculated for Black Creek and Deer Creek. The y-axis describes bacteria loading as counts per day and the x-axis represents the frequency for which a particular flow is met or exceeded. The load duration curves presented in Figures 6 and 7 represent the loading capacity as a solid curve over the range of flows. Observed loads measured during the recreational season are plotted as points. The flow condition ranges presented in each figure illustrate general base flow and surface-runoff conditions that are consistent with EPA guidance for using load duration curves for TMDL development (EPA 2007b). Tables 8 and 9 present selected TMDL loading capacities and TMDL allocations for Black Creek and Deer Creek respectively, representing each flow condition along the load duration curves.[18] Although different *E. coli* concentrations are targeted in the calculated load duration curves, because the water quality criteria for the protection of whole body contact recreation are expressed as geometric means, water quality standards in Deer Creek will not necessarily be violated by individual discharges from Black Creek. Pollutant reduction strategies implemented to reduce bacteria loading and achieve water quality standards in the Black Creek watershed will also result in loading reductions to Deer Creek.

[17] $Load\left(\frac{\text{count}}{\text{time}}\right) = Concentration\left(\frac{\text{count}}{\text{volume}}\right) * Flow\left(\frac{\text{volume}}{\text{time}}\right)$

[18] Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation.

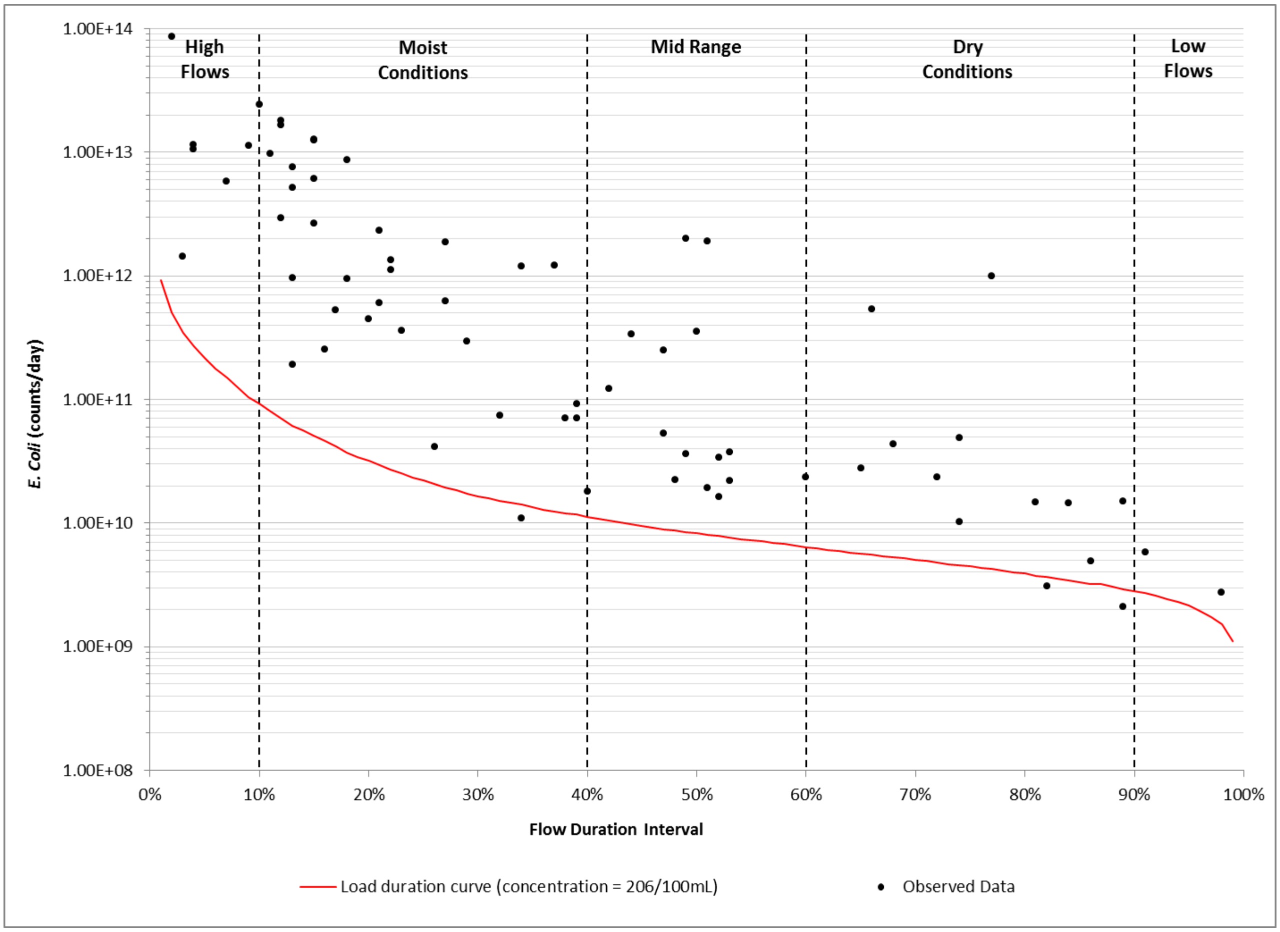

Figure 6. Black Creek load duration curve

Table 8. Selected *E. coli* TMDL values for Black Creek

Percent of time flow exceeded	*Flow m^3/s (ft^3/s)*	*TMDL (counts/day)*	*MS4 WLA (counts/day)*	*LA (counts/day)*
95	0.01 (0.43)	2.16E+09	2.16E+09	0
75	0.02 (0.88)	4.46E+09	4.46E+09	0
50	0.05 (1.64)	8.29E+09	8.29E+09	0
25	0.12 (4.37)	2.20E+10	2.20E+10	0
10	0.52 (18.31)	9.23E+10	9.23E+10	0

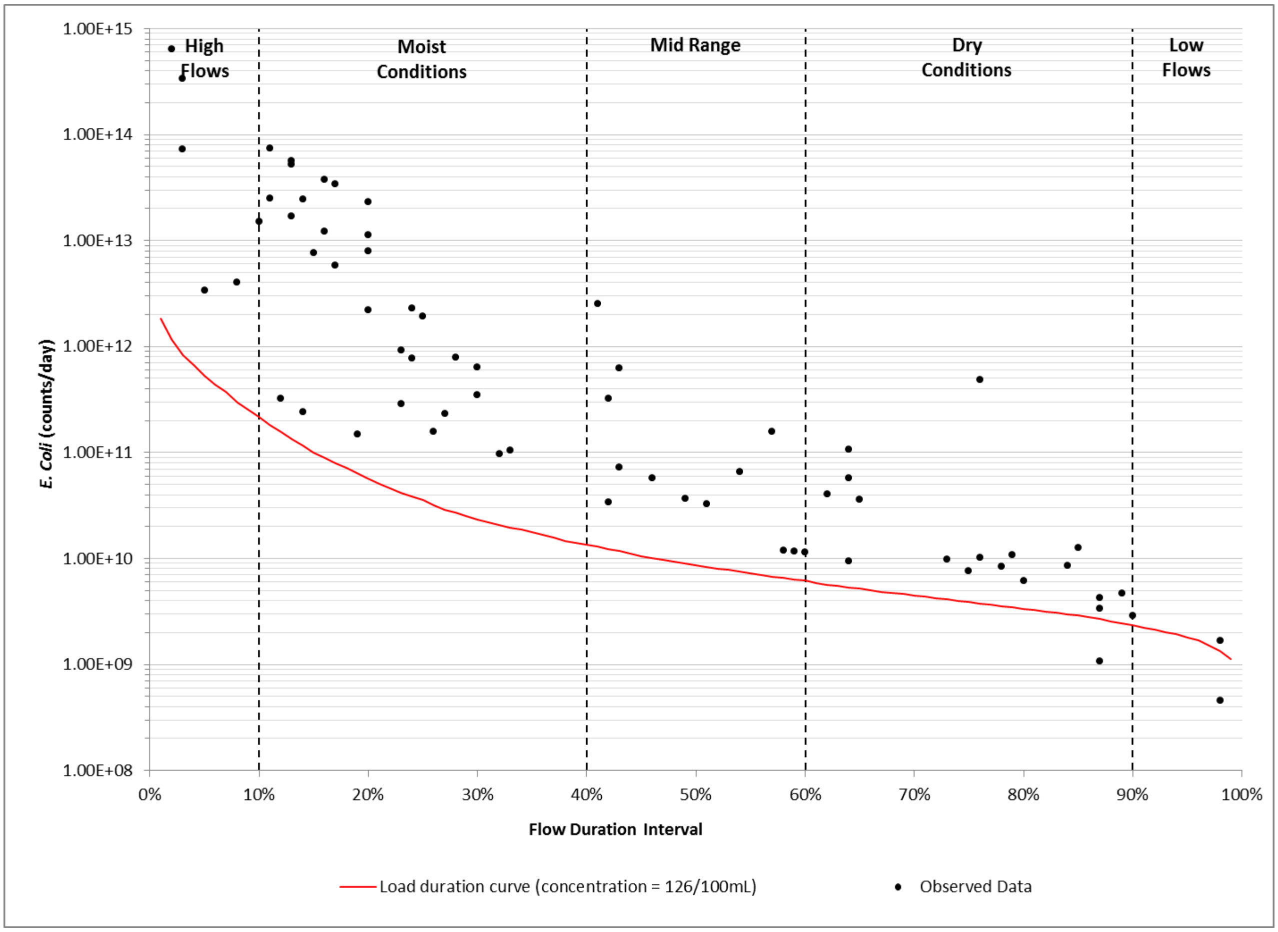

Figure 7. Deer Creek load duration curve

Table 9. Selected *E. coli* TMDL values for Deer Creek

Percent of time flow exceeded	***Flow*** m^3/s (ft^3/s)	***TMDL (counts/day)***	***MS4 WLA (counts/day)***	***LA (counts/day)***
95	0.02 (0.58)	1.80E+09	1.80E+09	0
75	0.04 (1.26)	3.88E+09	3.88E+09	0
50	0.08 (2.78)	8.58E+09	8.58E+09	0
25	0.33 (11.49)	3.54E+10	3.54E+10	0
10	1.99 (70.21)	2.16E+11	2.16E+11	0

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the allowable amount of the loading capacity that is assigned to existing or future point sources. Typically, point sources are permitted with limits for a given pollutant that are the most stringent of either technology-based effluent limits or water quality-based effluent limits. Technology-based effluent limits are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. Water quality-based effluent limits represent the most stringent concentration of a pollutant that a receiving stream can assimilate without violating applicable water quality standards at a specific location. Wasteload allocations for Black Creek are presented in Table 8 and for Deer Creek in Table 9.

8.1 Municipal and Domestic Wastewater Discharges

As noted in Section 5.1.1, domestic wastewater in the Deer Creek watershed is transferred through a sewerage system to a treatment works facility located outside of the watershed. Even so, sanitary sewer overflows and CSOs still occur and are likely contributors of bacteria to both Black Creek and Deer Creek. Discharges from sanitary sewer overflows are not authorized under the Clean Water Act. For this reason, the constructed sanitary sewer overflows in the Deer Creek watershed are given a wasteload allocation of zero. Elimination of bacteria loading from these sources will be accomplished through the requirements of the Metropolitan St. Louis Sewer District's consent decree. Similarly, contributions from CSOs within the Deer Creek watershed are expected to be eliminated following fulfillment of the goals included in the Metropolitan St. Louis Sewer District's CSO long-term control plan. Elimination of these CSOs will occur over a period of years as specified in the schedules provided by the long-term control plan and the district's consent decree. Due to the eventual elimination of these sources, CSOs within the Deer Creek watershed are assigned a wasteload allocation of zero.

8.2 Site-Specific Permitted Industrial and Non-Domestic Wastewater Facilities

There are no industrial or non-domestic wastewater facilities with site-specific permits in the Deer Creek watershed. Site-specific permitted industrial and non-domestic wastewater facilities are typically not significant sources of bacteria. For these reasons, site-specific permitted industrial and non-domestic wastewater facilities are not assigned a portion of the calculated wasteload allocation.

8.3 Municipal Separate Storm Sewer System (MS4) Permits

Wasteload allocations for MS4 discharges are presented in Tables 8 and 9. In the Deer Creek watershed, stormwater runoff discharged through MS4s is regulated through two MS4 permits. Permit number MO-0137910 regulates MS4 discharges from Missouri Department of Transportation right-of-ways and permit number MO-R040005 regulates MS4 discharges from all other areas of the watershed that are not serviced by the combined sewer system. Bacterial contributions from MS4 permitted entities are precipitation dependent and vary with flow. For this reason, wasteload allocation to the MS4s will also vary with flow. Because CSO discharges are to be eliminated in accordance with the district's consent decree, it is expected that areas formerly serviced by the combined sewer system will be regulated through MS4 permits. For this reason, all wasteload allocations for these TMDLs are allocated to the MS4s. An aggregated wasteload allocation is used, because the significance of any highway contributions of bacteria in the watershed cannot be quantified and bacteria loading from highway areas is assumed to be infrequent and minor. Future bacteria monitoring may provide more specific information regarding each MS4 area's actual contributions, including specific sources and mechanisms of transport, thereby allowing permit conditions to be modified accordingly.

8.4 General Wastewater and Non-MS4 Stormwater Permits

Table 6 lists other facilities with general or non-MS4 stormwater permits. For purposes of this TMDL, the department assumes that activities from these facilities in the watershed will be conducted in compliance with all permit conditions, including monitoring and discharge limitations and that compliance with these permits will result in bacterial loading at or below applicable targets. Because these facilities are not considered to be sources of bacteria loading to the impaired water bodies in the Deer Creek watershed, these facilities are not assigned a portion of the wasteload allocation and current permit conditions that would result in bacteria loading at or below current *de minimis* levels should be maintained.

8.5 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the Clean Water Act. For this reason, illicit straight pipe discharges are assigned a wasteload allocation of zero and any existing sources of this type must be eliminated. In areas of the watershed where stormwater is regulated by MS4 permits, the detection and elimination of illicit discharges is a required permit condition.

8.6 Considerations for Future Sources

For this TMDL, no specific portion of the loading capacity is allocated to a reserve capacity for future point sources. Even so, the wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources of bacteria in the watershed. Any future point sources should be evaluated against the TMDL and the range of flows, which any additional bacterial loading will affect, as well as any additional requirements associated with anti-degradation. Per federal regulations at 40 CFR 122.4(a), no permit may be issued when the conditions of the permit do not provide for compliance with the applicable requirements of the Clean Water Act, or regulations promulgated under the Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. Future general (MO-G) and stormwater (MO-R) permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above *de minimis* levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the amount of the pollutant load that is assigned to nonpoint sources and includes all existing and future nonpoint sources, as well as natural background contributions (40 CFR § 130.2(g)). Nonpoint sources identified in this TMDL report to be potential contributors of bacteria are onsite wastewater treatment systems. If functioning properly, these systems should not be contributing to the impaired conditions of Black Creek and Deer Creek. Onsite wastewater treatment systems are assigned a load allocation of zero. Other nonpoint sources are considered minimal for the purposes of this TMDL report and no load allocations are assigned to these sources.

10. Margin of Safety

A margin of safety is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The margin of safety is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety as part of the critical conditions for the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

The margin of safety for these TMDLs is implicit due to conservative assumptions in the modeling of the TMDLs, the use of multiple years of flow gage data collected under all flow conditions to create robust TMDL calculations, and the reduced uncertainty of the sources of impairment and their remediation through the Metropolitan St. Louis Sewer District's consent decree and CSO long-term control plan. Additionally, bacteria decay rates weren't applied and the direct recreational-season geometric mean was used for estimating the Clean Water Act required daily loading values.

11. Seasonal Variation

Missouri's water quality criteria for the protection of whole body contact recreation are applicable during the recreational season defined as being from April 1 to October 31. The TMDL load duration curves in Figures 6 and 7 represent stream flow under all conditions and use flow data collected in all seasons. For this reason, the *E. coli* targets and allocations established in this TMDL will be protective throughout the recreational season and during flow conditions associated with storm-driven events, including those associated with seasonal rain patterns, when bacteria loading is more likely. The advantage of a load duration curve approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided.

12. Monitoring Plans

The department has not yet scheduled post-TMDL monitoring for Deer Creek or Black Creek. Post-TMDL monitoring is usually scheduled and carried out by the department approximately three years after the approval of the TMDL or in a reasonable period following completion of permit compliance schedules and the application of new effluent limits, or following significant implementation activities such as removal of constructed sanitary sewer overflows or CSOs. The department will routinely examine water quality data collected by other local, state and federal entities in order to assess the effectiveness of TMDL implementation. Such entities may include the USGS, EPA, the Missouri Department of Health and Senior Services, the Missouri Department of Conservation, county health departments and the Metropolitan St. Louis Sewer

District. In addition, certain quality-assured data collected by universities, municipalities, private companies and volunteer groups may potentially be considered for monitoring water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is derived from the National Pollutant Discharge Elimination System, or NPDES. The wasteload allocation for MS4s will be implemented through the NPDES MS4 permits with the ultimate goal to employ an iterative process using best management practices (BMPs) to the maximum extent practicable (MEP), assessment, and refocused BMPs to the MEP, leading toward attainment of water quality standards (64 FR 68753).

The consent decree established as part of the *United States of America and the State of Missouri, and Missouri Coalition for the Environment Foundation v. Metropolitan St. Louis Sewer District*, No. 4:07-CV-1120 requires specific eliminations and reductions of point sources in the Metropolitan St. Louis Sewer District's service area. This court-approved decree will provide an additional reasonable assurance of bacteria reductions in Deer Creek from point sources over a 23-year period (EPA 2011b).

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. This generally occurs when the TMDL's combined nonpoint source load allocations and point source wasteload allocations do not exceed the water quality standards-based loading capacity and there is reasonable assurance that the TMDL's allocations can be achieved. Reasonable assurance that nonpoint sources will meet their allocated amount in the TMDL is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls or BMPs within the watershed. If BMPs or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed and approved for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. When a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls or BMPs are not feasible, durable, or will not result in the required load reductions, allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed plans, controls and practices to meet the required wasteload and load allocations in the TMDL and demonstrate additional reasonable assurance.

14. Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). Two water quality-limited segments, Black Creek and Deer Creek, in St. Louis County are included on Missouri's EPA-approved 2016 303(d) List of impaired waters. A 60-day public notice and comment period for this TMDL was scheduled from March 3, 2017 through May 2, 2017. Comments received and the department's responses to those comments are to be maintained on file with the department and on the Black Creek and Deer Creek TMDL record webpage at dnr.mo.gov/env/wpp/tmdl/3825-3826-black-cr-deer-cr-record.htm.

In addition to the public comment period previously described, the department also considered comments received during the public comment periods of four other *E. coli* TMDLs written for St. Louis area streams that were approved by EPA on July 13, 2016. These comment periods were held for 45 days each in 2012 and a combined 150 days in 2014. Additionally, comments provided by the Metropolitan St. Louis Sewer District in meetings with the department on July 22, 2014, Oct. 2, 2014, Dec. 30, 2014 and Dec. 7, 2016 were also considered in the drafting of this TMDL.

Groups that directly received the public notice announcement for this TMDL include, but are not limited to:

- Missouri Clean Water Commission
- Missouri Water Protection Forum
- Missouri Department of Conservation
- Missouri Department of Transportation
- St. Louis County Soil and Water Conservation District
- Metropolitan St. Louis Sewer District
- St. Louis County Department of Health
- St. Louis County Council
- University of Missouri Extension
- River des Peres Watershed Coalition
- Deer Creek Watershed Alliance
- Missouri Coalition for the Environment
- Stream Team volunteers living in or near the watershed
- Stream Teams United (formerly Missouri Stream Team Watershed Coalition)
- East-West Gateway Council of Governments
- Affected permitted entities
- Missouri state legislators representing areas within the watershed

Additionally, the public notice announcement, the TMDL Information Sheet, and this TMDL document have been posted on the department's TMDL webpage at dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm, making them available to anyone with Internet access.

The department also maintains an email distribution list for notifying subscribers regarding significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to these TMDL updates may do so by submitting their email address at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

An administrative record for the Black Creek and Deer Creek TMDLs has been assembled and is being kept on file with the department. It includes any studies, data and calculations on which the TMDL is based. This information is available upon request to the department at dnr.mo.gov/sunshine-form.htm. Any request for information about this TMDL will be processed in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the department's administrative policies and procedures governing Sunshine Law requests. For more information about open record/Sunshine requests, please consult the department's website at dnr.mo.gov/sunshinerequests.htm.

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Appendix A

Table A.1 – Deer Creek Recreational Season *E. coli* Data (2010 – 2016)

WBID	*Site Code*	*Site Description*	*Date*	*E. coli (count/100ml)*
3826	3826/0.7	Deer Cr.at Maplewood	4/7/2010	241.0
3826	3826/0.7	Deer Cr.at Maplewood	4/27/2010	3,650.0
3826	3826/0.7	Deer Cr.at Maplewood	7/12/2010	1,080.0
3826	3826/0.7	Deer Cr.at Maplewood	7/27/2010	703.0
3826	3826/0.7	Deer Cr.at Maplewood	8/16/2010	1,310.0
3826	3826/0.7	Deer Cr.at Maplewood	9/14/2010	228.0
3826	3826/0.7	Deer Cr.at Maplewood	10/19/2010	50.0
3826	3826/0.7	Deer Cr.at Maplewood	5/9/2011	520.0
3826	3826/0.7	Deer Cr.at Maplewood	6/7/2011	554.0
3826	3826/0.7	Deer Cr.at Maplewood	7/11/2011	860.0
3826	3826/0.7	Deer Cr.at Maplewood	8/9/2011	238.0
3826	3826/0.7	Deer Cr.at Maplewood	9/12/2011	360.0
3826	3826/0.7	Deer Cr.at Maplewood	10/10/2011	41.0
3826	3826/0.7	Deer Cr.at Maplewood	4/9/2012	230.0
3826	3826/0.7	Deer Cr.at Maplewood	5/14/2012	480.0
3826	3826/0.7	Deer Cr.at Maplewood	6/12/2012	24,000.0
3826	3826/0.7	Deer Cr.at Maplewood	4/15/2013	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	5/15/2013	230
3826	3826/0.7	Deer Cr.at Maplewood	6/11/2013	6,500
3826	3826/0.7	Deer Cr.at Maplewood	7/16/2013	200
3826	3826/0.7	Deer Cr.at Maplewood	8/13/2013	16,000
3826	3826/0.7	Deer Cr.at Maplewood	9/17/2013	230
3826	3826/0.7	Deer Cr.at Maplewood	10/1/2013	150
3826	3826/0.7	Deer Cr.at Maplewood	10/15/2013	24,000
3826	3826/0.7	Deer Cr.at Maplewood	10/29/2013	220
3826	3826/0.7	Deer Cr.at Maplewood	4/1/2014	240
3826	3826/0.7	Deer Cr.at Maplewood	4/15/2014	580
3826	3826/0.7	Deer Cr.at Maplewood	4/29/2014	24,000
3826	3826/0.7	Deer Cr.at Maplewood	5/13/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	5/27/2014	14,000
3826	3826/0.7	Deer Cr.at Maplewood	6/10/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	6/24/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	7/8/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	7/22/2014	160
3826	3826/0.7	Deer Cr.at Maplewood	8/5/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	8/19/2014	760
3826	3826/0.7	Deer Cr.at Maplewood	9/2/2014	> 24,196

3826	3826/0.7	Deer Cr.at Maplewood	9/30/2014	150
3826	3826/0.7	Deer Cr.at Maplewood	10/14/2014	9,200
3826	3826/0.7	Deer Cr.at Maplewood	10/28/2014	> 24,196
3826	3826/0.7	Deer Cr.at Maplewood	4/14/2015	1,000
3826	3826/0.7	Deer Cr.at Maplewood	4/28/2015	700
3826	3826/0.7	Deer Cr.at Maplewood	5/12/2015	4,900
3826	3826/0.7	Deer Cr.at Maplewood	5/26/2015	8,700
3826	3826/0.7	Deer Cr.at Maplewood	6/9/2015	7,300
3826	3826/0.7	Deer Cr.at Maplewood	6/23/2015	3,400
3826	3826/0.7	Deer Cr.at Maplewood	7/7/2015	17,000
3826	3826/0.7	Deer Cr.at Maplewood	7/21/2015	6,500
3826	3826/0.7	Deer Cr.at Maplewood	8/4/2015	290
3826	3826/0.7	Deer Cr.at Maplewood	8/18/2015	280
3826	3826/0.7	Deer Cr.at Maplewood	9/1/2015	2,500
3826	3826/0.7	Deer Cr.at Maplewood	9/15/2015	2,900
3826	3826/0.7	Deer Cr.at Maplewood	9/29/2015	240
3826	3826/0.7	Deer Cr.at Maplewood	10/13/2015	340
3826	3826/0.7	Deer Cr.at Maplewood	10/27/2015	1,700
3826	3826/0.7	Deer Cr.at Maplewood	4/12/2016	17,000
3826	3826/0.7	Deer Cr.at Maplewood	4/26/2016	9,800
3826	3826/0.7	Deer Cr.at Maplewood	5/10/2016	16,000
3826	3826/0.7	Deer Cr.at Maplewood	5/24/2016	340
3826	3826/0.7	Deer Cr.at Maplewood	6/7/2016	650
3826	3826/0.7	Deer Cr.at Maplewood	6/21/2016	890
3826	3826/0.7	Deer Cr.at Maplewood	7/5/2016	2,500
3826	3826/0.7	Deer Cr.at Maplewood	7/19/2016	860
3826	3826/0.7	Deer Cr.at Maplewood	8/2/2016	2,600
3826	3826/0.7	Deer Cr.at Maplewood	8/16/2016	8,700
3826	3826/0.7	Deer Cr.at Maplewood	8/30/2016	590
3826	3826/0.7	Deer Cr.at Maplewood	9/13/2016	1,785
3826	3826/0.7	Deer Cr.at Maplewood	9/27/2016	3,200
3826	3826/0.7	Deer Cr.at Maplewood	10/11/2016	390
3826	3826/0.7	Deer Cr.at Maplewood	10/25/2016	300

Table A.2 – Black Creek Recreational Season *E. coli* Data (2010 – 2016)

WBID	*Site Code*	*Site Description*	*Date*	*E. coli (count/100ml)*
3825	3825/0.2	Black Cr. at Manchester Rd.	4/7/2010	627.0
3825	3825/0.2	Black Cr. at Manchester Rd.	4/27/2010	2,910.0
3825	3825/0.2	Black Cr. at Manchester Rd.	7/12/2010	1,020.0
3825	3825/0.2	Black Cr. at Manchester Rd.	7/27/2010	717.0
3825	3825/0.2	Black Cr. at Manchester Rd.	8/16/2010	862.0
3825	3825/0.2	Black Cr. at Manchester Rd.	9/14/2010	495.0
3825	3825/0.2	Black Cr. at Manchester Rd.	10/19/2010	173.0
3825	3825/0.2	Black Cr. at Manchester Rd.	5/9/2011	529.0
3825	3825/0.2	Black Cr. at Manchester Rd.	6/7/2011	1,040.0
3825	3825/0.2	Black Cr. at Manchester Rd.	7/11/2011	2,380.0
3825	3825/0.2	Black Cr. at Manchester Rd.	8/9/2011	865.0
3825	3825/0.2	Black Cr. at Manchester Rd.	9/12/2011	440.0
3825	3825/0.2	Black Cr. at Manchester Rd.	10/10/2011	145.0
3825	3825/0.2	Black Cr. at Manchester Rd.	4/9/2012	430.0
3825	3825/0.2	Black Cr. at Manchester Rd.	5/14/2012	1,000.0
3825	3825/0.2	Black Cr. at Manchester Rd.	6/12/2012	20,000.0
3825	3825/0.2	Black Cr. at Manchester Rd.	4/15/2013	24,000
3825	3825/0.2	Black Cr. at Manchester Rd.	5/15/2013	750
3825	3825/0.2	Black Cr. at Manchester Rd.	6/11/2013	17,000
3825	3825/0.2	Black Cr. at Manchester Rd.	7/16/2013	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	8/13/2013	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	9/17/2013	460
3825	3825/0.2	Black Cr. at Manchester Rd.	10/1/2013	340
3825	3825/0.2	Black Cr. at Manchester Rd.	10/15/2013	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	10/29/2013	160
3825	3825/0.2	Black Cr. at Manchester Rd.	4/1/2014	590
3825	3825/0.2	Black Cr. at Manchester Rd.	4/15/2014	1,200
3825	3825/0.2	Black Cr. at Manchester Rd.	4/29/2014	8,700
3825	3825/0.2	Black Cr. at Manchester Rd.	5/13/2014	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	5/27/2014	10,000
3825	3825/0.2	Black Cr. at Manchester Rd.	6/10/2014	8,200
3825	3825/0.2	Black Cr. at Manchester Rd.	6/24/2014	20,000
3825	3825/0.2	Black Cr. at Manchester Rd.	7/8/2014	24,000
3825	3825/0.2	Black Cr. at Manchester Rd.	7/22/2014	2,200
3825	3825/0.2	Black Cr. at Manchester Rd.	8/5/2014	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	8/19/2014	1,200
3825	3825/0.2	Black Cr. at Manchester Rd.	9/2/2014	20,000
3825	3825/0.2	Black Cr. at Manchester Rd.	9/16/2014	1,700
3825	3825/0.2	Black Cr. at Manchester Rd.	9/30/2014	310

3825	3825/0.2	Black Cr. at Manchester Rd.	10/14/2014	2,800
3825	3825/0.2	Black Cr. at Manchester Rd.	10/28/2014	17,000
3825	3825/0.2	Black Cr. at Manchester Rd.	4/14/2015	6,500
3825	3825/0.2	Black Cr. at Manchester Rd.	4/28/2015	5,800
3825	3825/0.2	Black Cr. at Manchester Rd.	5/12/2015	8,200
3825	3825/0.2	Black Cr. at Manchester Rd.	5/26/2015	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	6/9/2015	16,000
3825	3825/0.2	Black Cr. at Manchester Rd.	6/23/2015	4,900
3825	3825/0.2	Black Cr. at Manchester Rd.	7/7/2015	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	7/21/2015	20,000
3825	3825/0.2	Black Cr. at Manchester Rd.	8/4/2015	1,000
3825	3825/0.2	Black Cr. at Manchester Rd.	8/18/2015	2,400
3825	3825/0.2	Black Cr. at Manchester Rd.	9/1/2015	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	9/15/2015	6,900
3825	3825/0.2	Black Cr. at Manchester Rd.	9/29/2015	> 24,196
3825	3825/0.2	Black Cr. at Manchester Rd.	10/13/2015	20,000
3825	3825/0.2	Black Cr. at Manchester Rd.	10/27/2015	7,700
3825	3825/0.2	Black Cr. at Manchester Rd.	4/12/2016	10,000
3825	3825/0.2	Black Cr. at Manchester Rd.	4/26/2016	6,900
3825	3825/0.2	Black Cr. at Manchester Rd.	5/10/2016	24,000
3825	3825/0.2	Black Cr. at Manchester Rd.	5/24/2016	320
3825	3825/0.2	Black Cr. at Manchester Rd.	6/7/2016	1,600
3825	3825/0.2	Black Cr. at Manchester Rd.	6/21/2016	880
3825	3825/0.2	Black Cr. at Manchester Rd.	7/5/2016	3,400
3825	3825/0.2	Black Cr. at Manchester Rd.	7/19/2016	1,100
3825	3825/0.2	Black Cr. at Manchester Rd.	8/2/2016	4,100
3825	3825/0.2	Black Cr. at Manchester Rd.	8/16/2016	3,200
3825	3825/0.2	Black Cr. at Manchester Rd.	8/30/2016	400
3825	3825/0.2	Black Cr. at Manchester Rd.	9/13/2016	1,211
3825	3825/0.2	Black Cr. at Manchester Rd.	9/27/2016	8,700
3825	3825/0.2	Black Cr. at Manchester Rd.	10/11/2016	1,000
3825	3825/0.2	Black Cr. at Manchester Rd.	10/25/2016	790

Appendix B

Development of Black Creek and Deer Creek Bacteria Load Duration Curves

B. 1 Overview

The load duration curve approach was used to develop *E. coli* TMDLs for Black Creek and Deer Creek. The load duration curve method allows for characterizing water quality concentrations (or water quality data) at different flow regimes and estimating the load allocations and wasteload allocations for each impaired segment. This method also provides a visual display of the relationship between stream flow and loading capacity. Using the duration curve framework, allowable loadings are easily presented.

B. 2 Methodology

Using the load duration curve method requires a long time series of flow data, a numeric water quality target, and bacteria data from the impaired streams. Bacteria data from the impaired segments are converted into an instantaneous load using the flow measurements for the same date and are plotted along with the load duration curve to illustrate conditions when the water quality targets may have been exceeded.

To develop a load duration curve, a long record of average daily flow data from a gage (or multiple gages) that is representative of the impaired reach is used. The flow record should be of sufficient length to be able to calculate percentiles of flow. If a flow record for an impaired stream is not available, then a synthetic flow record is needed. For the Black Creek and Deer Creek TMDLs, flow records from March 2004 to December 2016 collected from the gages shown in Table B.1 were used. The modeling approach assumes that discharge at the outlet of the impaired watershed is proportional to the discharge from the USGS gage station. Therefore, average daily flow values were corrected based on the proportion of the area draining to the impaired watershed to that draining to the flow gage. The developed flow duration curves for the impaired water bodies are presented in Figures B.1. These flows in units of ft^3/second are then multiplied by the applicable water quality target (126 counts/100 mL or 206 counts/100 mL) and a conversion factor of 24,465,715 in order to generate the allowable load in units of counts/day.[19] Despite the varying load, the targeted concentration is constant at all flow percentiles and reflects the static nature of the water quality standards.

Table B.1. Drainage areas of gage and impaired watersheds and correction factors

Location:	USGS Gage 07010086	USGS Gage 07010082	Deer Creek	Black Creek
Drainage Area:	94.5 km^2 (36.5 mi^2)	15.0 km^2 (5.81 mi^2)	95.3 km^2 (36.8 mi^2)	20.8 km^2 (8.03 mi^2)
Correction Factor:	--	--	1.008	1.382

[19] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{day}}\right) = \left[\boldsymbol{Target}\left(\frac{\text{count}}{\text{100ml}}\right)\right] * \left[\boldsymbol{Flow}\left(\frac{feet^3}{s}\right)\right] * [\boldsymbol{Conversion\ Factor}]$

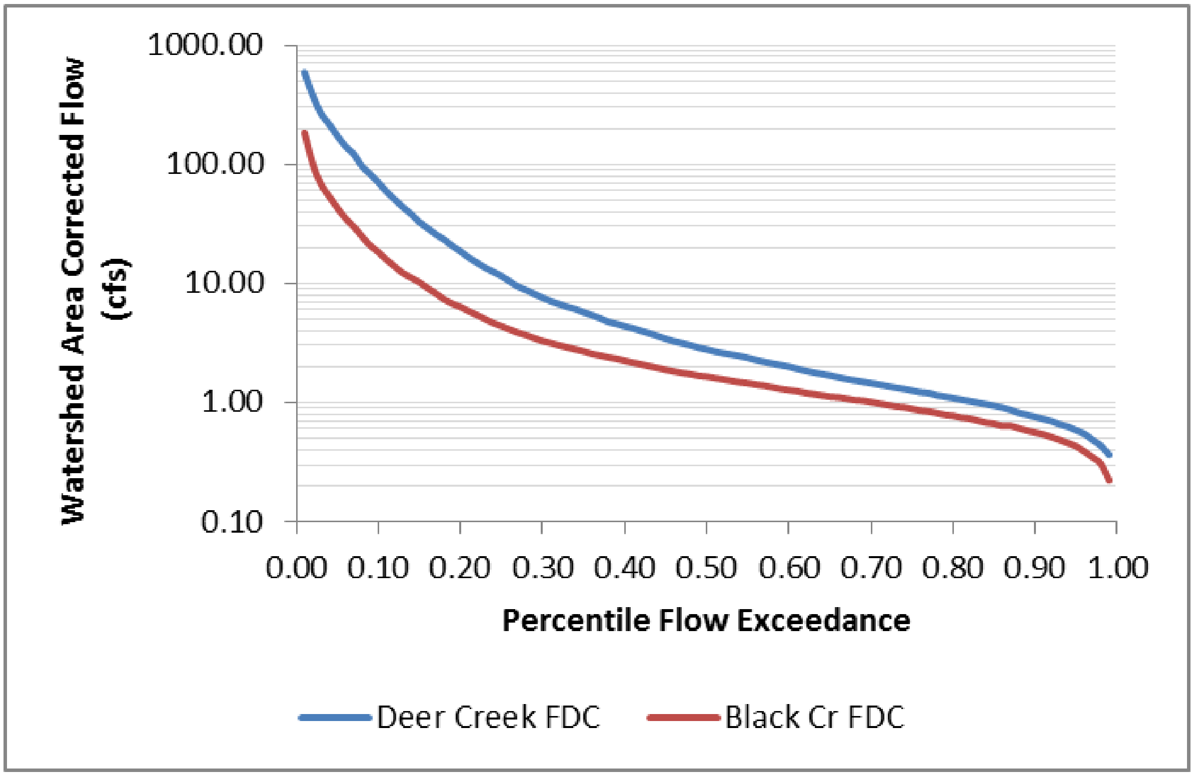

Figure B.1 Flow duration curves for Deer Creek and Black Creek