

**United States Environmental Protection Agency
Region 7
Total Maximum Daily Load
For Total Nitrogen, Total Phosphorus
and Total Suspended Solids**



**Long Branch (MO_0857)
Johnson and Pettis Counties, Missouri**

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12-20-10
Date

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**Maximum Daily Load (TMDL)
For Long Branch
303(d) Listed Pollutant: Unknown**

Name: Long Branch

Location: near Knob Noster in Johnson & Pettis Counties,
Missouri

Hydrologic Unit Code (HUC): 10300103-0402

Water Body Identification (WBID): 0857

Missouri Stream Classification: C¹

Designated Beneficial Uses:

- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation – Category B
- Livestock and Wildlife Watering (CSR 2009)



Location of Classified Segment: From 06, 45N, 23W to 09, 45N, 24W. From (latitude, longitude) 38.7028, -93.5619 to 38.7152, -93.5005

Impaired Use: Protection of Warm Water Aquatic Life

Size of Classified Segment: 4.5 miles²

Identified Pollutant on 303(d) List: Unknown

Identified Source on 303(d) List: Unknown

TMDL Priority Ranking: Medium

¹ Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations (CSR) 20-7.031 (1)(F). The WQS can be found at the following uniform resource locator (URL):

<http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf>

² The stream length listed corresponds to the EPA approved 2008 Missouri 303(d) List and Missouri WQS Table H. Due to the increased accuracy of GIS data layers for analysis over previous methods of stream length measurements, the stream length used in the TMDL analysis may not correspond exactly to Table H. As per the 2009 revision to Missouri's Water Quality Standards (10 CSR 20-7.031, Table H), the stream length is listed as 6 miles. However, the 2009 revision of the WQS has not yet been reviewed by EPA. The descriptive start and end point of each segment remains the same and this TMDL addresses the impaired segment in its entirety.

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List of Acronyms

Σ	Sum of
1G	General Criteria Pertaining to Protection of Aquatic Life
AFO	Animal Feeding Operation
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
C	Intermittent Stream
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
Ck	Creek
Cl	Chloride
CSR	Code of State Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
e.g.	For Example
EDU	Ecological Drainage Unit
EPA	United States Environmental Protection Agency
Gal/year	Gallons per Year
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IRP	Installation Restoration Program
LA	Load Allocation
LC	Loading Capacity
LDC	Load Duration Curve
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MoRAP	Missouri Resource Assessment Partnership
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MSDIS	Missouri Spatial Data Information Service
MSOP	Missouri State Operating Permit System
N	North
NA	Not Applicable
NASS	National Agricultural Statistics Service
NH ₃	Ammonia
NO ₂	Nitrite
NO ₃	Nitrate
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PAN	Plant Available Nitrogen
PCS	Permit Compliance System

SOD	Sediment Oxygen Demand
STEPL	Spreadsheet Tool for Estimating Pollutant Load
SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
Temp	Temperature
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
URS	URS Corporation
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VSS	Volatile Suspended Solids
WBID	Water Body Identification
WAFB	Whiteman Air Force Base
WLA	Wasteload Allocation
WQS	Water Quality Standards
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

1 Introduction

The Long Branch Total Maximum Daily Load (TMDL) is being established in accordance with Section 303(d) of the Clean Water Act (CWA). The water quality limited segment is included on the United States Environmental Protection Agency (EPA) approved 2008 Missouri 303(d) List and is identified as impaired due to unknown pollutants and sources. Total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) measurements in Long Branch are shown to be present at elevated levels and linked to the impaired beneficial use of the water body. This report addresses the Long Branch impairment by establishing TSS, TN and TP TMDLs in accordance with Section 303(d) of the CWA. EPA is establishing this TMDL to fulfill the requirements of the Consent Decree established as part of the *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001.

Section 303(d) of the CWA and Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires that states develop TMDLs for waters not meeting designated beneficial uses. The TMDL process quantitatively assesses the impairment factors so that states can establish water-quality based controls to reduce pollutants of concern and restore and protect the quality of their water resources. The purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without causing exceedances of the water quality standards (WQS) for that pollutant. WQS are benchmarks used to assess the quality of rivers and lakes. The TMDL also establishes the pollutant loading capacity (LC) necessary to meet the Missouri WQS established for each water body based on the relationship between pollutant sources and instream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA) and a margin of safety (MOS). The WLA is the portion of the allowable load that is allocated to point sources. The LA is the portion of the allowable load that is allocated to nonpoint sources. The MOS accounts for the uncertainty associated with linking pollutant load to the water quality impairment. This is often associated with model assumption and data limitations.

The goal of the TMDL program is to restore impaired designated beneficial uses of water bodies. Thus, reduction strategies for point and nonpoint sources and implementation of source controls throughout the watershed will be necessary to restore the protection of warm water aquatic life use in Long Branch. In addition to establishing a TMDL for Long Branch, this report provides a summary of information, results and recommendations related to the impairment based on a broad analysis of watershed information and detailed analysis of water quality data, flow data and comparison to a reference stream condition in the same ecoregion or ecological drainage unit (EDU) in which Long Branch is located.

Section 2 of this report provides background information on the Long Branch watershed and Section 3 describes potential sources of concern. Section 4 presents the applicable WQS and Section 5 describes the modeling and technical approach used to develop the TMDL. Sections 6 to 10 present the required TMDL elements (LC, WLA, LA, MOS, seasonal variation) and

Sections 11 to 13 summarize the follow-up monitoring plan, reasonable assurances and public participation. A summary of the administrative record is presented in Section 14.

2 Background

This section of the report provides information on Long Branch and its watershed.

2.1 The Setting

Long Branch is a 9.9-mile intermittent and perennial stream located within the Blackwater/Lamine EDU. Long Branch originates just southwest of Whiteman Air Force Base (WAFB) near Knob Noster, Missouri, in Johnson County. It flows predominantly east through its watershed of rural grassland and cropland until its confluence with Muddy Creek in western Pettis County. A 5.3-mile segment from its confluence with Muddy Creek at Section 34, T46N, R23W to Section 6, T45N, R23W is designated as class “P” (perennial stream) and the remaining upstream 4.5-mile segment is designated as class “C” (intermittent stream) (MDNR, 2008a).

EPA placed Long Branch on the 2002 Missouri 303(d) List for unknown pollutants. EPA based these listings on the state report, *Monitoring Report on 26 Waters*, published by the Missouri Department of Natural Resources (MDNR) and visual/benthic low flow surveys. Specific reasons cited included the presence of pollutant tolerant bloodworms at the upper most site and dense epilithic algae at all sites, which is indicative of high nutrients (MDNR, 2006a).

All classified waters of the state, per the Missouri WQS, must provide a suitable home for aquatic life. A combination of natural geology and land use in the prairie portions of the state where Long Branch is located is believed to have reduced the amount and quality of habitat for aquatic life. The major water quality problems are excessive nutrients and increased rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and stream channel heterogeneity due to channelization and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. The number one pollutant entering Missouri’s waters is sediment, with about 59 million tons of soil eroding from Missouri’s land each year (MSWDC, 2003). Sedimentation occurs when wind or water runoff carries soil particles from an area and transports them to a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants, covers fish spawning areas and food supplies and clogs the gills of fish. In addition, other pollutants like nitrogen, phosphorus, pathogens and heavy metals are often attached to soil particles and move into streams with the sediment (MDNR, 2009a). TMDLs are not written to address habitat but are written to correct water quality conditions. To address the unknown pollutant, this TMDL targets nutrients and sediment.

There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams. TSS was selected as the numeric target for sediment in this TMDL because it enables the use of the highest quality data available, including permit conditions and monitoring data. To address nutrients, both TN

and TP are selected because both nutrients are generally elevated by both point and nonpoint sources.

2.2 Physiographic Location, Geology and Soils

Long Branch is a tributary to Muddy Creek in the Lamine River watershed. Long Branch is located within the Osage Plains physiographic region. The larger Lamine River watershed basin is unglaciated and overlain by four to eight feet of derived soils. In the Long Branch watershed, the soil overlies limestone. The Lamine Basin lies primarily in the Cherokee Prairies soil region (MDC, 2010). The Long Branch watershed is located in the Cherokee geologic group of the Middle Pennsylvanian Middle Series-Desmonian Stage. The primary and secondary rock types are shale and sandstone, respectively (USDI, 2005).

The hydrologic group of a soil relates to the rate at which water enters the soil profile, which in turn affect the amount of water that enters the stream as direct runoff. Table 1 (NRCS, 2005a) provides a summary of soil types in the impaired Long Branch watershed. The dominant soil type, Group D, covers approximately 53 percent of the watershed. Soils within the second most represented group, C/D cover approximately 26 percent of the watershed. When a soil is assigned to a dual hydrologic group (A/D, B/D or C/D), the first letter corresponds to drained areas and the second to undrained areas. Only the soils that in their natural condition are in Group D are assigned to dual classes (NRCS, 2010b). Therefore, approximately 53 to 79 percent of the watershed could be categorized as Group D, depending on site drainage. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This hydrologic soil group has the highest runoff potential. These soils have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils, soils with a permanent high water table and soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. Approximately 7 percent of soils in the impaired watershed are categorized as Group C. Depending on the site drainage of those soils categorized as C/D, as much as 33 percent of the soils within the impaired watershed could be classified as Group C. Group C includes sandy clay loam soils that have a moderately fine to fine structure. These soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water. Less than 1 percent of soils in the impaired watershed are categorized as Group B. Group B includes silt loam and loam which have moderate infiltration rates. These soils consist of well drained soils with moderately fine to moderately coarse textures. The hydrologic soil groups within the impaired watershed are shown in Figure 1.

Table 1. Long Branch Watershed Soils Summary

Soil Type	Hydrologic Soil Group	Acres	Percent (%)
Deepwater silt loam, 5 to 9% slopes, eroded	B	21.8	0.23
Subtotal	B	21.8	0.23
Greenton silt loam, 2 to 5% slopes, eroded	C	491.7	5.27
Gorin silt loam, 5 to 9% slopes, eroded	C	6.1	0.07
Dockery silt loam, 0 to 2% slopes, frequently flooded	C	123.4	1.32
Subtotal	C	621.2	6.66
Haig silt loam, 0 to 2% slopes	C/D	2,356.2	25.27
Zook silty clay loam, 0 to 2% slopes, frequently flooded	C/D	85.2	0.91
Subtotal	C/D	2,441.4	26.18
Sampsel silty clay loam, 2 to 5% slopes	D	1,566.0	16.80
Sampsel silty clay loam, 5 to 9% slopes	D	140.0	1.50
Sampsel silty clay loam, 5 to 9% slopes, severely eroded	D	85.2	0.91
Hartwell silt loam, 0 to 1% slopes	D	1,185.3	12.71
Hartwell silt loam, 1 to 3% slopes, eroded	D	1,608.7	17.25
Norris channery silt loam, 14 to 35% slopes	D	0.4	0.005
Norris channery silt loam, 5 to 14% slopes	D	0.1	0.002
Lightning silt loam, 0 to 2% slopes, occasionally flooded	D	62.4	0.67
Lamine silt loam, 0 to 2 % slopes, occasionally flooded	D	288.7	3.10
Subtotal	D	4,936.8	52.95
Water/Miscellaneous Water	-	1302.6	13.97
Subtotal	-	1,302.6	13.97

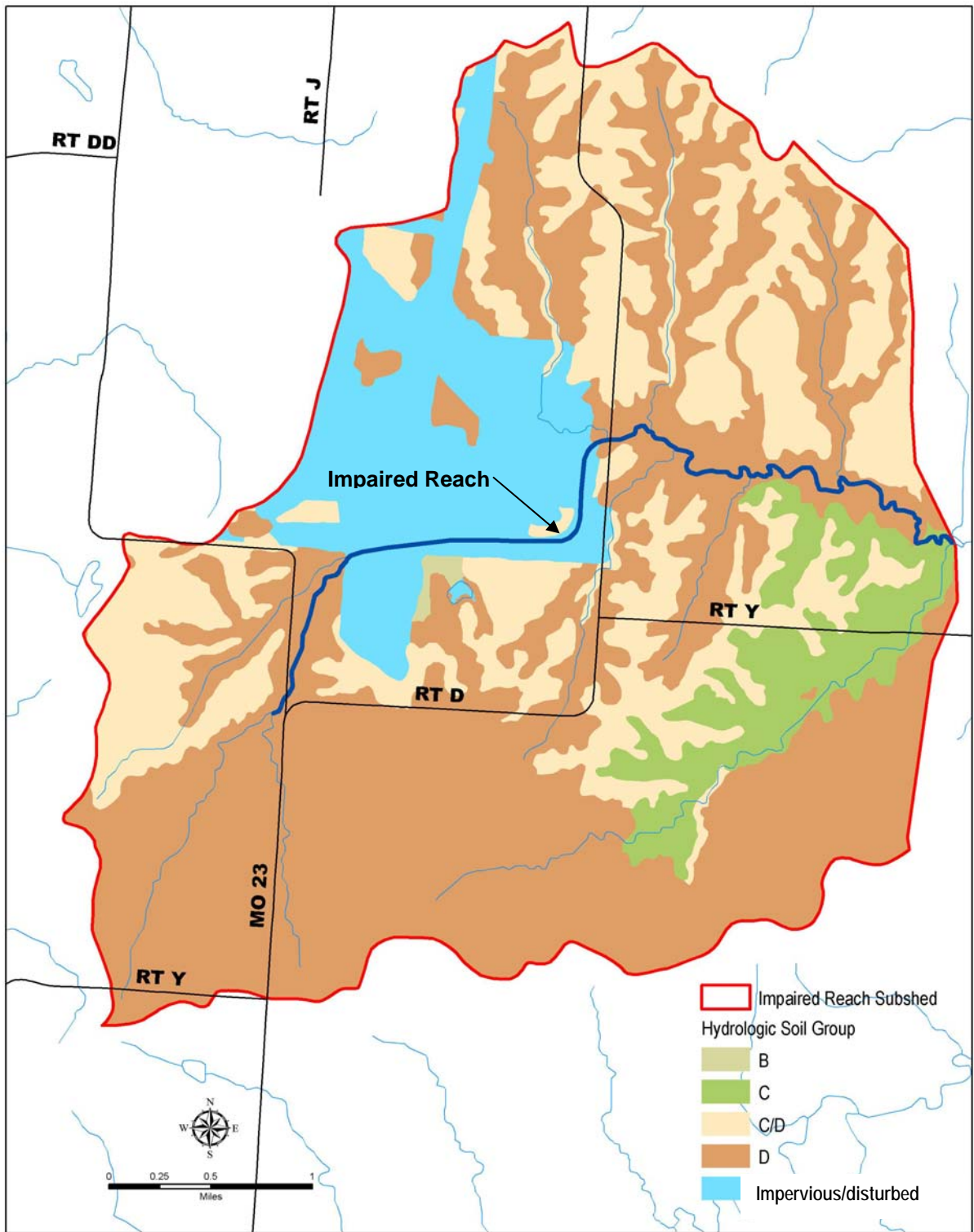


Figure 1. Hydrologic Soil Groups in the Long Branch Watershed

2.3 Rainfall and Climate

Weather stations provide useful information for developing a general understanding of the watershed. Precipitation is related to stream flow and runoff events that are related to erosion. The Whiteman Air Force Base (WAFB) Weather Station is the closest source of recent and available weather and climate data. It is located in Johnson County just outside the Long Branch watershed (Figure 2). Temperature and precipitation data for this station was obtained from accuweather.com. Seventeen years (1992 – 2009) of historical data were available. Figure 3 provides a summary of rainfall and climate data for the WAFB Station. The annual average precipitation and temperature over the 17-year period is 40.8 inches and 55.7 degrees Fahrenheit, respectively.

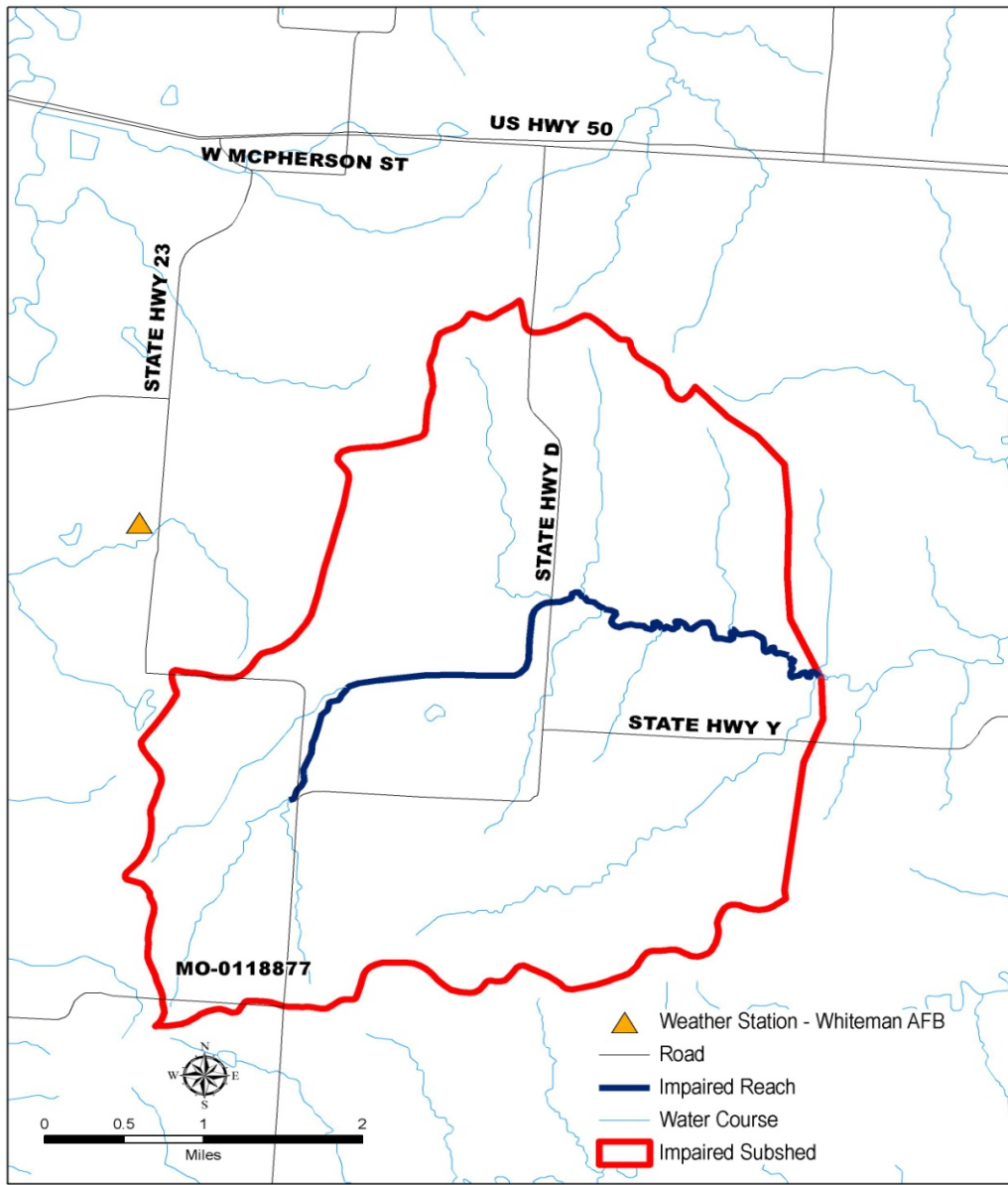


Figure 2. Location of Long Branch Watershed with Weather Station

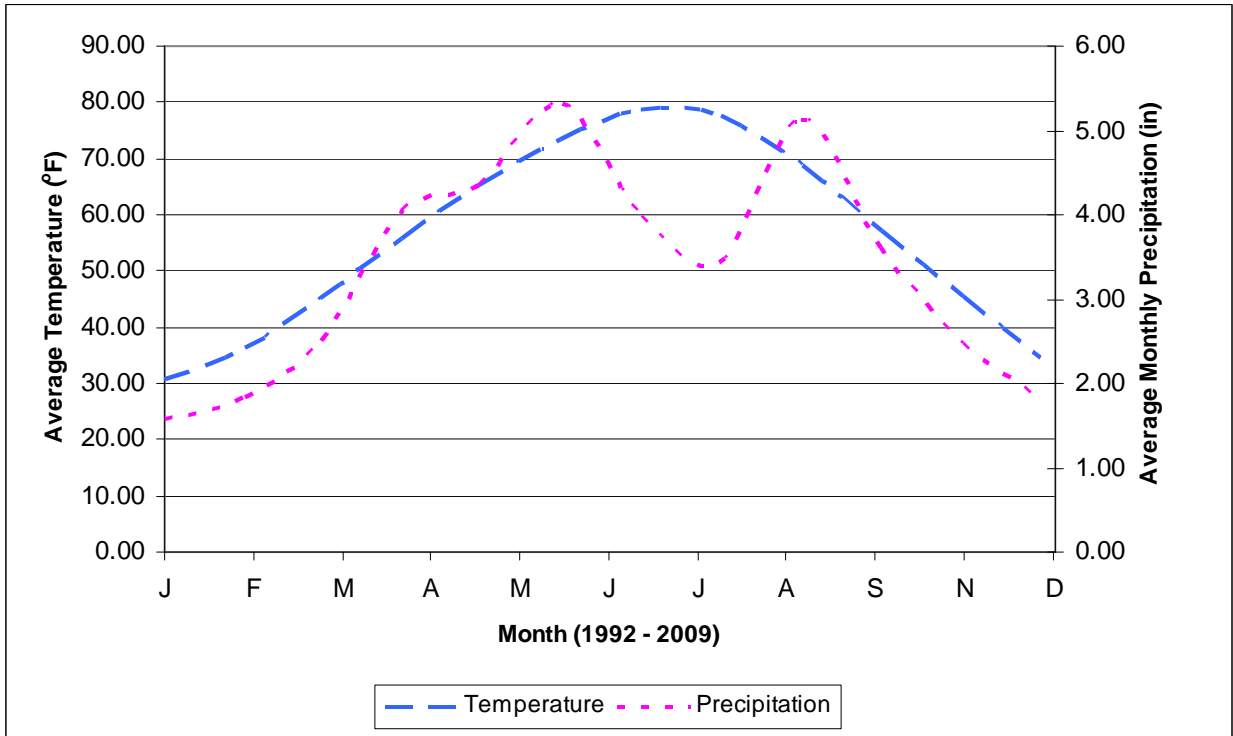


Figure 3. Seventeen Year Monthly Temperature and Precipitation Averages for Whiteman Air Force Base Station

2.4 Population

The U.S. Census reports that the 2000 population in Pettis County for all areas was 39,403 and the population in Johnson County for all areas was 48,258 (U.S. Census Bureau, 2000). The population data of the Long Branch watershed is not directly available. Population data is collected geographically in census tracts that vary in size between densely populated and sparsely populated areas. The boundaries of these census tracts bear no similarity to natural watershed boundaries. For this reason, a precise determination of population to the impaired segments is unknown. To produce an estimate of the number of people living in the Long Branch watershed, a drainage area map was superimposed over the map of census tracts using geographic information system (GIS) software. Whenever the centroid of a census tract fell within the watershed boundary its total population was included in the total. If the centroid of the census tract was outside the watershed boundary, the population was excluded. Based on this methodology the population of the Long Branch watershed is approximately 1,723 persons.

2.5 Land Use and Land Cover

The land use and land cover of the Long Branch watershed are shown in Figure 4 and summarized in Table 2 (MoRAP, 2005). The primary land uses and land covers are grassland (45.4 percent) and cropland (36.3 percent). Impervious, forest, high and low intensity urban, wetlands and water occupy the remaining 18.3 percent of the watershed area.

Table 2. Land Use and Land Cover in the Long Branch Watershed

Land Use and Land Cover [1]	Watershed Area		Percent
	Acres	Square Miles	
Impervious [2]	613.71	0.96	6.58%
High Intensity Urban [3]	15.83	0.02	0.17%
Low Intensity Urban [4]	270.31	0.42	2.90%
Grassland	4,235.99	6.62	45.43%
Cropland	3,386.46	5.29	36.32%
Deciduous Forest	561.22	0.88	6.02%
Deciduous Woody Herbaceous [5]	92.72	0.14	0.99%
Herbaceous Dominated Wetland [6]	59.52	0.09	0.64%
Woody Dominated Wetland [7]	34.29	0.05	0.37%
Open Water	53.82	0.08	0.58%
Total	9,323.87	14.55	100.00%

[1] MoRAP, 2005

[2] Impervious land uses include non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings.

[3] Vegetated urban environments with a high density of buildings

[4] Vegetated urban environments with a low density of buildings

[5] Open woodland (including young woodland) with less than 60 percent cover of evergreen trees

[6] Woody shrubland with less than 60 percent cover of trees with semi-permanent or permanent flood waters

[7] Forest with greater than 60% cover of trees with semi-permanent or permanent flood waters

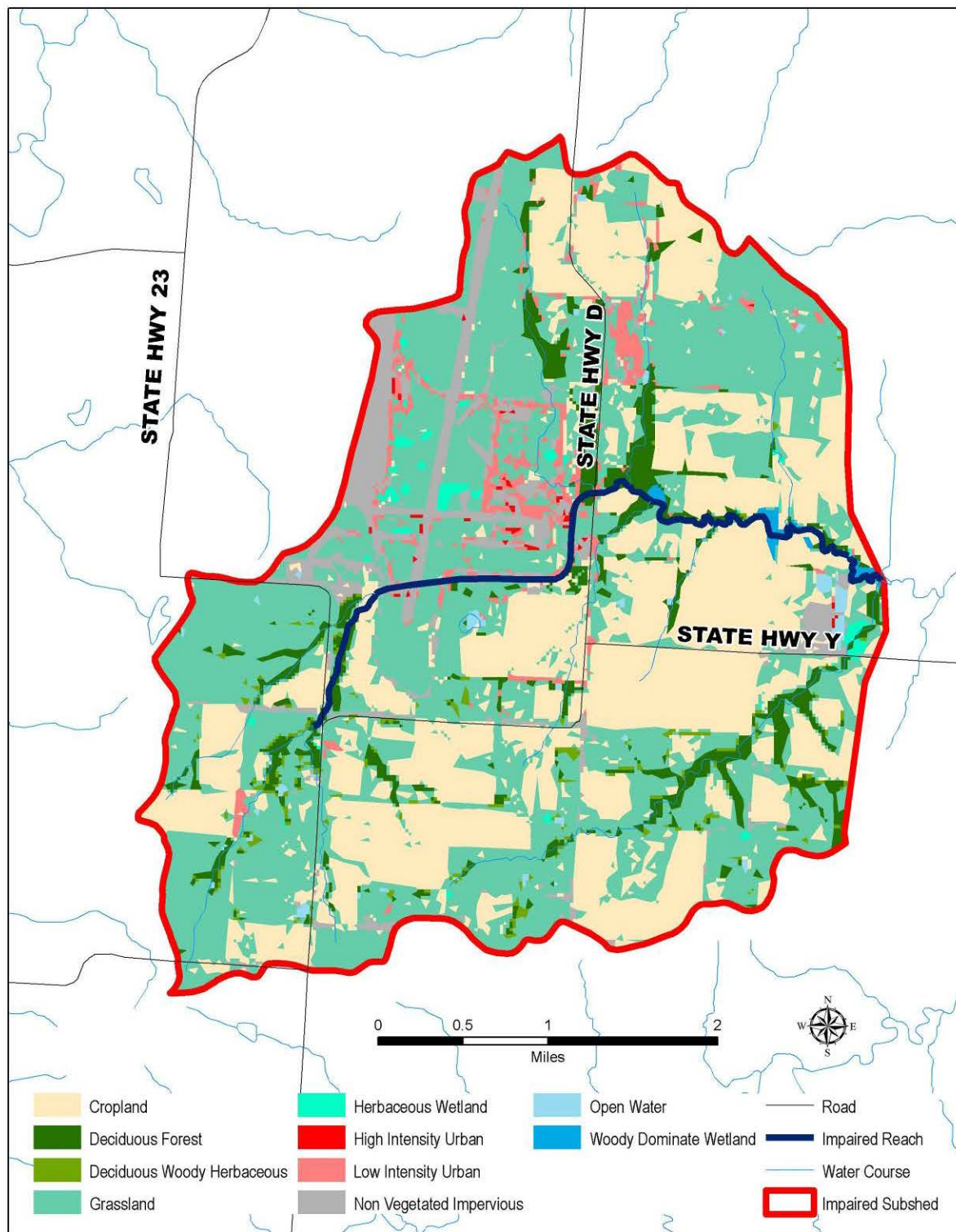


Figure 4. Land Use and Land Cover in the Long Branch Watershed

2.6 Defining the Problem

Long Branch is identified as impaired due to unknown pollutants and sources. A review of available historical water quality monitoring data for Long Branch shows dissolved oxygen (DO) below 5 milligrams per liter (mg/L) in 2 of 12 samples as well as elevated levels of TN, TP and TSS. The Missouri aquatic life criterion for DO in warm water fisheries is a daily minimum of 5 mg/L. Therefore, Long Branch is not in compliance with Missouri WQS.

Long Branch also exceeded the TMDL targets established for TN, TP and TSS. In the absence of Missouri numeric standards for TN, TP and TSS, targets were derived based on the 25th percentile of select data from the ecoregion. These targets were determined to be 0.855 mg/L for TN, 0.092 mg/L for TP and 17 mg/L for TSS. Section 4.2 and Section 5.1 contain more detailed information on how the TN, TP and TSS targets were developed. Table 3 below summarizes instream water quality data collected from Long Branch by the MDNR and National Pollutant Discharge Elimination System (NPDES) permit holder, Johnson County Egg Farm, from 2001-2009 (MDNR, 2009b). A complete listing of the data can be found in Appendix A.

Table 3. Long Branch Historical DO, TSS, TN and TP Water Quality Data (MDNR, 2009b)

Parameter	Sampling Events	Average Level (mg/L)	Criteria ³ (mg/L)	Number of Exceedances	Location of Exceedances [1]
TN	4	1.2	0.855	2	Whiteman AFB (Site 3.3) Thompson Rd. (Site 0.4)
TP	26	0.24	0.092	23	Thompson Rd. (Site 0.4) JCEF Outfall 3 JCEF Outfall 5
TSS	5	132	17	4	Thompson Rd. (Site 0.4) JCEF Outfall 3 JCEF Outfall 5
DO	12	9.5	5 [2]	2	Whiteman AFB (Site 3.3) Thompson Rd. (Site 0.4)

[1] JCEF = Johnson County Egg Farm

[2] As a minimum

Long Branch was recently sampled during various flow conditions in September and October 2009 and February and April 2010 to further assess the listed impairment due to unknown pollutants. Under contract with EPA, URS Corporation sampled and analyzed surface

³ Criteria for TN, TP and TSS based on reference conditions for TN and TP in Level III Ecoregion 40 streams and the 25th percentile of TSS calculated from all data available within the Blackwater / Lamine and Osage/South Grand EDUs. The criterion for DO is based on the Missouri WQS.

and interstitial water chemistry parameters, in-situ water quality parameters and physical stream characteristics. Four locations in Long Branch, established by EPA, were monitored.

Noteworthy items from the 2010 sampling report (URS, 2010) are bulleted below.

- Flow rates in the October sampling event were higher than those of the other three sampling events.
- Eleven of sixteen TN samples exceeded the target concentration of 0.855 mg/L. Note that TN is comprised of the sum of total Kjeldahl nitrogen (TKN) and nitrate + nitrite. Ammonia was only detected once at the laboratory limit, throughout all four events. The greatest concentration of nitrate + nitrite as nitrogen consistently occurred at location #1 (furthest downstream). The pattern of TKN concentrations observed by sample location was similar to the pattern observed for nitrate + nitrite as nitrogen; however, in addition to showing a spike in the concentration at the most downstream location (#1), TKN concentrations also showed a spike in concentration at the most upstream location (#4) (URS, 2010). The Johnson County Egg Farm is located between sampling locations #1 and #2. It seems that the Egg Farm is a contributor of the TN loads to Long Branch.
- TP and orthophosphate showed similar patterns to the nitrogen samples. The highest concentrations for both constituents were observed in the October 2009 event and concentration peaks occurred at locations #4 (most upstream) and #1 (most downstream). Observed concentrations of TP and orthophosphate were similar across the September 2009, February 2010 and April 2010 events and showed little variation (URS, 2010). Six of sixteen TP samples exceeded the target concentration of 0.092 mg/L.
- TSS concentrations were similar across sample locations and across the four sampling events. The TSS concentration observed at location #4 during the September 2009 sampling event was noticeably higher than other detected concentrations (URS, 2010). Ten of sixteen TSS samples exceeded the target concentration of 17 mg/L. TSS is comprised of both organic and inorganic fractions. Volatile suspended sediment (VSS) is a measure of the organic fraction. VSS concentrations were low in comparison to TSS concentrations indicating that inorganic matter comprised the majority of the TSS concentration in Long Branch. Therefore, the primary sources for TSS loading to Long Branch are likely not from organic wasteload generators.
- DO concentrations were consistently higher in February 2010 than those found in September and October 2009 and April 2010. Diel studies conducted at three of the sampling locations showed noticeable DO fluctuations throughout the day (URS 2010). Three of sixteen DO samples were below the Missouri daily minimum criterion of 5 mg/L for the protection of aquatic life designated use.

A summary of the 2009 and 2010 water quality data, including average concentration, water quality criteria and exceedances for select parameters, is presented in Table 4.

Table 4. Long Branch 2009 - 2010 Water Quality Data (URS, 2010)

Parameter	Sampling Events	Average Level (mg/L)	Criteria ⁴ (mg/L)	Number of Exceedances	Location of Exceedances [1]
TN	16	1.260	0.855	11	Thompson Rd. Crossing (Site 1) HWY D Crossing (Site 2) SE Corner of WAFB (Site 3) HWY 23 Crossing, US of WAFB (Site 4)
TP	16	0.108	0.092	6	Thompson Rd. Crossing (Site 1) HWY D Crossing (Site 2) SE Corner of WAFB (Site 3) HWY 23 Crossing, US of WAFB (Site 4)
TSS	16	33.7	17	10	Thompson Rd. Crossing (Site 1) HWY D Crossing (Site 2) SE Corner of WAFB (Site 3) HWY 23 Crossing, US of WAFB (Site 4)
DO	16	7.96	5 [2]	3	Thompson Rd. Crossing (Site 1) HWY 23 Crossing, US of WAFB (Site 4)

[1] US = Upstream, HWY = Highway, SE = Southeast

[2] As a minimum

WAFB = Whiteman Air Force Base

DO in streams is affected by several factors including water temperature, the amount of decaying matter (i.e., organic sediment) in the stream, turbulence at the air-water interface and the amount of photosynthesis occurring in plants within the stream. Excessive nitrogen and phosphorus loading to water bodies can also contribute to DO problems because nutrients can accelerate algal growth.

Algae growth in streams is most frequently assessed based on the amount of chlorophyll-*a* in the water or attached to the stream bed. Algal growth is affected by numerous biotic and abiotic factors including light availability, flow and water velocity, nutrients (particularly phosphorus in freshwater systems), grazing and other influences. In the presence of light, respiration and photosynthesis can occur simultaneously in algae. However, the respiration rate is low compared with the photosynthesis rate, resulting in a net production of oxygen. In the absence of light, algal respiration continues while photosynthesis stops, resulting in a net consumption of oxygen. The breakdown of dead, decaying algae also removes oxygen from

⁴ Criteria for TN, TP and TSS based on reference conditions for TN and TP in Level III Ecoregion 40 streams and the 25th percentile of TSS calculated from data available within the Blackwater/Lamine and Osage/South Grand EDUs. The criterion for DO is based on the Missouri WQS.

water. The most common approach to reducing excessive algal growth involves controls on activities that contribute phosphorus to the water body.

Organic sediments can contribute to fluctuating DO concentrations. Decaying matter can come from wastewater effluent as well as agricultural and urban runoff and is typically measured instream as biochemical oxygen demand (BOD). Decaying matter can also accumulate on the bottom of a stream and cause sediment oxygen demand (SOD). SOD is a combination of all of the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of ammonia, while SOD found several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese and sulfide (Wang, 1980; Walker and Snodgrass, 1986). Organic sediment can settle out of the water column and can smother aquatic invertebrates and fish eggs and cause offensive odors and unsightliness.

The DO problem could be due to one or more of the following:

- Excessive loads of biodegradable matter, as measured by BOD and/or carbonaceous biochemical oxygen demand (CBOD);
- Excessive algae in the stream as a result of excessive nutrient loading;
- High consumption of oxygen from decaying organic matter on the streambed and
- Chemical oxygen demand from ammonia and other substances.

The 2009 and 2010 sampling data show elevated levels of nutrients, including TP and TN and low levels of VSS. Chlorophyll-*a*, SOD, BOD and CBOD levels were not evaluated as a part of the sampling effort. Although sufficient data is not available to complete a detailed analysis to determine the sources of low DO levels, the available data suggests that elevated levels of TN and TP may be the primary contributors to low DO levels in Long Branch.

Following the 2009 and 2010 water quality sampling, a stressor study was conducted on Long Branch to identify and evaluate potential stressors to the aquatic life in Long Branch. The study identified three primary causes for limited habitat (Versar, 2010):

- Lack of quality instream habitat, likely resulting from excessive sedimentation;
- Excessive levels of nitrogen, particularly in the forms of nitrate + nitrite nitrogen and TKN and
- Excessive sedimentation.

3 Source Inventory

A source assessment is used to identify and characterize the known and suspected sources contributing to the impairment in Long Branch. For the purpose of this report, sources have been divided into two broad categories: point sources and nonpoint sources. Point sources can be defined as ones which occur at a fixed location in a watershed, either constant or time transient.

Nonpoint sources are generally accepted to be diffuse sources not entering a water body at a specific location.

3.1 Point Sources

The term “point source” refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit by which pollutants are transported to a water body. For the purposes of TMDL development, point sources are defined as sources regulated through the National Pollutant Discharge Elimination System (NPDES) program. Missouri has its own program for administering the NPDES program, referred to as the Missouri State Operating Permit (MSOP) system. The NPDES and MSOP programs are the same and for the purposes of this document the term “NPDES” will be used. The following regulated entities are included in this source category:

- Municipal and industrial wastewater treatment plants (WWTPs);
- Concentrated animal feeding operations (CAFOs);
- Storm water runoff from Municipal Separate Storm Sewer System (MS4) and
- General permitted facilities (e.g., including storm water runoff from construction and industrial sites).

General permits (as opposed to site specific permits) are issued to activities that are similar enough to be covered by a single set of requirements. Storm water permits are issued to activities that discharge only in response to precipitation events.

Point sources in the Long Branch watershed were identified by consulting EPA’s Permit Compliance System (PCS) website⁵ (EPA, 2009a) and MDNR’s GIS inventory⁶ of NPDES permitted facilities covered under storm water or general permits (see Table 4 and Figure 5). Of the eight unique permit numbers listed, one is a storm water permit, three are site specific permits and four are construction storm water permits.

Johnson County Egg Farm, LLC (MO0118877) is the only permitted CAFO within the watershed and includes a combined design waste flow of 0.0623 million gallons per day (MGD). The egg farm is designed for 1,940,000 layer hens and 709,920 pullets. The facility holds a “no discharge” permit (e.g., waste effluent is land applied) and would only discharge waste in the event of an extreme storm event. Wastewater is stored in the lagoons and land applied based on the plant available nitrogen (PAN) approach. The permit regulates 14 outfalls within the facility. The permitted outfalls for the Johnson County Egg Farm are detailed below. It should be noted that the designation “outfall” does not necessarily imply a direct discharge to a surface water body. In some cases, “outfall” is used to define: the location at which process waste discharged from the facility is stored until land application, a storm water discharge from the site or a location of required stream monitoring. Additionally, all of the permitted outfalls are not located within the watershed of the impaired reach of Long Branch.

⁵ www.epa.gov/enviro/html/pcs/index.html

⁶ GIS layers updated May 2009 and June 2009 (MSDIS, 2009)

Wastes from twelve confinement buildings, domestic wastes and wastes from the egg processing and truck wash maintenance building are diverted to and stored within six concrete pits (Outfall 001) and a three cell earthen storage basin (Outfall 002). The concrete pits (Outfall 001) receive manure from production buildings. Any manure that cannot be land applied from the pits is pumped into the storage basin at Outfall 002. The design storage of the concrete pits (Outfall 001) is 13 days. The three cell earthen storage basin (Outfall 002) receives manure, egg wash water and domestic wastewater from employee restrooms, break rooms and showers. Contaminated storm water runoff from the production buildings and feed mill is diverted to the three cell earthen storage basin (Outfall 002) while uncontaminated storm water is diverted to a fresh water earthen storage basin. The combined design storage for the waste storage facilities associated with Outfalls 001 and 002 is 365 days, which includes provisions for rainfall onto the basins based on 1-in-10 year flows. Rainfall events greater than a 1-in-10-year flow may result in, but does not ensure, a discharge of waste to Long Branch.

Waste from buildings 13 and 14 are stored in concrete pits (Outfall 013), and removed from the buildings approximately every 18 to 24 months and land applied at rates calculated using the PAN approach. Manure from the three pullet buildings is stored inside a concrete manure storage building (Outfall 014). Design storage for the waste storage facilities associated with Outfalls 013 and 014 is 545 days and 180 days, respectively. The waste storage facilities for Outfalls 013 and 014 are underground and therefore receive no rainfall or runoff input.

Besides the four outfalls noted above, there are ten other outfalls at the egg farm. Outfalls 004, 006, 007, 008, 009 and 010 are storm water outfalls, ultimately discharging to Long Branch. Outfalls 006 and 007 are located outside of the impaired watershed. Although deemed “outfalls” in the permit, these outfalls are not necessarily point discharges to Long Branch. Rather, the permitted outfalls identify the location at which storm water runoff from the production facility leaves the site, often via a swale or ditch. The Egg Farm is obligated to monitor these outfalls to ensure that process waste is not discharged at these locations. Storm water runoff with ammonia concentrations greater than 2.5 mg/L is considered process waste and must comply with no discharge requirements. Storm water runoff with ammonia concentrations less than 2.5 mg/L is considered agricultural storm water runoff and is not regulated under the permit.

Outfalls 003 and 005 designate stream monitoring sites for Long Branch. Outfall 005 is located downstream of the impaired reach. Outfalls 011 and 012 designate stream monitoring sites within Muddy Creek, which is not a tributary to Long Branch. As a part of the permit requirements, the Johnson County Egg Farm monitors Long Branch and Muddy Creek at locations upstream and downstream of the production facility and/or land application areas to characterize what impact, if any, the Egg Farm has to the water quality of Long Branch and Muddy Creek.

The second site specific permit within the Long Branch watershed is for the Twin Oaks Estates wastewater treatment facility (WWTF). The treatment process includes septic tanks and a recirculating sand filter with sludge disposed of by a contract hauler. The design flow is 20,000 gallons per day for a design population equivalent of 185.

The third site specific permit within the Long Branch watershed is for the Villages at Whiteman sludge lagoon facility. The facility includes an aerated, three cell lagoon. Sludge is retained in the lagoon. The design flow is 100,000 gallons per day for a design population equivalent of 1,000.

There is one general storm water permit within the watershed issued to the WAFB. The WAFB storm water permit includes four storm water outfalls. One outfall (Outfall 1) discharges to Long Branch and three outfalls discharge to Clear Fork. As the outfalls that discharge to Clear Fork do not contribute flow to Long Branch, they have been omitted from this analysis and are not detailed below. Outfall 1, located at the east edge of the site, consists of a natural channel with a concrete weir overflow structure. The tributary area for Outfall 1 is approximately 1,923 acres with approximately 20 percent impervious surfaces (Ecology and the Environment, 2005). Storm water runoff from the weapons storage area, flight line, runways, taxiways, B-2 docks, several Installation Restoration Program (IRP) sites, deicing areas and grassland is directed to Outfall 1.

A number of storm water Best Management Practices (BMPs) are currently in place upstream of Outfall 1 as detailed in the current Storm Water Pollution Prevention Plan (Ecology and the Environment, 2005). These practices are described below.

- Deicing agents are used on runways only when necessary and in the correct quantities. Runway deicing materials potentially exposed to storm water include: potassium acetate liquid used as an ice preventative, sodium formate solid used as an ice melter, sodium acetate and sand mix used only in emergencies and ice slice has replaced salt usage.
- Current BMPs in place for preventing de-icing materials from entering Long Branch from the alternate aircraft deicing area include: scheduling or delaying flights in order to avoid deicing activities, encouraging aircraft to find alternate bases when deicing may be required and parking aircraft in hangars to avoid the need for deicing.
- The concrete and asphalt recycling area is surrounded by grass swales to prevent discharge of contaminants. In this area, materials potentially exposed to storm water include: fluids from parked vehicles and equipment, open piles of recycled asphalt and concrete, sediment from open piles and disturbed soil areas.
- IRP sites have soil cover or treatment systems to prevent contact with or contamination of runoff.
- Storm water runoff from the compost yard, which includes one pile of compost and various garbage receptacles and storage containers, flows from a concrete pad to grass swales where it infiltrates. The SWPP identified one open garbage drum and recommended it be stored closed, placed under a cover or removed from the site.
- The drainage basin for Outfall 1 includes a number of areas where vehicle and equipment maintenance is performed and/or where hazardous materials are stored. With one exception, all maintenance is performed and hazardous materials are stored indoors. The exception is noted for the Weapons Storage Area Emergency Generator/Gas Station. For this area, it is noted that outside spills would flow in natural channels to Long Branch.

Construction storm water permits have BMPs required (through the general storm water permit) that should be protective of the impairment. However, facilities will be inspected prior to permit renewal and if more stringent effluent limitations or monitoring are required, the facility will be required to apply for a site specific permit to ensure compliance with WQS.

Illicit straight pipe discharges of household waste are also potential sources of suspended sediment and nutrients in rural areas. Illicit discharges drain directly or indirectly to streams and are different than illicitly connected sewers. Critical periods for impacts from illicit straight pipe connections would be low flow periods, not wet weather conditions. There is no specific information on the number of illicit straight pipe discharges of household wastes in the Long Branch watershed; however, illicit straight pipe discharges are not known or expected to be a significant source of suspended sediment and nutrients in Long Branch.

Table 5 details the permitted facilities located within the Long Branch watershed. Outfalls located within the impaired reach watershed are shown in Figure 5.

Table 5. Permitted Facilities in the Long Branch Watershed

<i>Storm Water Permit</i>							
Facility ID and Name	Receiving Stream	Design Flow	Reporting Requirements	Permit Expiration	Classification/Description		
MOR80F035, USAF, Whiteman Air Force Base	Long Branch	Storm Water Permit	N/A	10/04/2012	Airports, Flying Field & Service		
<i>Site Specific Permits</i>							
Facility ID and Name	Outfall Type	Receiving Stream	Outfall Number	Design Flow (Gal/Year) [4]	Reporting Requirements [2]	Permit Expiration	Classification/Description
MO0109142, Villages at Whiteman	Aerated lagoons/sludge storage	Tributary to Long Branch Creek	001	36,500,000	Fecal coliform, flow, BOD, TSS, NH ₃ , pH, Temp	12/13/2010	Village Sewerage System
MO0132021, Twin Oaks Estates RSF	Septic tanks/recirculating sand filter	Unnamed Tributary to Long Branch Creek	001	7,300,000	Fecal coliform, flow, BOD, TSS, NH ₃ , pH	3/2/2011	Subdivision - SIC
<i>Construction Storm Water Permits</i>							
Facility ID and Name	Receiving Stream	Design Flow	Reporting Requirements	Permit Expiration	Classification/Description		
MOR108787, USAF, Army Aviation Support Facility	Unnamed Tributary to Long Branch	Storm Water Permit	N/A	02/07/2012	Heavy Construction		
MOR10B317, USAF, Squadron Ops Building	Unnamed Tributary to Long Branch	Storm Water Permit	N/A	02/07/2012	Heavy Construction		
MOR10B474, USAF, Runway 19	Unnamed Tributary to Long Branch	Storm Water Permit	N/A	02/07/2012	Heavy Construction		
MOR10C159, USAF, Army Aviation Support Facility	Unnamed Tributary to Long Branch	Storm Water Permit	N/A	02/07/2012	Heavy Construction		

<i>Site Specific Permits with a Classified Receiving Stream</i>							
Facility ID and Name	Outfall Description	Classified Receiving Stream	Outfall Number	Design Waste Storage [1]	Reporting Requirements [2]	Permit Expiration	Classification/Description [3]
MO0118877, Johnson County Egg Farm, LLC	Land application of waste from manure storage pits/lagoons (Discharge only during extreme rain events)	Long Branch	001	22,734,000 gallons 365 days	Flow, DO, NH ₃ , BOD, pH, Temp., TKN, TP, NO ₃ , NO ₂	09/29/2010	CAFO 1A, Egg Farm
		Long Branch	002				
	Stream monitoring (No discharge to Long Branch)	Long Branch	003	N/A	Flow, pH, NH ₃ , NO ₃ , NO ₂ , TP, Temp., DO		
			005				
		Muddy Creek (Outside of Long Branch Watershed)	011				
			012				
	Uncontaminated storm water	Long Branch	006	N/A	Flow, pH, NH ₃ , NO ₃ , NO ₂ , TP, TSS, Temp.		
			007				
	Uncontaminated storm water	Long Branch (Downstream of the Impaired Reach)	004	N/A	Flow, pH, NH ₃ , NO ₃ , NO ₂ , TP, TSS, Temp.		
			008				
			009				
			010				
	Land application of waste from manure storage pits/lagoons (No discharge to Long Branch)	Long Branch	013	N/A	Flow, DO, NH ₃ , BOD, pH, Temp., TKN, TP, NO ₃ , NO ₂		
	Land application of waste from manure storage pits/lagoons (No discharge to Long Branch)	Long Branch	014	N/A			

[1] "N/A" = Not Applicable (no design flow regulated by the permit)

[2] "DO" = Dissolved Oxygen, "NH₃" = Ammonia Nitrogen, "BOD" = Biochemical Oxygen Demand, "Cl" = Chloride, "Temp" = Temperature, "TKN" = Total Kjeldahl Nitrogen, "TP" = Total Phosphorus, "NO₃" = Nitrate Nitrogen, "NO₂" = Nitrite Nitrogen, "TSS" = Total Suspended Solids

[3] CAFO 1A is a concentrated animal feeding operation with 7,000 animal unit equivalents, CAFO IC has 1,000 to 2,999 animal unit equivalents and CAFO II has 300 to 999 animal unit equivalents (MDNR, 2010)

[4] "Gal/Year" = Gallons per year

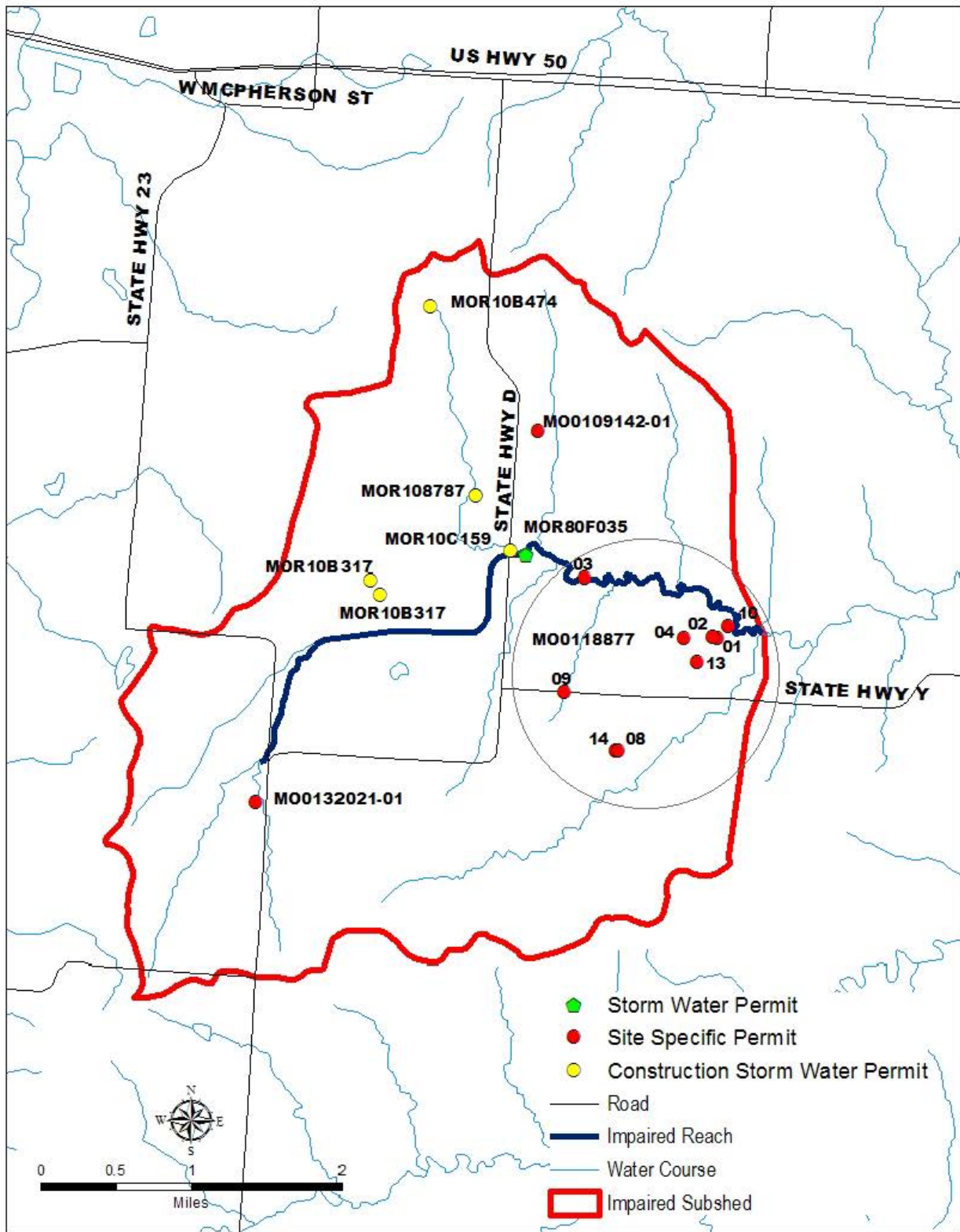


Figure 5. Location of Permitted Facilities in the Long Branch Watershed

3.2 Nonpoint Sources

Nonpoint sources include all other categories not classified as point sources. Potential nonpoint sources contributing to the impairment in Long Branch include runoff from agricultural areas, such as cropland and pasture, runoff from urban areas, non-regulated animal feeding areas, onsite wastewater treatment systems and various sources associated with riparian corridor conditions. Each of these is discussed further in the following sections.

In the absence of an NPDES permit, the discharges associated with nonpoint sources were applied as LA, as opposed to a WLA for the purposes of this TMDL. The decision to allocate these sources to a LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutants in this TMDL are found to be or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLAs in this TMDL. WLA in addition to that is not available here.

3.2.1 Runoff from Agriculture Areas

The 2005 land use/land cover data (MoRAP, 2005) indicate there are 3,386 cropland acres in the watershed, which comprises 36.3 percent of the entire watershed (Figure 4). Twenty percent of the riparian buffer is classified as cropland (see Table 5 in Section 3.2.4).

Countywide data from the National Agriculture Statistics Service (NASS) (USDA, 2007) for Johnson County were combined with the land cover data for the Long Branch watershed to estimate that there are approximately 2,570 cattle in the watershed⁷. The cattle are most likely located on the approximately 6.62 square miles of grassland / pastureland in the watershed. The density of cattle in the Long Branch watershed (176 cattle per square mile or 2,570 cattle in the entire watershed) suggests they are a potential source of TSS and nutrients to the stream. NASS also reports there were approximately 4,880 hogs and pigs and 2,970 horses and ponies in Johnson County. There were no county level data available for chickens in Johnson County. The large percentage of grassland and pasture in the watershed may serve as ideal seasonal grazing lands for livestock during the winter months, which may account for highly variable livestock populations within the watershed from one year to the next.

Lands used for agricultural purposes can be a source of sediment, nutrients and oxygen consuming substances. Accumulation of nitrogen and phosphorus on cropland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta and irrigation water. Sediment can be dislodged from the soil matrix by agricultural animals in confined spaces and pastures and stream bank erosion

⁷ According to the NASS there are approximately 81,800 head of cattle in Johnson County (USDA, 2007). According to the 2005 MoRAP there are 464 square miles of grasslands in Johnson County (MoRAP, 2005). These values result in a cattle density of approximately 176 cattle per square mile of grasslands in Johnson County. This density was multiplied by the number of grassland square miles within the Long Branch Watershed to estimate the number of cattle in the watershed.

can occur when cattle access streams for drinking water. Runoff from these areas can be potential sources of sediment, nutrients and oxygen consuming substances. Animals grazing in pasture areas deposit manure directly upon the land surface and even though a pasture may be relatively large and animal densities low, the manure will often be concentrated near the feeding and watering areas in the field. These areas can quickly become barren of plant cover, increasing the possibility of erosion and contaminated runoff during a storm event. Since the watershed is dominated by grassland and pasture the number of smaller animal feeding operations that are not registered is presumably high, particularly during seasonal feeding months in the winter. In addition, when pastureland is not fenced off from the stream, cattle or other livestock may contribute nutrients directly to the stream while walking in or adjacent to the water body. Additional discussion on CAFOs in the Long Branch watershed is provided in Section 3.1 of this report. The animal wastes from both confined and unconfined feeding sites are considered a major potential source of nutrient loading to Long Branch.

Permitted CAFOs identified in this TMDL are part of the assigned WLA. At this time, Animal Feeding Operations (AFOs) and unpermitted CAFOs are considered under the LA because there is currently not enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that such a facility does not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

Any CAFO that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a manmade conveyance.

3.2.2 Runoff from Urban Areas

Only a small portion (3 percent) of the Long Branch watershed is classified as low or high intensity urban and only 6.6 percent of the watershed is identified as impervious. A large portion of the land classified as impervious is associated with the WAFB. Runoff from WAFB is regulated under their NPDES permit and therefore is not considered to be nonpoint urban runoff. It is unlikely that runoff from urban areas is a significant source of pollutants in the watershed. However, storm water runoff from impervious and urban areas can contribute pollutants during precipitation events. A general description of potential impacts from urban runoff is provided below.

Storm water runoff from urban areas can be a significant source of sediment, nutrients and oxygen consuming substances, such as organic material and chemicals (pesticides and fertilizers). Lawn fertilization can lead to high nutrient loads and pet wastes can contribute both nutrient loads and organic material. For example, phosphorus loads from residential areas can be comparable to or higher than loading rates from agricultural areas (Reckhow *et al.*, 1980;

Athayde *et al.*, 1983). Leaking or illicitly connected sewers can also be a significant source of pollutant loads within urban areas. Storm water runoff from urban areas such as parking lots and buildings is also warmer than runoff from grassy and woodland areas, which can lead to higher temperatures that lower the dissolved oxygen saturation capacity of the stream. Excessive discharge of suspended solids from urban areas can also lead to streambed siltation problems. Since there is very little impervious or urban area in the watershed, it is unlikely that runoff from these sources is a significant contributor of nutrients and sediment to Long Branch.

3.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. When these treatment systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsley and Witten, 1996). Failing systems are sources of nutrients and pathogens that can reach nearby streams through both runoff and subsurface flows.

The exact number of onsite wastewater systems in the Long Branch watershed is unknown. However, EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL)⁸ reports there are 8,914 septic systems within the Lamine River watershed, which is the eight digit HUC watershed that contains the Long Branch watershed. A total of 3,974 septic systems exist within Johnson and Pettis Counties within the Lamine River watershed. Overall, the Lamine River watershed has an average population per septic system of 1.8. Considering only Johnson County, the average population per septic system is 2.66. As discussed in Section 2.4, the estimated rural population of the Long Branch watershed is approximately 1,723 persons. Based on this population and an average density of 2.32 persons per septic system, approximately 743 systems are estimated to be in the watershed. At this failure rate there would be approximately 290 failing systems in the watershed. No information was identified that would suggest failing onsite wastewater treatment systems are a significant problem in the Long Branch watershed. Based on this lack of evidence, impacts from failing onsite wastewater treatment systems are not considered a significant source of nutrients or sediment.

3.2.4 Riparian Corridor Conditions

Riparian⁹ (streamside) conditions can have a strong influence on instream water quality. Well-vegetated riparian corridors are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of nutrients and chemicals in the water column (i.e., they act as buffers). Therefore, a well-vegetated riparian corridor is better able to moderate the impacts of high nutrient loads and chemical runoff on a stream than is a poorly vegetated corridor. Wooded riparian buffers can also provide shading, which reduces stream temperatures and increases the DO saturation capacity of the stream. In addition, tree roots better stabilize stream banks and resist erosion more effectively than do grasses, row crops or shrubbery.

⁸ <http://bering.tetrattech-ffx.com/website/stepl/viewer.htm>

⁹ A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

As indicated in Table 6, 51.6 percent of the land in the Long Branch riparian corridor (defined as 30-meter buffer on either side of Long Branch) is classified as grassland, 34.4 percent is cropland and 8.7 percent is impervious (MoRAP, 2005). Compared to wooded areas or wetlands, grasslands (which may include pasture areas) and cropland generally provides less shading and higher pollutant loads due to livestock and related agricultural activity. Approximately 86 percent of the riparian areas around Long Branch are grassland or cropland.

Table 6. Percentage Land Use/Land Cover Within Riparian Buffer, 30-Meter

Land Use/Land Cover [1]	Acres	Square Miles	Percent (%)
Grassland	2286.14	3.5721	51.6
Cropland	1522.16	2.3784	34.4
High Intensity Urban [2]	1.78	0.0028	0.04
Low Intensity Urban [3]	28.78	0.0450	0.65
Impervious [4]	385.81	0.6028	8.71
Deciduous Forest	165.65	0.2588	3.74
Deciduous Woody Herbaceous [5]	4.20	0.0066	0.09
Herbaceous Wetland [6]	0.67	0.0010	0.02
Woody Dominate Wetland [7]	32.72	0.0511	0.74
TOTAL	4,427.91	6.92	100

[1] MoRAP, 2005

[2] Vegetated urban environments with a high density of buildings

[3] Vegetated urban environments with a low density of buildings

[4] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings

[5] Open woodland (including young woodland) with less than 60 percent cover of evergreen trees

[6] Woody shrubland with less than 60 percent cover of trees with semi-permanent or permanent flood waters

[7] Forest with greater than 60 percent cover of trees with semi-permanent or permanent flood waters

4 Applicable Water Quality Standards and Numeric Water Quality Targets

Section 303(d) of the CWA and Chapter 40 of the CFR § Part 130 require 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 pollutants of concern from both point and nonpoint sources and work to restore and protect the quality of their water resources. The water quality based approach allows the pollutants entering the water body to be set at a level protective of its designated beneficial uses.

Under the CWA, every state must adopt WQS to protect, maintain and improve the quality of the nation’s surface waters (U.S. Code Title 33, Chapter 26, Subchapter III [U.S. Code, 2008]). These standards represent a level of water quality that will support the CWA’s goal of “fishable/swimmable” waters. Missouri’s WQS (10 Code of State Regulation [CSR, 2009] 20-7.031) consist of three components: designated beneficial uses, criteria (general and numeric) to protect these uses and an antidegradation policy.

Beneficial or designated uses for Missouri streams are found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H (CSR, 2009). Criteria for designated uses are found at 10 CSR 20-7.031, Tables A and B (CSR, 2009). Missouri's antidegradation policy is outlined at 10 CSR 20-7.031(2) (CSR, 2009).

4.1 Designated Beneficial Uses

The impaired reach includes a 4.5 mile segment of Long Branch (WBID 0857) with designated beneficial uses classified as:

- Protection of Warm Water Aquatic Life;
- Protection of Human Health (Fish Consumption);
- Whole Body Contact Recreation – Category B; and
- Livestock and Wildlife Watering (CSR, 2009).

The impaired use is the “Protection of Warm Water Aquatic Life.” The designated beneficial uses and stream classifications for Missouri may be found in the WQS at 10 CSR 20-7.031(1)(C), (1)(F) and Table H available from the Missouri Secretary of State (CSR, 2009).

4.2 Criteria

In the 2008 Missouri 303(d) List, Long Branch is listed as impaired due to unknown pollutants. Water quality monitoring has revealed excursions of the DO WQS. Additionally, elevated levels of TN, TP and TSS have been detected in Long Branch. Dissolved oxygen in streams is affected by several factors, including elevated levels of nitrogen and phosphorus which accelerate algae growth in streams. Consequently TN, TP and TSS are being used as surrogates for the designated beneficial use impairments and narrative criteria.

The amount of DO in water is one of the most commonly used indicators of river and stream health. Under extended hypoxic (low DO) or anoxic (no DO) conditions, many higher forms of life are driven off or die. Fish, mussels, macroinvertebrates and all other aquatic life use DO to create energy and metabolize food. The WQS for all classified Missouri streams except cold water fisheries require a daily minimum of 5 mg/L DO (10 CSR 20-7.031 Table A [CSR, 2009]).

All water bodies in Missouri are protected by the general criteria (standards) contained in Missouri's WQS, 10 CSR 20-7.031(3). These criteria are also called narrative criteria, since they do not contain specific numerical limits. The narrative criteria not being met in Long Branch are (3) (A), (C), (D) and (G) as described below.

- (3) (A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses.
- (3) (C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses.

- (3) (D) Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life.
- (3) (G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

In the absence of Missouri numeric standards for nutrients in freshwater streams, ambient water quality criteria recommendations provided by EPA (EPA, 2000) are used to quantify TN and TP LCs in Ecoregion 40 and Long Branch. Reference conditions for TN and TP in level III Ecoregion 40 streams are as follows: TN = 0.855 mg/L and TP = 0.092 mg/L. For this TMDL, recommended TN and TP criteria are used directly in developing LCs for TN and TP. As noted in Section 2.6, water quality data collected in 2009 and 2010 support the assumption that elevated levels of TN and TP are primary contributors to low DO levels in Long Branch. Therefore, TN and TP ecoregion criteria are proposed to address DO WQS exceedances.

There are many quantitative indicators of sediment, such as TSS, turbidity and bedload sediment, which are appropriate to describe sediment in rivers and streams (EPA, 2006). A concentration of TSS was selected to represent the numeric target for this TMDL because it enables the use of the highest quality available data and is included in monitoring data. Missouri's WQS do not include specific numeric criteria for this pollutant, but given the natural effects of sediment on aquatic life, Missouri's narrative criteria are applicable. Additional discussion on watershed-specific targets used to develop LCs for TSS, TN and TP is provided in Section 5.1 of this report.

4.3 Antidegradation Policy

Missouri's WQS include EPA's "three-tiered" approach to antidegradation, which may be found at 10 CSR 20-7.031(2) (CSR, 2009).

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 November 28, 1975, the date of EPA's first WQS 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 anti-degradation 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 BMPs 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.

5 Modeling Approach

When stream flow gage information is available, a load duration curve (LDC) is useful in identifying and differentiating between storm-driven and steady-input sources (Cleland, 2002 and Cleland, 2003). For Long Branch, the LDC approach was used to: 1) provide a visual representation of stream flow conditions under which TSS, TN and TP criteria exceedances have occurred; 2) assess critical conditions; and 3) quantify the level of reduction necessary to meet the surface water quality targets for TSS, TN and TP in the stream.

A limited amount of flow data is available in the Long Branch watershed (Appendix A), which was inadequate for developing a LDC. To develop a synthetic flow record and a flow duration curve for Long Branch, information from six United States Geological Survey (USGS) gaging stations (Table 7) in the same region were used to establish a daily flow per square mile estimate. Average daily flow per square mile from the six stations was calculated for each day of record and multiplied by the impaired watershed area (14.57 square miles). This approach was used to estimate average daily flow for each day during the period from January 1, 1987, through July 31, 2010. A detailed discussion of methods used to develop the TSS, TN and TP LDCs is presented in Appendix B and Appendix C.

Table 7. Stream Flow Stations Used to Estimate Flows in Long Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi²)	Discharge Record	Latitude/ Longitude
Blue River near Stanley, KS	USGS	06893080	46	1974-2010	N38°48'45", W94°40'32"
Lamine River near Otterville, MO	USGS	06906800	543	1987-2010	N38°42'08.1", W92°58'43.8"
Little Osage River at Fulton, KS	USGS	06917000	314	1948-2010	N38°00'32", W94°42'14"
Little Osage River at Horton, MO	USGS	06917060	498	2000-2010	N37°59'41.3", W94°22'09.5"
Marmaton near Uniontown, KS	USGS	06917240	84	2001-2010	N37° 50' 08", W94° 58' 52"
Marmaton near Marmaton, KS	USGS	06917380	292	1990-2008	N37° 49' 03", W94° 47' 30"

5.1 Criterion to Support the TMDL

In Long Branch, where narrative standards are targeted for the impaired segment, a reference approach was used to define TMDL targets. The TSS, TN and TP targets were developed as criteria for the impaired use and are protective of the stream's general uses. Missouri does not have a numeric criterion for TSS, TN and TP; therefore, a statistical approach

is used to develop a target for TSS and EPA’s (2000) ecoregion nutrient criteria are used for TN and TP. Each method is described below.

The TSS target was derived based on a reference approach by targeting the 25th percentile of TSS measurements (USGS, non-filterable residue) from sites within the geographic region in which Long Branch is located. In this approach, only TSS data from representative sampling sites could be used. Representative sampling sites are those sites that have similar watershed characteristics (land use, size, etc.) to Long Branch. Typically, sampling sites within the Long Branch EDU (Blackwater/Lamine) would be used; however, some of these sites represented urbanized watersheds, so they could not be included in the 25th percentile calculation. In order to ensure that the TSS target was based on an adequate amount of data, data from additional sampling sites were used from the neighboring EDU (Osage/South Grand), which is in the same ecoregion as Long Branch. A complete list of sites used in determining the TSS target and the TSS data are included in Appendix D and E, respectively. A detailed discussion of the method used to develop the TSS target is provided in Appendix B. The resulting criterion used as a target in developing TSS TMDLs is presented in Table 8.

TN and TP TMDL targets and the resulting LCs are based on EPA recommended Ecoregion 40 criteria and water quality observations at locations throughout the ecoregion. For this analysis, the 25th percentile of data for all seasons is used as the target. This value is calculated by taking the median of the four seasonal 25th percentiles of data within an ecoregion (EPA, 2000). TN and TP concentrations from monitoring locations within Missouri and in Ecoregion 40 are plotted with flow to define the relationship between load and flow unique to Missouri streams in this ecoregion. In developing this relationship, individual water quality measurements are “corrected” based on the ecoregion target such that the median of the dataset is equal to the ecoregion target. Allowable pollutant loads are calculated for all flow conditions by multiplying flow by either the EPA-recommended ecoregion target concentration or the concentration established using the Missouri Ecoregion 40 streams, whichever concentration is higher. Reference conditions for TN and TP in Level III Ecoregion 40 streams are provided in Table 3e of *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria for Rivers and Streams in Nutrient Ecoregion IX* (EPA, 2000) and in Section 4.2 of this report. A detailed discussion of the method used to develop the TN and TP targets is provided in Appendix C. The resulting criteria used as targets in developing TN and TP LCs are also presented in Table 8.

Table 8. Criteria Used to Develop TSS, TN and TP TMDLs

	TSS EDU Target (mg/L)	TN Ecoregion Criteria (mg/L)	TP Ecoregion Criteria (mg/L)
EDU and Ecoregion Targets and Criteria	17	0.855	0.092

6 Calculation of Loading Capacity

LC is defined as the greatest amount of a pollutant that a water body can assimilate without exceeding WQS. The TMDL quantifies and allocates the LC to known point and nonpoint sources in the form of WLAs and LAs, a MOS and natural background conditions. The

MOS accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by Equation 1.

$$LC = \Sigma WLA_s + \Sigma LA_s + MOS \qquad \text{Equation 1}$$

Where:

- LC = Loading Capacity
- WLA = Wasteload Allocations (point source)
- LA = Load Allocations (nonpoint source)
- MOS = Margin of Safety (may be implicit and factored into a conservative WLA or LA or explicit)

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to known pollutant sources within the watershed so appropriate control measures can be implemented and the WQS achieved. The CFR (40 CFR § 130.2 (1)) states that TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For Long Branch, TSS, TN and TP TMDLs are expressed as pounds per day using a LDC (Figure 6, Figure 7, Figure 8, Table 10, Table 11 and Table 12). The LDC represents the LC as a solid red line over the range of flow conditions expected in the stream. Water quality measurements, shown as round (black) points, are loads calculated from TSS, TN and TP concentrations collected in Long Branch at four sampling locations in 2009 and 2010.

As presented in Figures 6 through 8, excursions to the TSS and TN threshold occurred under all of the sampled flow conditions. Of the EPA contractor sampling data, 11 of 16 TN values and 6 of 16 TP values were found to be above the EPA-recommended Ecoregion 40 criteria. A total of 10 of 16 TSS values were found to be above the EDU criteria developed as a part of this TMDL. It is helpful to note that each of the four sampling events represent a unique percent exceedance, as summarized in Table 9, meaning that a range of flow conditions were represented in the 2009/2010 sampling. Other sampling data from MDNR and monitoring data from permit holders is also plotted in Figures 6 through 8.

Table 9. Flow Exceedances for Each Sampling Event

Sampling Event	Percent Exceedance
September 2, 2009	75.9%
October, 6 2009	61.5%
February 12, 2010	18.4%
April 20, 2010	42.0%

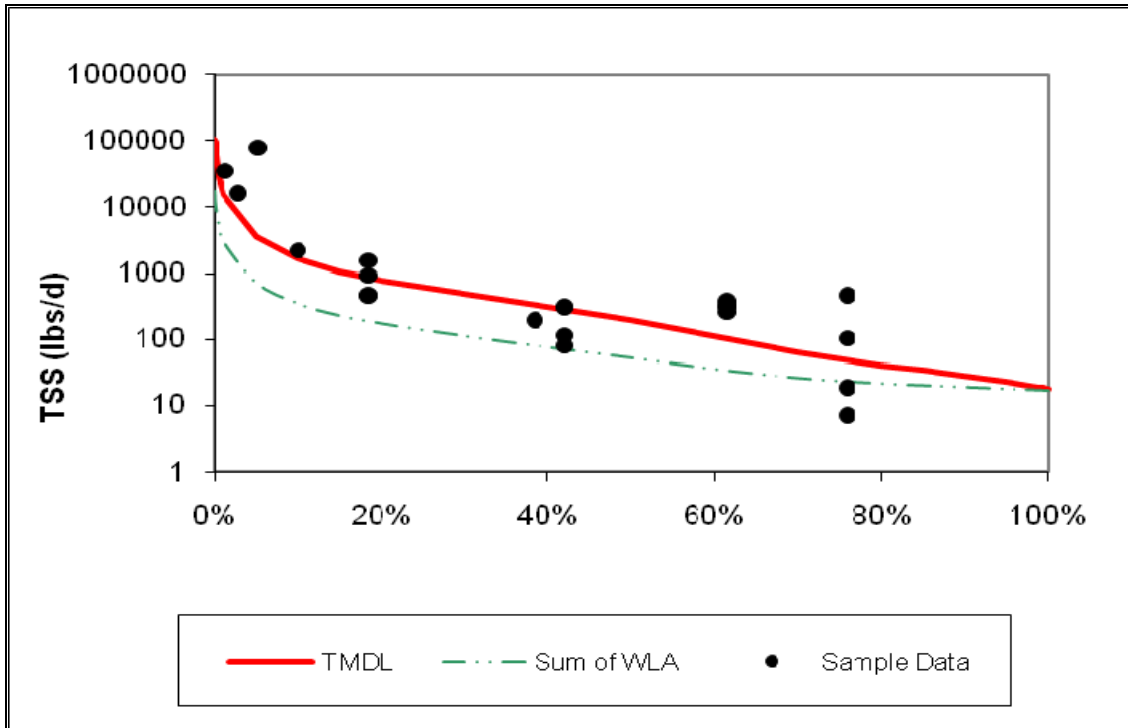


Figure 6. TSS LDC for Long Branch

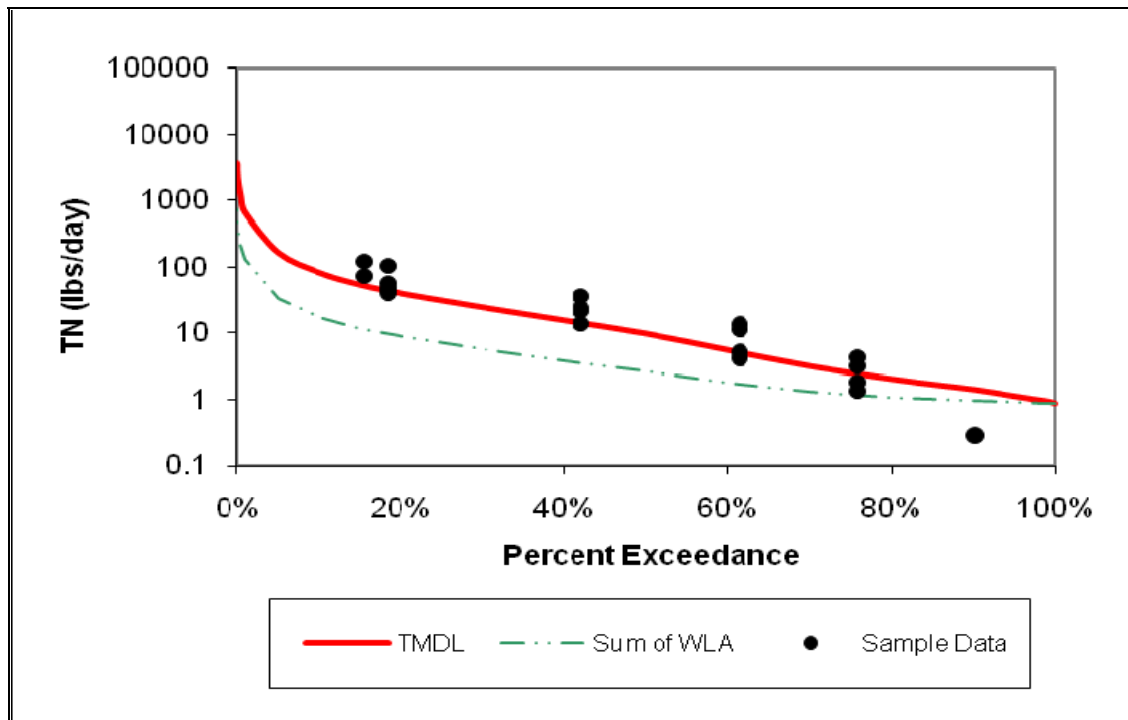


Figure 7. TN LDC for Long Branch

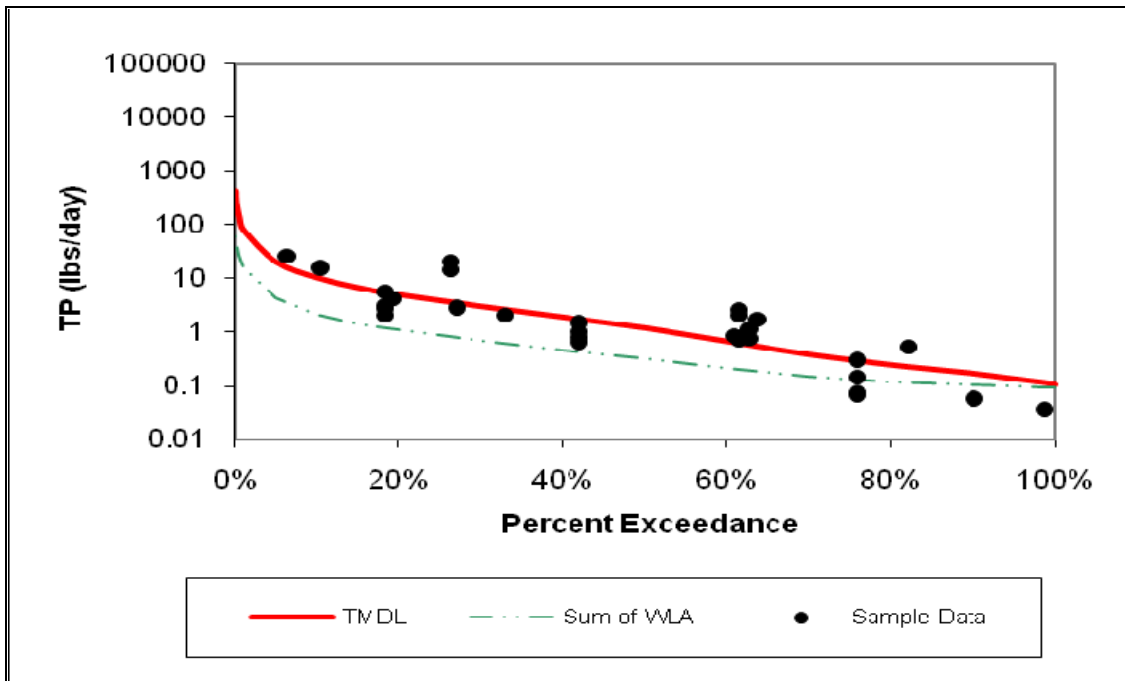


Figure 8. TP LDC for Long Branch

Table 10. TSS TMDL Under a Range of Flow Conditions in Long Branch

Flow Exceedance	Estimated Flow (cfs)	TSS TMDL (lbs/day)	TSS LA (lbs/day)	TSS WLA (lbs/day)
95%	0.2	22.66	4.47	18.19
90%	0.3	28.43	9.05	19.38
70%	0.7	63.20	36.66	26.54
50%	2.1	194.03	140.54	53.49
30%	5.3	485.37	371.86	113.51
10%	17.8	1664.30	1308.00	356.30
5%	34.9	3554.92	2809.47	745.45

Table 11. TN TMDL Under a Range of Flow Conditions in Long Branch

Flow Exceedance	Estimated Flow (cfs)	TN TMDL (lbs/day)	TN LA (lbs/day)	TN WLA (lbs/day)
95%	0.2	1.1	0.2	0.9
90%	0.3	1.4	0.4	1.0
70%	0.7	3.2	1.8	1.3
50%	2.1	9.8	7.1	2.7
30%	5.3	24.4	18.7	5.7
10%	17.8	82.2	64.6	17.6
5%	34.9	163.1	128.8	34.3

Table 12. TP TMDL Under a Range of Flow Conditions in Long Branch

Flow Exceedance	Estimated Flow (cfs)	TP TMDL (lbs/day)	TP LA (lbs/day)	TP WLA (lbs/day)
95%	0.2	0.14	0.04	0.10
90%	0.3	0.17	0.06	0.11
70%	0.7	0.39	0.24	0.15
50%	2.1	1.20	0.88	0.32
30%	5.3	3.02	2.33	0.69
10%	17.8	10.29	8.10	2.19
5%	34.9	20.31	16.06	4.25

7 Wasteload Allocations (Point Source Loads)

The WLA is the portion of the LC allocated to existing or future point sources of pollutants. Two of the eight permitted facilities within the impaired watershed are expected to have non-storm water discharges to Long Branch: the Twin Oaks Recirculating Sand Filter (MO0132021) and the Villages at Whiteman Aerated Lagoon (MO0109142). The total combined daily design flow for these two facilities is 120,000 gallons per day. The permits for these facilities do not include a limit for TN and TP concentrations. However, the discharges from these facilities are expected to contain certain levels of TN and TP. TN and TP WLAs for these facilities are based on daily design flows and the water quality target for TN and TP, respectively. The WLAs for TN and TP are included in the gross WLAs shown in Tables 11 and 12 at various percentiles of flow exceedance.

The permits for the Twin Oaks Recirculating Sand Filter and the Villages of Whiteman Aerated Lagoons prescribe maximum daily and monthly concentrations of TSS that exceed the TSS water quality target for Long Branch. While TSS is used for establishing this TMDL, the sampling data shows that the volatile (organic) portion of the TSS concentration is quite low. The TSS discharges from these two facilities would most likely be high in organic content due to the nature of their waste. As such, these facilities are not considered to be contributing to the impairment in Long Branch. Therefore, TSS WLAs for these facilities are based on daily design flows and the water quality target for TSS. The WLAs for TSS are included in the gross TSS WLAs shown in Table 10 at various percentiles of flow exceedance. Current permit effluent limits will remain in effect for both the Twin Oaks Recirculating Sand Filter and the Villages of Whiteman Aerated Lagoons treatment facilities. Neither of these facilities currently has effluent limits for total nitrogen nor total phosphorous. Since the facilities have a very low design flow, these facilities are not considered to be causing or contributing to the impairment and no new wasteload allocation-based nutrient effluent limits will be developed at this time,

The only general storm water permit within the impaired watershed is held by WAFB (MOR80F035). The general permitted storm water WLA is set based on the percentage of the watershed covered under the general storm water permit. As noted in Section 3.1, only one of four permitted outfalls within the WAFB (Outfall 1) discharges to Long Branch. The land area contributing flow to Outfall 1 is 1,923 acres (Ecology and the Environment, 2005), out of a total 9,324 acres within impaired watershed (MoRAP, 2005). This results in the general storm water

permit receiving a WLA equivalent to 20.6 percent of the diffuse load to the stream. These WLAs are included in the gross WLAs listed in Tables 10, 11 and 12 and vary with percentile of flow exceedance.

WAFB also holds four construction storm water permits in the watershed (MOR108787, MOR10B317, MOR10B474 and MOR10C159). EPA assumes that construction activities in the watershed will be conducted in compliance with Missouri's Storm Water Permit including monitoring and discharge limitations. As required under the permit, Storm Water Pollution Prevention Plans (SWPPP) ensure the design, implementation and maintenance of BMPs. Compliance with the SWPPP should result in sediment loading from construction sites at or below applicable targets. Therefore, the construction permits are assigned a zero WLA.

JCEF, LLC operates the Johnson County Egg Farm under permit MO0118877. The facility is classified as a CAFO. Waste is stored in three earthen storage basins and six concrete pits. Wastewater is stored in the lagoons and land applied based on the PAN approach. The JCEF facility holds a "no discharge" permit and would only discharge in the event of a large storm event that exceeds the wastewater storage capacity of the facility. Since this facility is not expected to discharge, it should not cause or contribute to the TSS, TN and TP impairments. Therefore, this facility was assigned a zero WLA.

A summary of the facilities included in the gross WLAs is provided in Table 13. Additionally, Table 13 details the outfalls that were assigned a WLA of zero. Only permitted outfalls located within the impaired watershed are included. The WLAs listed in this TMDL (Table 13) do not preclude the establishment of future point sources of sediment or nutrient loading in the watershed. Any future point sources should be evaluated in light of the established TMDLs.

Table 13. TSS, TN and TP WLAs for Permitted Facilities in the Long Branch Watershed

Facility ID	Facility Name [1]	Outfall Number [2]	Receiving Stream [3]	WLA for TSS, TN and TP (lbs per day)
MO0118877	Johnson County Egg Farm	001	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	002	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	003	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	004	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	008	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	009	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	010	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	013	Unnamed Tributary	0.0
MO0118877	Johnson County Egg Farm	014	Long Branch	0.0
MO0132021	Twin Oaks Estates RSF	001	Unnamed Tributary	Current Limits
MO0109142	Villages at Whiteman Lagoon	001	Unnamed Tributary	Current Limits
MOR80F035	Whiteman Air Force Base	001	Unnamed Tributary	Included in Gross WLA
MOR108787	Army Aviation Support Facility	N/A	Unnamed Tributary	0.0
MOR10B317	USAF Squadron Ops Building	N/A	Unnamed Tributary	0.0
MOR10B474	USAF Runway 19	N/A	Unnamed Tributary	0.0
MOR10C159	Army Aviation Support Facility	N/A	Unnamed Tributary	0.0

[1] RSF = “Recirculating Sand Filter,” USAF = U.S. Air Force

[2] Only outfalls within the Long Branch watershed are listed

[3] Unnamed Tributaries are tributaries to Long Branch

8 Load Allocation (Nonpoint Source Loads)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)). The LA for the Long Branch TMDL is for all nonpoint sources of TN, TP and TSS, which could include loads from agricultural lands, runoff from urban areas outside of WAFB, livestock and failing onsite wastewater treatment systems during critical low flow periods. The LA is the remainder of the TMDL after removing allowances for the WLAs and MOS. The resulting TSS, TN and TP LAs are provided in Table 14.

Table 14. TSS, TN and TP LAs in Long Branch Watershed

Flow Exceedance	Estimated Flow (cfs)	TSS LA (lbs/day)	TN LA (lbs/day)	TP LA (lbs/day)
95%	0.2	4.47	0.2	0.04
90%	0.3	9.05	0.4	0.06
70%	0.7	36.66	1.8	0.24
50%	2.1	140.54	7.1	0.88
30%	5.3	371.86	18.7	2.33
10%	17.8	1308.00	64.6	8.10
5%	34.9	2809.47	128.8	16.06

9 Margin of Safety

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

- 1) Explicit – Reserve a numeric portion of the LC as a separate term in the TMDL
- 2) Implicit – Incorporate the MOS as part of the critical conditions for the WLA and the LA calculations by making conservative assumptions in the analysis.

An implicit MOS was incorporated into the TMDL based on conservative assumptions used in the development of the LDCs. The use of ecoregion targets in lieu of national or state-wide targets serves to ensure that implementation will result in either pristine or minimally impacted stream systems. The 25th percentile is considered a surrogate for establishing a reference population of the pristine systems (EPA 2000). TN and TP targets are conservative because they are based on the 25th percentile of all TN and TP data gathered from Ecoregion 40 of Aggregate Nutrient Ecoregion IX, from data not directly influenced by permitted dischargers. In the case of nutrients, the targets are the median calculated from the four seasonal 25th percentile values. As a result, both high concentrations seen during the periods of spring runoff and winter flow from snowmelt (and low concentrations seen during low flow conditions in both summer and fall) are incorporated into the annual reference targets. In the case of sediment, the approach used was to target the 25th percentile of all concentration data available in the EDU in which Long Branch is located as well as an adjacent EDU within the same Ecoregion (see Appendix B and D). The use of these refined and/or EDU specific data ensures that all local geological and landscape conditions are addressed in this TMDL.

10 Critical Conditions and Seasonal Variation

The TMDL curve represents flow under all seasonal conditions. The TMDL (expressed as concentrations) is applicable at all flow conditions, hence all seasons. The advantage of the LDC approach is that all flow conditions are considered and the constraints associated with using a single-flow critical condition are avoided. There was insufficient water quality data to

determine any flow-based patterns as most of the sampling events occurred during low to mid-range flows (Figure 5, Figure 7 and Figure 8). Within the flow rates represented, exceedances of TSS and TN were observed under each condition while most of the TP exceedances occurred during the highest of the flow events, which occurred during the October 2009 sampling event. It should be noted that all of the TSS and TP samples and three of the four TN samples collected during the October 2009 sampling event exceeded the recommended targets.

11 Monitoring Plans

A stressor study was conducted on Long Branch in 2010 by Versar, Inc. No future monitoring has been scheduled for Long Branch at this time. In general, future stream monitoring is scheduled and conducted by MDNR approximately three years after the approval of this TMDL, or in a reasonable time frame following the completion of permit compliance schedules and/or the application of new effluent limits. MDNR will routinely examine physical habitat, water quality, invertebrate and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring Program. This program randomly samples streams across Missouri on a five- to six-year rotating schedule.

12 Reasonable Assurances

MDNR has the authority to issue and enforce state operating permits. Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to MDNR should provide reasonable assurance that instream WQS will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for WLAs to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL's combined nonpoint source LAs and point source WLAs do not exceed the WQS-based LC and there is reasonable assurance that the TMDL's allocations can be achieved. Discussion of reduction efforts relating to nonpoint sources can typically be found in the implementation section of the TMDL.

13 Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR §130.7). EPA is providing public notice of this draft TMDL for Long Branch on the EPA, Region 7, TMDL Website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: <http://www.epa.gov/region07/water/apprtmdl.htm#Missouri>.

This water quality limited segment of Long Branch in Johnson and Pettis Counties, Missouri, is included on the EPA-approved 2008 Missouri 303(d) List. This TMDL is being established by EPA to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W,

February 27, 2001. EPA is developing this TMDL in cooperation with the state of Missouri and EPA is establishing this TMDL at this time to meet the *American Canoe* consent decree milestones. Missouri may submit and EPA may approve a revised or modified TMDL for this water at any time.

Before finalizing EPA-established TMDLs (such as this TMDL), the public is notified that a comment period is open on the EPA Region 7 Website for at least 30 days. EPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed or other potentially impacted parties. After the comment period closes, EPA reviews all comments, edits the TMDL as appropriate, writes a Summary of Response to Comments and establishes the TMDL. For Missouri TMDLs, groups receiving the public notice announcement include a distribution list provided by MDNR, the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, stream team volunteers, state legislators, county commissioners, the County Soil and Water Conservation District and potentially impacted cities, towns and facilities. EPA followed this public notice process for this TMDL. Links to active public notices for draft TMDLs, final (approved and established) TMDLs and Summary of Response to Comments are posted on the EPA Website: <http://www.epa.gov/region07/water/tmdl.htm>.

14 Administrative Record and Supporting Documentation

An administrative record on the Long Branch TMDL has been assembled and is being kept on file with EPA.

List of Appendices

- Appendix A – Long Branch Water Quality Data
- Appendix B – Development of TSS Targets Using Reference LDCs
- Appendix C – Development of Nutrient Targets Using Ecoregion Nutrient Criteria with LDCs
- Appendix D – Stream Flow and Water Quality Stations Used to Develop TMDLs in Long Branch
- Appendix E – Raw Data Used to Develop Load Duration Curves
- Appendix F – Supplemental Implementation Plan

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Appendix A - Long Branch Water Quality Data

Org. ¹	Site	Site Name ²	Date	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Flow (cfs)	DO (mg/L)	NH ₃ N (mg/L)	NO ₃ N (mg/L)	TSS Method
JCEF	857/2.1	Long Branch US JCEF (Site 3)	May-01						0.8	1.2	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Sep-01						0.2	0.5	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Mar-01						0.3	0.9	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Aug-02						0.6	0.5	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Oct-01						5.8	0.7	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Jul-02						0.6	1.2	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	11-Mar-03				1.9		0.1	0.8	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Nov-01						0.3	0.5	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Apr-01						1.1	0.9	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Jul-01						0.3	0.7	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Jun-01						0.8	1	
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Aug-01						0.5	0.5	
MDNR	857/0.4	Long Branch at Thompson Rd.	12-Feb-09				19.4	13			
JCEF	857/2.1	Long Branch US JCEF (Site 3)	Sep-02						0.6	1	
MDNR	857/3.3	Long Branch @ WAFB	25-Sep-07		0.1	0.5		1.7	0.015	0.04	
MDNR	857/3.3	Long Branch @ WAFB	24-Mar-08		0.1	1.4	0.19	9.9	0.04	0.59	
MDNR	857/0.4	Long Branch at Thompson Rd.	01-May-09				6.6	7.8			
MDNR	857/0.4	Long Branch at Thompson Rd.	12-Mar-09				9.6	11			
MDNR	857/0.4	Long Branch at Thompson Rd.	24-Mar-08		0.1	2.3	0.5	11	0.32	1.06	
MDNR	857/0.4	Long Branch at Thompson Rd.	10-Apr-09				45				
MDNR	857/0.4	Long Branch at Thompson Rd.	27-Sep-07		0.1	0.8	0.23	4.3	0.07	0.28	
MDNR	857/0.4	Long Branch at Thompson Rd.	26-Feb-09				1	12			
MDNR	857/0.4	Long Branch at Thompson Rd.	12-Mar-09	27			9.6	11.4			SM2540-D
MDNR	857/0.4	Long Branch at Thompson Rd.	12-Feb-09	62			19.4	12.5			SM2540-D
MDNR	857/0.4	Long Branch at Thompson Rd.	26-Feb-09	12			1	11.9			SM2540-D
MDNR	857/0.4	Long Branch at Thompson Rd.	10-Apr-09	496			45				SM2540-D
MDNR	857/0.4	Long Branch at Thompson Rd.	1-May-09	61			6.6	7.8			SM2540-D
JCEF		Long Branch at JCEF (Site 3)	24-Mar-04						0.7	1.3	
JCEF		Long Branch at JCEF (Site 5)	24-Mar-04						0.7	1.3	
JCEF		Long Branch at JCEF (Site 3)	22-Apr-04						0.3	0.9	
JCEF		Long Branch at JCEF (Site 5)	22-Apr-04						0.1	1.4	
JCEF		Long Branch at JCEF (Site 3)	17-May-04						0.5	5.1	
JCEF		Long Branch at JCEF (Site 5)	17-May-04						0.4	8	
JCEF		Long Branch at JCEF (Site 3)	24-Jun-04						0.2	1.3	

Org. ¹	Site	Site Name ²	Date	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Flow (cfs)	DO (mg/L)	NH ₃ N (mg/L)	NO ₃ N (mg/L)	TSS Method
JCEF		Long Branch at JCEF (Site 5)	24-Jun-04						0.2	1.4	
JCEF		Long Branch at JCEF (Site 3)	19-Jul-04						0.2	1.9	
JCEF		Long Branch at JCEF (Site 5)	19-Jul-04						0.2	1.9	
JCEF		Long Branch at JCEF (Site 3)	16-Aug-04						0.3	0.9	
JCEF		Long Branch at JCEF (Site 5)	16-Aug-04						0.2	0.9	
JCEF		Long Branch at JCEF (Site 3)	20-Sep-04						1.6	0.7	
JCEF		Long Branch at JCEF (Site 5)	20-Sep-04						1.6	0.7	
JCEF		Long Branch at JCEF (Site 3)	18-Oct-04						0.7	1.4	
JCEF		Long Branch at JCEF (Site 5)	18-Oct-04						0.8	1.9	
JCEF		Long Branch at JCEF (Site 3)	15-Nov-04						0.7	0.9	
JCEF		Long Branch at JCEF (Site 5)	15-Nov-04						0.9	1.9	
JCEF		Long Branch at JCEF (Site 3)	14-Mar-05						0.2	0.6	
JCEF		Long Branch at JCEF (Site 5)	14-Mar-05						0.3	0.8	
JCEF		Long Branch at JCEF (Site 3)	12-Apr-05						0.2	0.8	
JCEF		Long Branch at JCEF (Site 5)	12-Apr-05						0.2	0.6	
JCEF		Long Branch at JCEF (Site 3)	26-May-05						1.6	0.7	
JCEF		Long Branch at JCEF (Site 5)	26-May-05						2	0.9	
JCEF		Long Branch at JCEF (Site 3)	15-Jun-05						1.2	1.5	
JCEF		Long Branch at JCEF (Site 5)	15-Jun-05						1.1	2.6	
JCEF		Long Branch at JCEF (Site 3)	10-Oct-05						0	1	
JCEF		Long Branch at JCEF (Site 5)	10-Oct-05						0.2	0.5	
JCEF		Long Branch at JCEF (Site 5)	14-Oct-05						1.6	0.5	
JCEF		Long Branch at JCEF (Site 3)	14-Nov-05						2.1	0.6	
JCEF		Long Branch at JCEF (Site 3)	27-Apr-06		0.5				0.4	2.2	
JCEF		Long Branch at JCEF (Site 5)	27-Apr-06		0.7				0.4	3.2	
JCEF		Long Branch at JCEF (Site 3)	12-Jun-06		0.2				0.1	0.8	
JCEF		Long Branch at JCEF (Site 5)	12-Jun-06		0.2				0.4	0.9	
JCEF		Long Branch at JCEF (Site 3)	21-Aug-06		0.3				0.4	0.8	
JCEF		Long Branch at JCEF (Site 5)	21-Aug-06		0.3				0.9	1	
JCEF		Long Branch at JCEF (Site 3)	26-Mar-07		0.1				0.5	0.6	
JCEF		Long Branch at JCEF (Site 5)	26-Mar-07		0.1				0.5	0.5	
JCEF		Long Branch at JCEF (Site 3)	15-May-07		0.1				0.2	1.4	
JCEF		Long Branch at JCEF (Site 5)	15-May-07		0.2				0.4	1.7	
JCEF		Long Branch at JCEF (Site 5)	14-Aug-07		0.5				0.6	0.9	
JCEF		Long Branch at JCEF (Site 3)	29-Oct-07		0.2				0.3	0.3	
JCEF		Long Branch at JCEF (Site 5)	29-Oct-07		0.2				0.3	0.4	
JCEF		Long Branch at JCEF (Site 3)	21-May-08		0.1				0.8	0.8	

Org. ¹	Site	Site Name ²	Date	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Flow (cfs)	DO (mg/L)	NH ₃ N (mg/L)	NO ₃ N (mg/L)	TSS Method
JCEF		Long Branch at JCEF (Site 5)	21-May-08		0.1				0.8	1.5	
JCEF		Long Branch at JCEF (Site 3)	21-Jul-08		0.3				0.4	0.8	
JCEF		Long Branch at JCEF (Site 5)	21-Jul-08		0.2				0.4	1.6	
JCEF		Long Branch at JCEF (Site 3)	13-Oct-08		0.5				0.1	0.6	
JCEF		Long Branch at JCEF (Site 5)	13-Oct-08		0.5				0.5	0.7	
JCEF		Long Branch at JCEF (Site 3)	5-May-09		0.2				0.4	1.1	
JCEF		Long Branch at JCEF (Site 5)	5-May-09		0.2				1.4	1.1	
JCEF		Long Branch at JCEF (Site 3)	27-Aug-09		0.2				0.6	1.8	
URS		Long Branch, Site 1	2-Sep-09	6.6	0.108	1.554	0.66	3.31	< 0.5	0.727	
URS		Long Branch, Site 2	2-Sep-09	2.5	0.025	0.480	0.34	9.98	< 0.5	0.138	
URS		Long Branch, Site 3	2-Sep-09	36.8	0.029	0.657	0.35	5.70	< 0.5	0.147	
URS		Long Branch, Site 4	2-Sep-09	166.2	0.052	1.133	0.28	4.45	< 0.5	0.020	
URS		Long Branch, Site 1	6-Oct-09	43.3	0.445	1.859	13.67	2.32	0.5	0.355	
URS		Long Branch, Site 2	6-Oct-09	54.7	0.131	0.860	15.4	8.50	< 0.5	0.243	
URS		Long Branch, Site 3	6-Oct-09	63.1	0.122	0.707	16.48	7.40	< 0.5	0.277	
URS		Long Branch, Site 4	6-Oct-09	52.1	0.350	2.253	4.56	8.59	< 0.5	0.319	
URS		Long Branch, Site 1	12-Feb-10	9.2	0.112	2.031	1.80	12.19	< 0.5	0.631	
URS		Long Branch, Site 2	12-Feb-10	18.1	0.040	0.803	0.44	10.93	< 0.5	0.311	
URS		Long Branch, Site 3	12-Feb-10	9.0	0.061	1.125	0.63	10.40	< 0.5	0.422	
URS		Long Branch, Site 4	12-Feb-10	30.4	0.061	0.932	0.41	12.73	< 0.5	0.333	
URS		Long Branch, Site 1	20-Apr-10	18	0.091	2.200	-	8.32	< 0.5	0.997	
URS		Long Branch, Site 2	20-Apr-10	6.9	0.040	0.831	0.40	8.26	< 0.5	0.080	
URS		Long Branch, Site 3	20-Apr-10	5.0	0.024	1.330	0.44	7.40	< 0.5	0.487	
URS		Long Branch, Site 4	20-Apr-10	18.9	0.049	1.420	0.13	6.91	< 0.5	0.285	

¹ MDNR = Missouri Department of Natural Resources, JCEF = Johnson Co. Egg Farm, URS = URS Corporation

² JCEF = Johnson Co. Egg Farm, US = Upstream, WAFB = Whiteman Air Force Base

³ NH₃N = Ammonia Nitrogen as N

⁴ NO₃N = Nitrite plus Nitrate as N

Appendix B - Development of TSS Targets Using Reference LDCs

Overview

This procedure is used when a lotic¹⁰ system is placed on the 303(d) List for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the EDU in which the water body is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case, a synthetic flow record is needed. In order to develop a synthetic flow record, calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. Selection of these gages is based on location, land use/soil/topography similarities to the Long Branch watershed and the availability of flow data of sufficient age and duration. In some cases gages from outside an EDU must be used if there are limited numbers of gages or periods of record, such is the case in the EDU in which Long Branch is located. From this synthetic record develop flow duration from which to build a LDC for the pollutant within the EDU.

From this population of load durations, follow the reference method used in setting nutrient targets for streams and rivers in Nutrient Ecoregion IX (EPA, 2000). See EPA (2000) for more detailed information as to how recommended ecoregion nutrient criteria were developed. In this methodology the average concentration of the 25th percentile of pooled data from the EDU is targeted in the TMDL, in the absence of available reference stream data. In this case, data for streams within the EDU and an adjacent, similar EDU were used because of limited data in the target EDU.

Methodology

The first step in this procedure is to locate available pollutant data within the EDU of interest. These data, along with the instantaneous flow measurement taken at the time of sample collection for the specific date, are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more).

¹⁰ Lotic = pertaining to moving water

Figure B-1 shows the application of the approach in the Long Branch EDU (Central Irregular Plains/Blackwater/Lamine and Central Irregular Plains Osage/South Grand EDU). Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure B-1, Table B-1).

Table B-1. Stream Flow Stations Used to Estimate Flows in Long Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi²)	Lognormal Nash-Sutcliffe
Blue River near Stanley, KS	USGS	06893080	46	70%
Lamine River near Otterville, MO	USGS	06906800	543	83%
Little Osage River at Fulton, KS	USGS	06917000	314	70%
Little Osage River at Horton, MO	USGS	06917060	498	83%
Marmaton near Uniontown, KS	USGS	06917240	84	74%
Marmaton near Marmaton, KS	USGS	06917380	292	69%

Table B-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate sediment discharge relationship for the EDU. These are log transformed data for the sediment yield (lbs/day) and the instantaneous stream flow (cfs). Figure B-2 shows the EDU sediment flow relationship. To derive the TMDL curve, the synthetic (or normalized) flow values are multiplied by the watershed area and then applied to the sediment-stream flow relationship to calculate the desirable reference stream sediment loads for various flow conditions (see Figure 6).

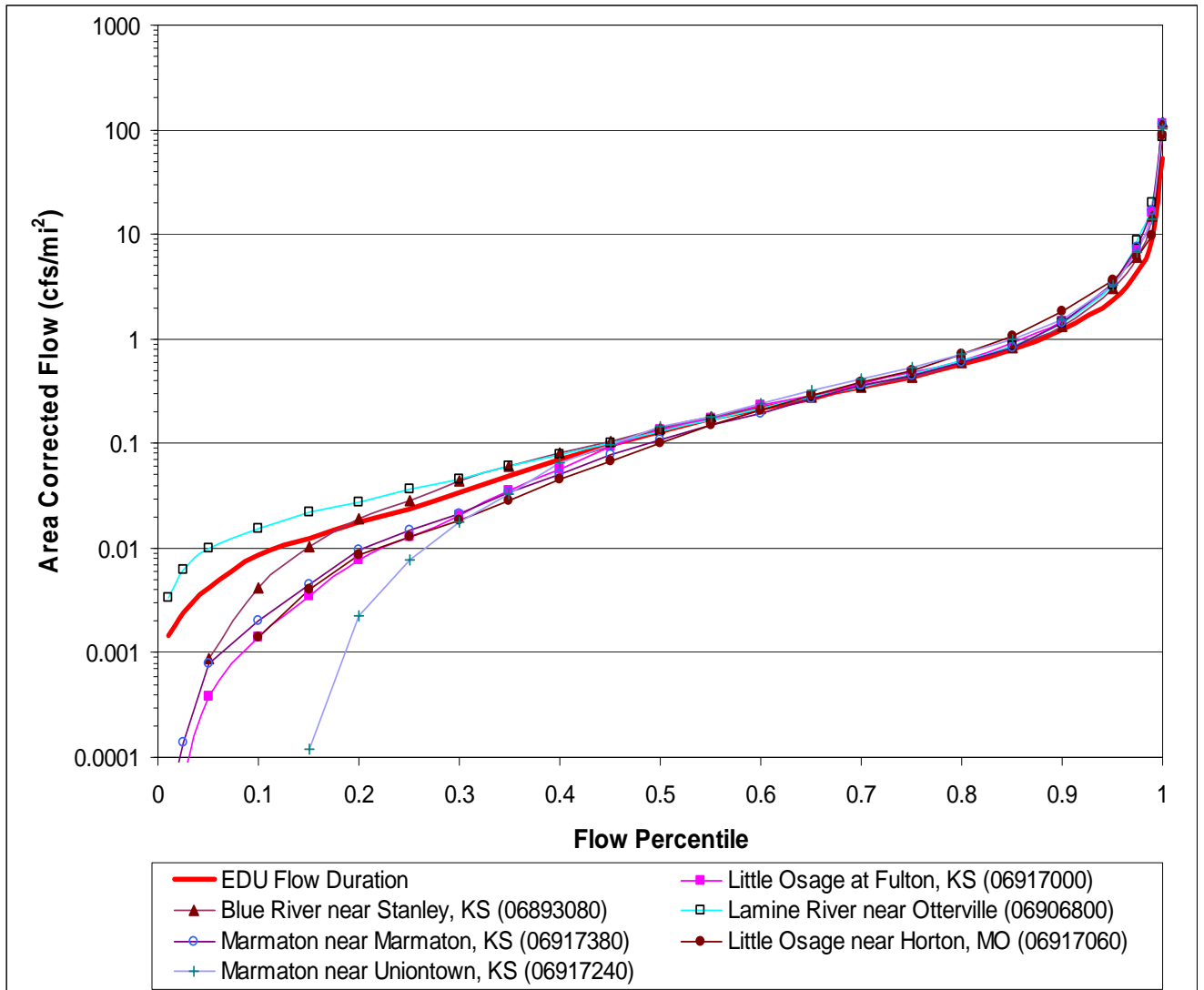


Figure B-1. Synthetic Flow Development in the Central Irregular Plains/Blackwater/Lamine EDU and Central Irregular Plains Osage/South Grand EDU

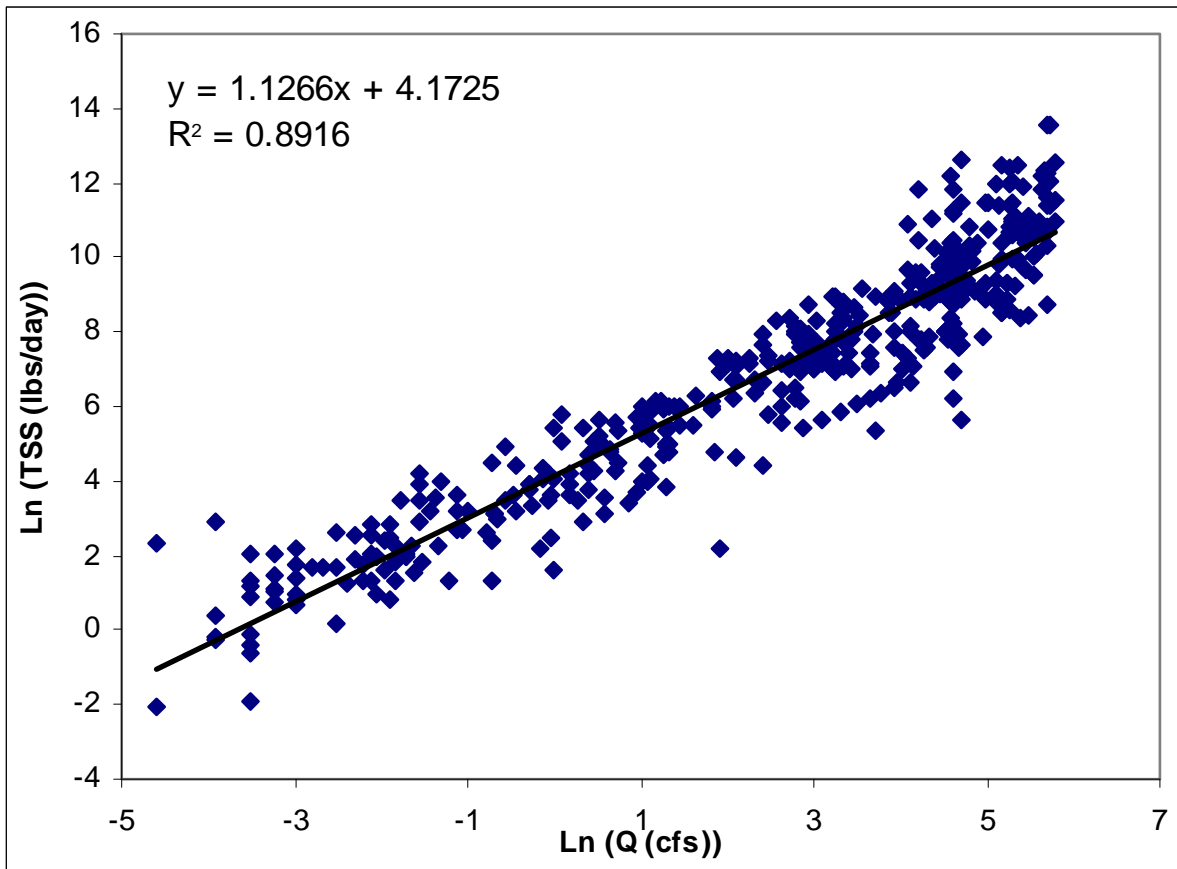


Figure B-2. Estimate of Power Function from Instantaneous Flow in the Central Irregular Plains Blackwater/Lamine and Central Irregular Plains Osage/South Grand EDUs

For more information contact:

U. S. Environmental Protection Agency, Region 7
 Water, Wetlands and Pesticides Division
 Total Maximum Daily Load Program
 901 North 5th Street
 Kansas City, Kansas 66101
 Website: <http://www.epa.gov/region07/water/tmdl.htm>

Appendix C - Development of Nutrient Targets Using Ecoregion Nutrient Criteria with LDCs

Overview

This procedure is used when a lotic system is placed on the 303(d) List of Impaired Waters for nutrient pollutants and the designated use being addressed is aquatic life. In cases where EPA-approved state numeric criteria for the impaired stream are not available a reference approach is used. The target for pollutant loading is the EPA recommended ecoregion nutrient criteria for the specific ecoregion in which the water body is located (EPA, 2000). If a flow record for the impaired stream is not available a synthetic flow record is needed. To develop a synthetic flow record a user should calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is contained within the EDU. Selection of these gages is based on location, land use/soil/topography similarities to the Long Branch watershed and the availability of flow data of sufficient age and duration. In some cases gages from outside an EDU must be used if there are limited numbers of gages or periods of record. Such is the case in the EDU in which Long Branch is located. From this synthetic record develop a flow duration and build a LDC for the pollutant within the EDU.

See EPA (2000) for more detailed information as to how recommended ecoregion nutrient criteria were developed. This appendix describes how the nutrient criteria (TN and TP) are expressed in this TMDL.

Methodology

The first step in this procedure is to gather available nutrient data within the ecoregion of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are required to develop the LDC. Both dates and nutrient concentrations are needed in order to match the measured data used with the synthetic EDU flow record.

Secondly, collect average daily flow data from gages with a variety of drainage areas for a period of time to cover the nutrient record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build the synthetic flow record calculate the Nash-Sutcliffe value to determine if the relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is then used to develop the LDC for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow (typically 20 years or more).

The following example shows the application of the approach for the Central Irregular Plains Blackwater/Lamine and Central Irregular Plains Osage/South Grand EDU. Watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set of all the gages (Figure C-1, Table C-1). Table C-1 demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

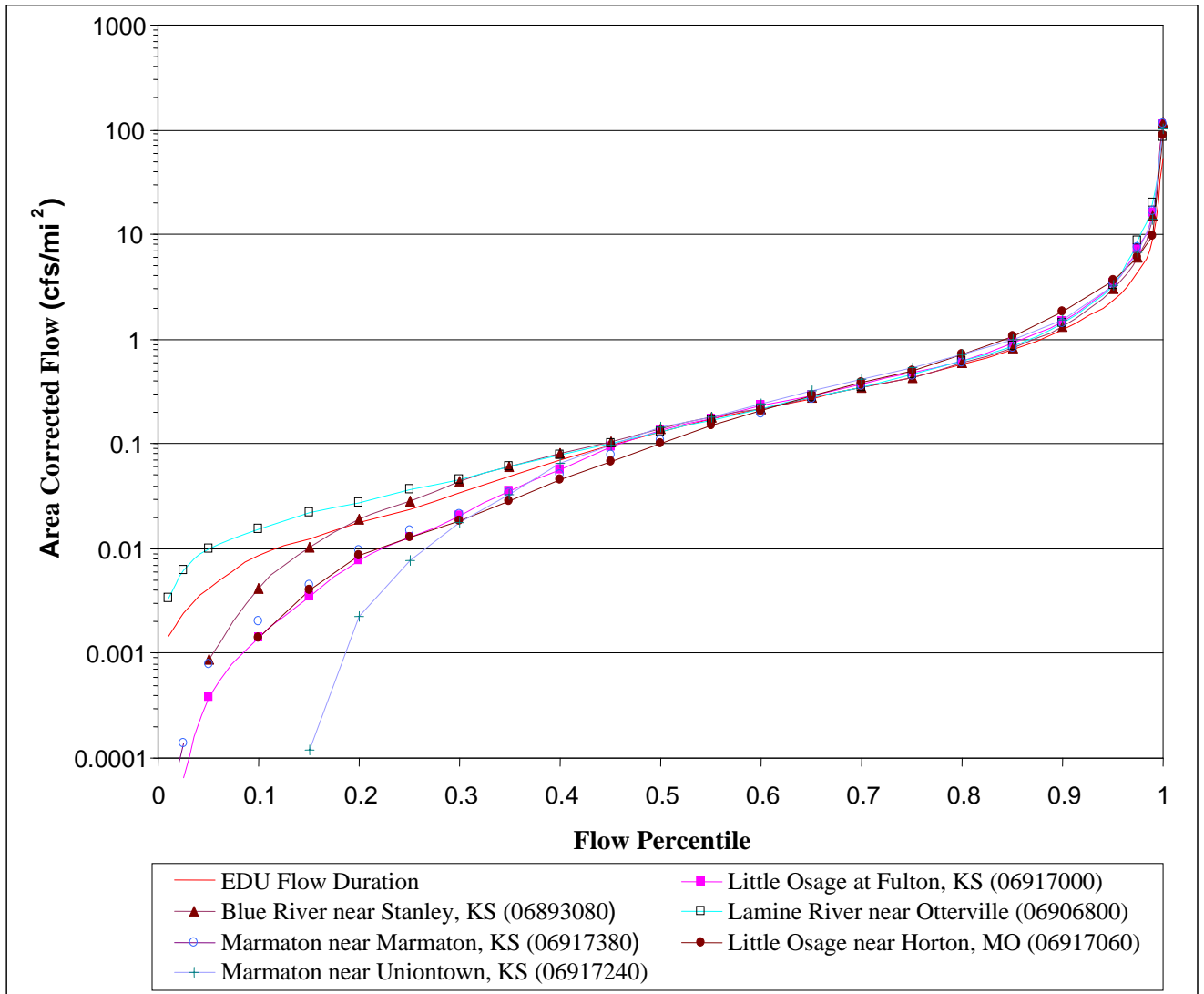


Figure C-1. Synthetic Flow Development in the Central Irregular Plains Blackwater/Lamine and Central Irregular Plains Osage/South Grand EDUs

Table C-1. Stream Flow Stations Used to Estimate Flows in Long Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi ²)	Lognormal Nash-Sutcliffe
Blue River near Stanley, KS	USGS	06893080	46	70%
Lamine River near Otterville, MO	USGS	06906800	543	83%
Little Osage River at Fulton, KS	USGS	06917000	314	70%
Little Osage River at Horton, MO	USGS	06917060	498	83%
Marmaton near Uniontown, KS	USGS	06917240	84	74%
Marmaton near Marmaton, KS	USGS	06917380	292	69%

The next step was to collect previously measured water quality data from within the ecoregion and ideally within the EDU in which the target stream is located. Measured TN and TP concentrations are generally adjusted so their median is equal to the EPA recommended ecoregion criterion. This is accomplished by multiplying each measured data concentration by the ratio of the ecoregion criterion to the measured data median.

The next step was to calculate the TN and TP discharge relationship for the ecoregion using the adjusted data; this is natural log transformed data for the yield (pounds/day) and the instantaneous flow (cfs). Figures C-2 and C-3 show these relationships for this TMDL.

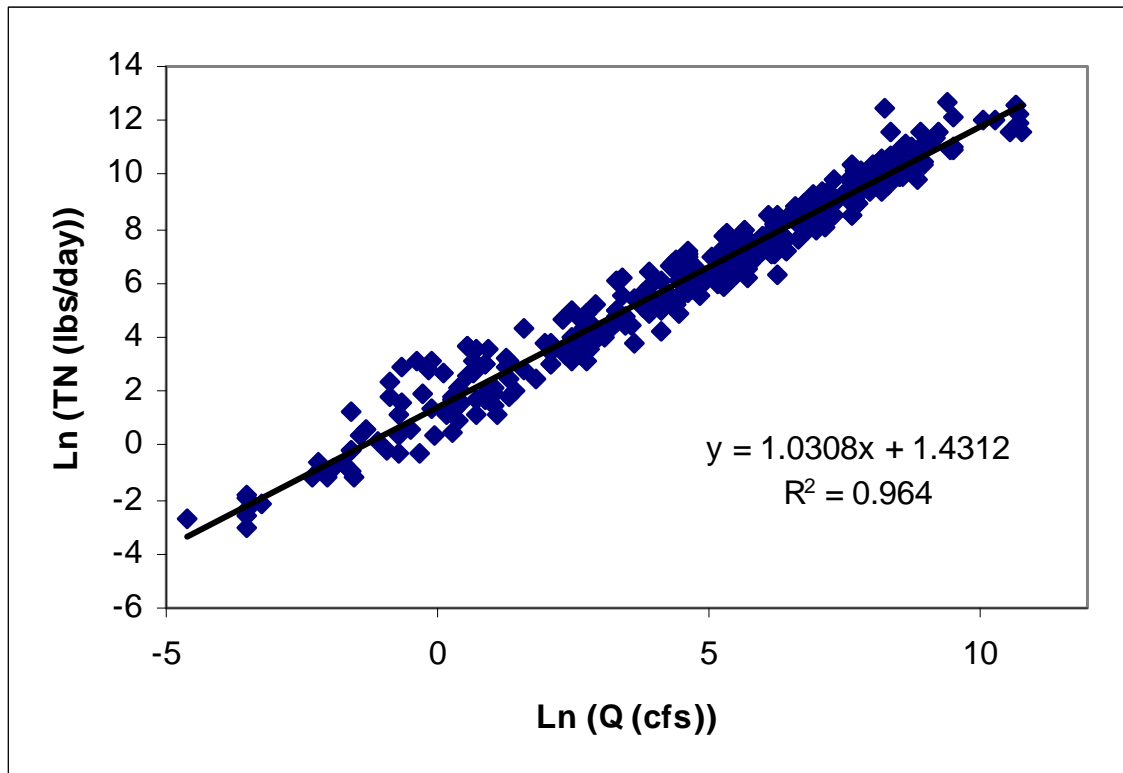


Figure C-2. Load / Flow Relationship Used to Set LDC for TN

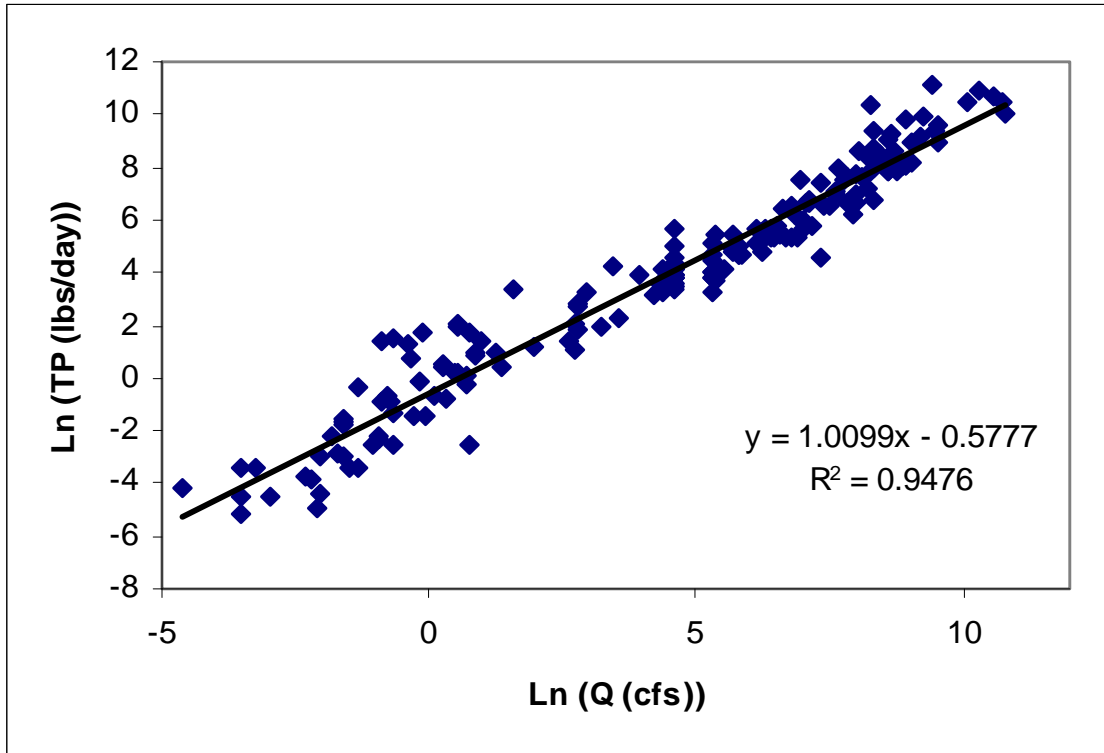


Figure C-3. Load / Flow Relationship Used to Set LDC for TP

This relationship was used to develop a LDC for which the relationship between flow and nutrient distribution is taken into account. In this LDC the targeted concentration is allowed to change at different percentiles of flow exceedance. However, meeting the LDC will result in a water body in which the median concentration is equal to the EPA recommended ecoregion criterion.

To apply this process to a specific watershed entails using the individual watershed data compared to the TMDL curve that has been multiplied by the watershed area (mi^2). Data from the impaired segment is then plotted as a load (pounds/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis. These data points do not have to be collected at the segment outlet. The spreadsheet applies an outlet flow (percentile exceedance) to the concentration based on the synthetic flow estimate for the specific date the sample was taken (Figure C-4).

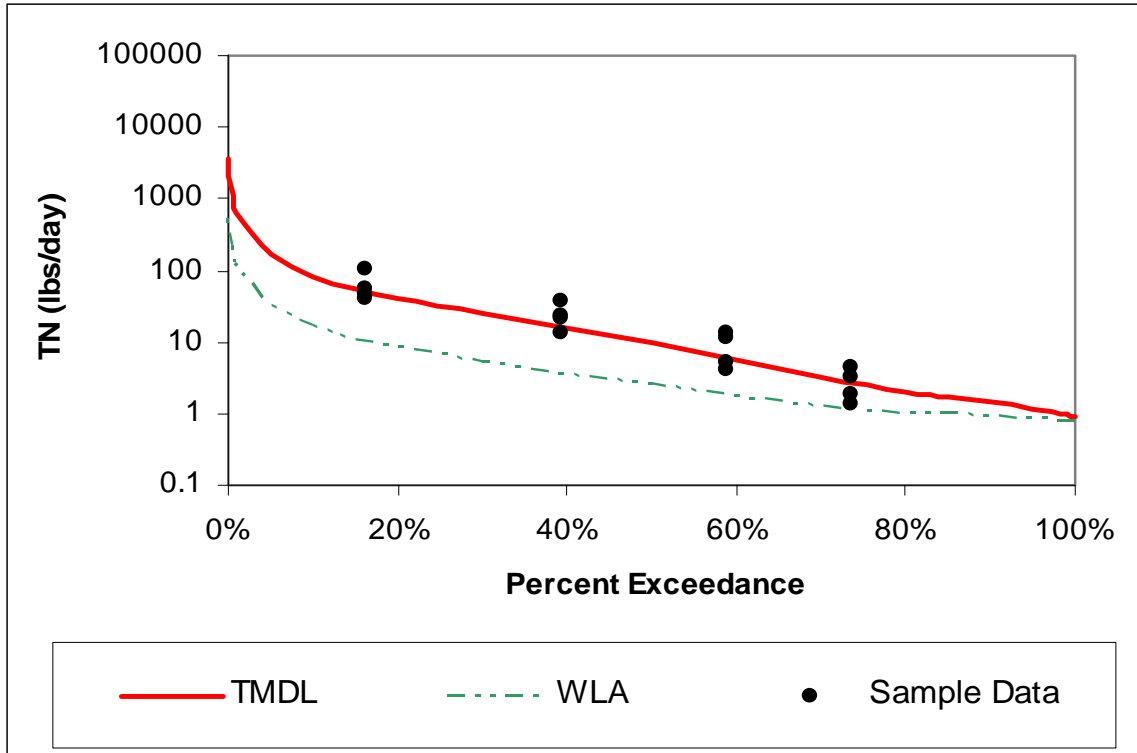


Figure C-4. Example of TMDL LDC Using This Method

The resulting LDC with plotted site specific measured data can now be used to target implementation by identifying flows in which TN concentrations are higher than would be expected in a stream meeting the EPA recommended ecoregion TN criterion.

For more information contact:

U. S. Environmental Protection Agency, Region 7
 Water, Wetlands and Pesticides Division
 Total Maximum Daily Load Program
 901 North 5th Street
 Kansas City, Kansas 66101
 Website: <http://www.epa.gov/region07/water/tmdl.htm>

Appendix D - Stream Flow and Water Quality Stations Used to Develop TMDLs in Long Branch

Table D-1. Stream Flow Stations Used to Estimate Flows in Long Branch

River/Station Name	Data Source	Station Number	Drainage Area (mi ²)
Blue River near Stanley, KS	USGS	06893080	46
Lamine River near Otterville, MO	USGS	06906800	543
Little Osage River at Fulton, KS	USGS	06917000	314
Little Osage River at Horton, MO	USGS	06917060	498
Marmaton near Uniontown, KS	USGS	06917240	84
Marmaton near Marmaton, KS	USGS	06917380	292
Blue River near Stanley, KS	USGS	06893080	46

Table D-2. Stations Used to Develop Water Quality Data Targets in Long Branch

USGS Gage Number	Station Name
06890800	Black Water River at Blue Lick, MO
06893080	Blue River near Stanley, KS
06906800	Lamine River near Otterville, MO
06907300	Lamine River near Pilot Grove, MO
06908800	Lamine River near Blackwater, MO
06914948	Big Bull Tributary near Edgerton, KS
06914950	Big Bull Creek near Edgerton, KS
06914960	Rock Creek near Wellsville, KS
06914970	Smith Branch near Spring Hill, KS
06914980	Wade Branch near Wellsville, KS
06914987	Little Bull Creek near Gardner, KS
06914990	Little Bull Creek near Spring Hill, KS
06916600	Marais des Cygnes River near KS-MO State Line
06917000	Little Osage River at Fulton, KS
06917060	Little Osage River at Horton, MO
06917380	Marmaton near Marmaton, KS
06917630	East Drywood Creek at Prairie State Park
06918070	Osage River above Schell City, MO
06921582	South Grand River below Freeman, MO
06921590	South Grand River at Archie, MO
06921720	Big Creek near Blainstown, MO
06922190	West Fork Tebo Creek near Lewis, MO
06922200	Tebo Creek at Leesville, MO
3844410942043	South Trib Muddy Creek near Harrisonville, MO
3845250942233	Muddy Creek near Harrisonville, MO
3846130942231	North Trib Muddy Creek near Harrisonville, MO

Appendix E

Raw Data Used to Develop Load Duration Curves

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06914950	Big Bull Creek near Edgerton, KS	5/25/1994	USGS-WRD	2.4		3.2	0.338	
06914950	Big Bull Creek near Edgerton, KS	5/25/1994	USGS-WRD	2.4		3.1	0.33	
06914950	Big Bull Creek near Edgerton, KS	8/16/1994	USGS-WRD	0.2		1.6	0.351	
06914950	Big Bull Creek near Edgerton, KS	8/16/1994	USGS-WRD	0.2		1.5	0.291	
06914950	Big Bull Creek near Edgerton, KS	11/1/1994	USGS-WRD	4.9		5.8	1.84	
06914950	Big Bull Creek near Edgerton, KS	3/8/1995	USGS-WRD	1.7		8.8	1.43	
06914950	Big Bull Creek near Edgerton, KS	3/8/1995	USGS-WRD	1.7		8.7	1.32	
06914950	Big Bull Creek near Edgerton, KS	5/10/1995	USGS-WRD	16		2.9	0.354	
06914950	Big Bull Creek near Edgerton, KS	5/10/1995	USGS-WRD	16		2.9	0.319	
06914950	Big Bull Creek near Edgerton, KS	11/4/2002	USGS-WRD	0.46	12		0.35	13
06914950	Big Bull Creek near Edgerton, KS	7/14/2003	USGS-WRD	0.01	5 ¹			9
06914950	Big Bull Creek near Edgerton, KS	3/14/2007	USGSKSWC	5.2	42			37
06914950	Big Bull Creek near Edgerton, KS	4/5/2010	USGSKSWC	11	100			89
06914950	Big Bull Creek near Edgerton, KS	5/25/1994	USGS-WRD	2.4		3.2	0.338	
06914950	Big Bull Creek near Edgerton, KS	5/25/1994	USGS-WRD	2.4		3.1	0.33	
06914950	Big Bull Creek near Edgerton, KS	8/16/1994	USGS-WRD	0.2		1.6	0.351	
06914950	Big Bull Creek near Edgerton, KS	8/16/1994	USGS-WRD	0.2		1.5	0.291	
06914950	Big Bull Creek near Edgerton, KS	11/1/1994	USGS-WRD	4.9		5.8	1.84	
06914950	Big Bull Creek near Edgerton, KS	3/8/1995	USGS-WRD	1.7		8.8	1.43	
06914950	Big Bull Creek near Edgerton, KS	3/8/1995	USGS-WRD	1.7		8.7	1.32	
06914950	Big Bull Creek near Edgerton, KS	5/10/1995	USGS-WRD	16		2.9	0.354	
06914950	Big Bull Creek near Edgerton, KS	5/10/1995	USGS-WRD	16		2.9	0.319	
06914950	Big Bull Creek near Edgerton, KS	11/4/2002	USGS-WRD	0.46	12		0.35	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06914950	Big Bull Creek near Edgerton, KS	7/14/2003	USGS-WRD	0.01	5 ¹			
06914950	Big Bull Creek near Edgerton, KS	3/14/2007	USGSKSWC	5.2	42			
06914950	Big Bull Creek near Edgerton, KS	4/5/2010	USGSKSWC	11	100			
06914948	Big Bull Tributary near Edgerton, KS	5/24/1994	USGS-WRD	0.67		13	1.67	
06914948	Big Bull Tributary near Edgerton, KS	8/16/1994	USGS-WRD	0.42		9.4	3.04	
06914948	Big Bull Tributary near Edgerton, KS	11/1/1994	USGS-WRD	0.9		8.8	1.96	
06914948	Big Bull Tributary near Edgerton, KS	3/8/1995	USGS-WRD	0.52		13	2.89	
06914948	Big Bull Tributary near Edgerton, KS	5/10/1995	USGS-WRD	2.1		5.9	0.854	
06914948	Big Bull Tributary near Edgerton, KS	5/24/1994	USGS-WRD	0.67		13	1.67	
06914948	Big Bull Tributary near Edgerton, KS	8/16/1994	USGS-WRD	0.42		9.4	3.04	
06914948	Big Bull Tributary near Edgerton, KS	11/1/1994	USGS-WRD	0.9		8.8	1.96	
06914948	Big Bull Tributary near Edgerton, KS	3/8/1995	USGS-WRD	0.52		13	2.89	
06914948	Big Bull Tributary near Edgerton, KS	5/10/1995	USGS-WRD	2.1		5.9	0.854	
06921720	Big Creek near Blairstown, MO	10/9/2008	USGS-WRD	11	78		0.21	
06921720	Big Creek near Blairstown, MO	11/4/2008	USGS-WRD	62	19	0.85	0.17	
06921720	Big Creek near Blairstown, MO	1/6/2009	USGS-WRD	144	19	1.1	0.08	
06921720	Big Creek near Blairstown, MO	3/24/2009	USGS-WRD	191	324	1.2	0.34	
06921720	Big Creek near Blairstown, MO	5/19/2009	USGS-WRD	218	76	1.8	0.2	
06921720	Big Creek near Blairstown, MO	7/7/2009	USGS-WRD	28	62	1.3	0.21	
06921720	Big Creek near Blairstown, MO	9/24/2009	USGSMOLS	26	57	1.3	0.3	
06921720	Big Creek near Blairstown, MO	10/28/2009	USGS-WRD	400	60	1.2	0.28	
06921720	Big Creek near Blairstown, MO	11/17/2009	USGS-WRD	777	105	1.9	0.33	
06921720	Big Creek near Blairstown, MO	12/22/2009	USGS-WRD	63	7.5 ¹	E 0.38	0.07	
06921720	Big Creek near Blairstown, MO	1/21/2010	USGS-WRD	2180	347	2.4	0.6	
06921720	Big Creek near Blairstown, MO	2/5/2010	USGS-WRD	238	7.5 ¹	1.1	0.09	
06921720	Big Creek near Blairstown, MO	3/10/2010	USGS-WRD	235	53	0.76	0.13	
06921720	Big Creek near Blairstown, MO	4/27/2010	USGSMOLS	505	146	2	0.28	
06921720	Big Creek near Blairstown, MO	5/27/2010	USGSMOLS	515	226	2.6	0.4	
06921720	Big Creek near Blairstown, MO	6/23/2010	USGS-WRD	174	73	1.4	0.18	
06908000	Black Water River at Blue Lick, MO	5/3/2007	USGS-WRD	2200	500	4.5	0.64	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06893080	Blue River near Stanley, KS	5/24/1990	USGS-WRD	4880				
06893080	Blue River near Stanley, KS	7/18/2003	USGS-WRD	0.08				
06893080	Blue River near Stanley, KS	3/14/2007	USGSKSWC	17		11		
06893080	Blue River near Stanley, KS	4/5/2010	USGSKSWC	20		22		
06917630	East Drywood Creek at Prairie State Park, MO	11/23/1993	USGS-WRD	1.5			0.04	
06917630	East Drywood Creek at Prairie State Park, MO	1/25/1994	USGS-WRD	3	22	0.4	0.02	
06917630	East Drywood Creek at Prairie State Park, MO	3/17/1994	USGS-WRD	0.92		0.24	0.03	
06917630	East Drywood Creek at Prairie State Park, MO	3/17/1994	USGS-WRD			0.24	0.03	
06917630	East Drywood Creek at Prairie State Park, MO	4/19/1994	USGS	1.6			0.03	
06917630	East Drywood Creek at Prairie State Park, MO	6/22/1994	USGS-WRD	0.1	26		0.05	
06917630	East Drywood Creek at Prairie State Park, MO	11/29/1994	USGS-WRD	3			0.02	
06917630	East Drywood Creek at Prairie State Park, MO	1/9/1995	USGS-WRD	0.93	14		0.05	
06917630	East Drywood Creek at Prairie State Park, MO	3/7/1995	USGS-WRD	3			0.04	
06917630	East Drywood Creek at Prairie State Park, MO	4/14/1995	USGS-WRD	0.9			0.03	
06917630	East Drywood Creek at Prairie State Park, MO	5/16/1995	USGS-WRD	0.95			0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	6/27/1995	USGS-WRD	2	14		0.05	
06917630	East Drywood Creek at Prairie State Park, MO	1/7/1996	USGS-WRD	0.94				
06917630	East Drywood Creek at Prairie State Park, MO	3/18/1996	USGS-WRD	0.1			0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	4/1/1996	USGS-WRD	0.11		0.92	0.06	
06917630	East Drywood Creek at Prairie State Park, MO	4/24/1996	USGS-WRD	0.76			0.04	
06917630	East Drywood Creek at Prairie State Park, MO	5/7/1996	USGS-WRD	14	11	0.87	0.06	
06917630	East Drywood Creek at Prairie State Park, MO	6/19/1996	USGS-WRD	0.5	18	2.2	0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	8/28/1996	USGS-WRD	12			0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	11/5/1996	USGS-WRD	1.6			0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	1/7/1997	USGS	0.94			0.01	
06917630	East Drywood Creek at Prairie State Park, MO	1/23/1997	USGS-WRD	2.6	6	1.1	0.04	
06917630	East Drywood Creek at Prairie State Park, MO	3/4/1997	USGS-WRD	1.6			0.06	
06917630	East Drywood Creek at Prairie State Park, MO	4/15/1997	USGS-WRD	1.7			0.02	
06917630	East Drywood Creek at Prairie State Park, MO	6/24/1997	USGS		9		0.01 ¹	
06917630	East Drywood Creek at Prairie State Park, MO	10/15/1997	USGS-WRD	1.6			0.05	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917630	East Drywood Creek at Prairie State Park, MO	4/23/2008	USGS-WRD	1.5	11		E 0.03	
06917630	East Drywood Creek at Prairie State Park, MO	5/13/2008	USGS-WRD	1.8	5 ¹		E 0.03	
06917630	East Drywood Creek at Prairie State Park, MO	7/29/2008	USGS-WRD	0.18	16	0.97	0.1	17
06917630	East Drywood Creek at Prairie State Park, MO	9/10/2008	USGS-WRD	0.22		E 0.52	0.05	11
06917630	East Drywood Creek at Prairie State Park, MO	11/5/2008	USGS-WRD	0.26			0.04	14
06917630	East Drywood Creek at Prairie State Park, MO	1/7/2009	USGS-WRD	1.8	7.5 ¹		E 0.03	
06917630	East Drywood Creek at Prairie State Park, MO	4/15/2009	USGS-WRD	2.8	7.5 ¹	0.9	0.04	
06917630	East Drywood Creek at Prairie State Park, MO	5/20/2009	USGS-WRD	0.97	15 ¹		E 0.03	
06917630	East Drywood Creek at Prairie State Park, MO	10/14/2009	USGS-WRD	3	7.5 ¹		0.05	
06917630	East Drywood Creek at Prairie State Park, MO	1/20/2010	USGS-WRD	2.9	7.5 ¹	0.55	E 0.03	
06917630	East Drywood Creek at Prairie State Park, MO	3/11/2010	USGS-WRD	6.3	7.5 ¹	E 0.7	0.07	
06917630	East Drywood Creek at Prairie State Park, MO	5/26/2010	USGSMOLS	0.37	26		0.06	
06914987	L Bull Creek near Gardner, KS	5/23/1994	USGS-WRD	0.42		5.2	0.309	
06914987	L Bull Creek near Gardner, KS	8/15/1994	USGS-WRD	0.2		6.5	0.28	
06914987	L Bull Creek near Gardner, KS	10/31/1994	USGS-WRD	19		3.5	0.442	
06914987	L Bull Creek near Gardner, KS	3/9/1995	USGS-WRD	0.86		6.9	0.333	
06914987	L Bull Creek near Gardner, KS	5/9/1995	USGS-WRD	2.6		5	0.492	
06914990	L Bull Creek near Springhill KS	5/23/1994	USGS-WRD	2		2.7	0.172	
06914990	L Bull Creek near Springhill KS	8/15/1994	USGS-WRD	0.16			0.224	
06914990	L Bull Creek near Springhill KS	10/31/1994	USGS-WRD	31		5.8	0.714	
06914990	L Bull Creek near Springhill KS	3/9/1995	USGS-WRD	1.1		5.1	0.146	
06914990	L Bull Creek near Springhill KS	5/9/1995	USGS-WRD	14		2.7	0.093	
06908800	Lamine River near Blackwater, MO	3/20/1979	USGS	3720		3.9	0.39	366
06908800	Lamine River near Blackwater, MO	4/19/1979	USGS	874		3.4	0.22	133
06908800	Lamine River near Blackwater, MO	5/8/1979	USGS	965		3.1	0.18	
06908800	Lamine River near Blackwater, MO	6/12/1979	USGS	2160		5.7	0.43	609
06908800	Lamine River near Blackwater, MO	7/10/1979	USGS	214		4	0.33	480
06908800	Lamine River near Blackwater, MO	4/1/1980	USGS	7460		5.5	0.78	910
06908800	Lamine River near Blackwater, MO	6/2/1980	USGS	3890		25	2.6	3880
06908800	Lamine River near Blackwater, MO	7/6/1981	USGS	4080		3.7	0.51	1430

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06908800	Lamine River near Blackwater, MO	11/2/1981	USGSNWQL	2500		3.8	0.26	1960
06908800	Lamine River near Blackwater, MO	1/4/1982	USGSNWQL	880		3.2	0.25	13
06908800	Lamine River near Blackwater, MO	3/8/1982	USGSNWQL			2.7	0.15	20
06908800	Lamine River near Blackwater, MO	5/10/1982	USGSNWQL	760		2.9	0.25	127
06908800	Lamine River near Blackwater, MO	7/13/1982	USGSNWQL			3	0.1	119
06908800	Lamine River near Blackwater, MO	9/21/1982	USGSNWQL	100		2.9	0.26	84
06908800	Lamine River near Blackwater, MO	11/2/1982	USGSNWQL			5.1	0.52	11
06908800	Lamine River near Blackwater, MO	1/4/1983	USGSNWQL	E 100		4.5	0.2	38
06908800	Lamine River near Blackwater, MO	3/7/1983	USGSNWQL	100		3.9	0.22	298
06908800	Lamine River near Blackwater, MO	5/10/1983	USGS-WRD	200		4.3	0.14	110
06908800	Lamine River near Blackwater, MO	7/18/1983	USGS-WRD	100		3.4	0.15	57
06908800	Lamine River near Blackwater, MO	9/27/1983	USGS-WRD			3.6	0.16	81
06908800	Lamine River near Blackwater, MO	10/11/1983	USGS-WRD	50		4.7	0.33	38
06908800	Lamine River near Blackwater, MO	11/23/1983	USGS-WRD	12500		10	1.8	3060
06908800	Lamine River near Blackwater, MO	12/15/1983	USGS-WRD	100		4.4	0.21	15
06908800	Lamine River near Blackwater, MO	1/12/1984	USGS-WRD	100		3.9	0.16	78
06908800	Lamine River near Blackwater, MO	2/16/1984	USGS-WRD	100		2.7	0.12	50
06908800	Lamine River near Blackwater, MO	3/15/1984	USGS-WRD	4220		3.9	0.23	278
06908800	Lamine River near Blackwater, MO	4/12/1984	USGS-WRD	10000		3.2	0.3	295
06908800	Lamine River near Blackwater, MO	5/15/1984	USGS-WRD	450		4.2	0.12	47
06908800	Lamine River near Blackwater, MO	6/14/1984	USGS-WRD	1500		4.5	0.35	445
06908800	Lamine River near Blackwater, MO	7/24/1984	USGS-WRD	100		1.9	0.11	50
06908800	Lamine River near Blackwater, MO	8/21/1984	USGS-WRD	100		2.1	0.16	77
06908800	Lamine River near Blackwater, MO	9/18/1984	USGS-WRD	200		2.4	0.28	122
06908800	Lamine River near Blackwater, MO	10/10/1984	USGS-WRD	100		2.1	0.31	277
06908800	Lamine River near Blackwater, MO	11/13/1984	USGS-WRD			2.5	0.21	76
06908800	Lamine River near Blackwater, MO	12/11/1984	USGS-WRD	100		2.2	0.19	134
06908800	Lamine River near Blackwater, MO	1/15/1985	USGS-WRD	100		3.6	0.11	29
06908800	Lamine River near Blackwater, MO	2/13/1985	USGS-WRD	100		5	0.15	24
06908800	Lamine River near Blackwater, MO	3/12/1985	USGS-WRD	5340		4.2	0.49	576

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06908800	Lamine River near Blackwater, MO	4/2/1985	USGS-WRD	100		2.6	0.17	48
06908800	Lamine River near Blackwater, MO	5/7/1985	USGS-WRD	100		1.8	0.91	10
06908800	Lamine River near Blackwater, MO	6/4/1985	USGS-WRD	10400		3.6	0.66	1870
06908800	Lamine River near Blackwater, MO	7/16/1985	USGS-WRD	100		3.2	0.46	535
06908800	Lamine River near Blackwater, MO	8/13/1985	USGS-WRD	100		1.9	0.14	56
06908800	Lamine River near Blackwater, MO	9/17/1985	USGS-WRD	100		1.6	0.19	120
06908800	Lamine River near Blackwater, MO	11/12/1985	USGS-WRD	80		4.2	0.26	54
06908800	Lamine River near Blackwater, MO	12/10/1985	USGS-WRD	85		2.4	0.14	44
06908800	Lamine River near Blackwater, MO	1/13/1986	USGS-WRD	75		3.6	0.15	10
06908800	Lamine River near Blackwater, MO	2/3/1986	USGS-WRD	170		6.3	0.34	
06908800	Lamine River near Blackwater, MO	3/5/1986	USGS-WRD	100		3.2	0.12	4
06908800	Lamine River near Blackwater, MO	4/1/1986	USGS-WRD	100		1.5	0.14	56
06908800	Lamine River near Blackwater, MO	5/8/1986	USGS-WRD	100		1.1	0.09	26
06908800	Lamine River near Blackwater, MO	6/2/1986	USGS-WRD	100		3.6	0.16	52
06908800	Lamine River near Blackwater, MO	7/18/1986	USGS-WRD	2000		1.7	0.2	66
06908800	Lamine River near Blackwater, MO	8/14/1986	USGS-WRD	100		1.8	0.15	2
06908800	Lamine River near Blackwater, MO	9/2/1986	USGS-WRD	300		0.81	0.24	8
06907300	Lamine River near Pilot Grove, MO	11/8/1999	USGS-WRD	28	17		0.27	
06907300	Lamine River near Pilot Grove, MO	1/4/2000	USGS-WRD	40		2	0.47	
06907300	Lamine River near Pilot Grove, MO	2/2/2000	USGS-WRD	16		5.5	2	
06907300	Lamine River near Pilot Grove, MO	3/7/2000	USGS-WRD	113		2.3	0.41	
06907300	Lamine River near Pilot Grove, MO	4/4/2000	USGS-WRD	40		0.88	0.35	
06907300	Lamine River near Pilot Grove, MO	5/2/2000	USGS-WRD	30	23		0.24	
06907300	Lamine River near Pilot Grove, MO	6/13/2000	USGS-WRD	259		2.3	0.31	
06907300	Lamine River near Pilot Grove, MO	7/11/2000	USGS-WRD	107	30	1.1	0.2	
06907300	Lamine River near Pilot Grove, MO	9/13/2000	USGS-WRD	15			0.18	
06907300	Lamine River near Pilot Grove, MO	11/21/2000	USGS-WRD	68	14	1.4	0.28	
06907300	Lamine River near Pilot Grove, MO	2/13/2001	USGS-WRD	689		3	0.33	
06907300	Lamine River near Pilot Grove, MO	3/6/2001	USGS-WRD	909		2.9	0.25	
06907300	Lamine River near Pilot Grove, MO	4/17/2001	USGS-WRD	1550		2.4	0.44	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06907300	Lamine River near Pilot Grove, MO	5/2/2001	USGS-WRD	144	31		0.18	
06907300	Lamine River near Pilot Grove, MO	6/18/2001	USGS-WRD	370		1.6	0.29	
06907300	Lamine River near Pilot Grove, MO	7/11/2001	USGS-WRD	117	71	1.7	0.29	
06907300	Lamine River near Pilot Grove, MO	9/5/2001	USGS-WRD	51		1.5	0.45	
06907300	Lamine River near Pilot Grove, MO	11/6/2001	USGS-WRD	87	74	E 0.55	0.2	
06907300	Lamine River near Pilot Grove, MO	1/8/2002	USGS-WRD	51	5 ¹	2.6	1.33	
06907300	Lamine River near Pilot Grove, MO	2/4/2002	USGS-WRD	526	68	3.4	0.35	
06907300	Lamine River near Pilot Grove, MO	3/6/2002	USGS-WRD	234	26	E 1.0	0.28	
06907300	Lamine River near Pilot Grove, MO	4/10/2002	USGS-WRD	128	28	E 0.76	0.35	
06907300	Lamine River near Pilot Grove, MO	5/7/2002	USGS-WRD	2030	395	3.4	0.72	
06907300	Lamine River near Pilot Grove, MO	6/11/2002	USGS-WRD	98	26	2.4	0.39	
06907300	Lamine River near Pilot Grove, MO	7/16/2002	USGS-WRD	94	111		0.21	
06907300	Lamine River near Pilot Grove, MO	9/5/2002	USGS-WRD	17	23	E 0.74	0.17	
06907300	Lamine River near Pilot Grove, MO	11/12/2002	USGS-WRD	18	5 ¹	1.6	1.51	
06907300	Lamine River near Pilot Grove, MO	1/13/2003	USGS-WRD	27	5 ¹	6.1	2.24	
06907300	Lamine River near Pilot Grove, MO	2/3/2003	USGS-WRD	33	5 ¹	0.95	1.63	
06907300	Lamine River near Pilot Grove, MO	3/10/2003	USGS-WRD	38	5 ¹	0.44	E 0.02	
06907300	Lamine River near Pilot Grove, MO	4/9/2003	USGS-WRD	302	39	0.62	0.22	
06907300	Lamine River near Pilot Grove, MO	5/27/2003	USGS-WRD	82	36		0.28	
06907300	Lamine River near Pilot Grove, MO	6/16/2003	USGS-WRD	113	64	2.2	0.39	
06907300	Lamine River near Pilot Grove, MO	7/15/2003	USGS-WRD	16	12		0.22	
06907300	Lamine River near Pilot Grove, MO	9/3/2003	USGS-WRD	1040	106	2.6	0.53	
06907300	Lamine River near Pilot Grove, MO	11/24/2003	USGS-WRD	163	16	2.5	0.39	
06907300	Lamine River near Pilot Grove, MO	1/14/2004	USGS-WRD	187	15	2.3	0.24	
06907300	Lamine River near Pilot Grove, MO	2/2/2004	USGS-WRD	196	11	2.5	0.43	
06907300	Lamine River near Pilot Grove, MO	3/9/2004	USGS-WRD	782	90	2.8	0.28	
06907300	Lamine River near Pilot Grove, MO	4/19/2004	USGS-WRD	98	17	1.3	0.28	
06907300	Lamine River near Pilot Grove, MO	5/20/2004	USGS-WRD	6490	548	3.6	0.95	
06907300	Lamine River near Pilot Grove, MO	6/15/2004	USGS-WRD	877	166	2.6	0.48	
06907300	Lamine River near Pilot Grove, MO	7/6/2004	USGS-WRD	755	460	3.2	0.97	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06907300	Lamine River near Pilot Grove, MO	9/20/2004	USGS-WRD	357	29	1.5	0.21	
06907300	Lamine River near Pilot Grove, MO	11/30/2004	USGS-WRD	1260	123	1.9	0.32	
06907300	Lamine River near Pilot Grove, MO	1/24/2005	USGS-WRD	401	27	2.2	0.16	
06907300	Lamine River near Pilot Grove, MO	2/15/2005	USGS-WRD	5370	182	2.5	0.42	
06907300	Lamine River near Pilot Grove, MO	3/8/2005	USGS-WRD	1130	135	2.5	0.46	
06907300	Lamine River near Pilot Grove, MO	4/4/2005	USGS-WRD	112	26	1	0.12	
06907300	Lamine River near Pilot Grove, MO	5/2/2005	USGS-WRD	164	29	1.1	0.17	
06907300	Lamine River near Pilot Grove, MO	6/22/2005	USGS-WRD	78	56	4.2	0.25	
06907300	Lamine River near Pilot Grove, MO	7/12/2005	USGS-WRD	32	36		0.16	
06907300	Lamine River near Pilot Grove, MO	9/7/2005	USGS-WRD	51	15	1	0.14	
06907300	Lamine River near Pilot Grove, MO	11/2/2005	USGS-WRD	207	20	4.7	1.01	
06907300	Lamine River near Pilot Grove, MO	1/3/2006	USGS-WRD	44	5 ¹	2.4	0.67	
06907300	Lamine River near Pilot Grove, MO	2/6/2006	USGS-WRD	62	5 ¹	2.6	0.92	
06907300	Lamine River near Pilot Grove, MO	3/7/2006	USGS-WRD	38	12	2.3	0.63	
06907300	Lamine River near Pilot Grove, MO	4/10/2006	USGS-WRD	95	30	1.2	0.27	
06907300	Lamine River near Pilot Grove, MO	5/4/2006	USGS-WRD	299	58	3.7	0.29	
06907300	Lamine River near Pilot Grove, MO	6/14/2006	USGS-WRD	89	62	1.9	0.36	
06907300	Lamine River near Pilot Grove, MO	7/6/2006	USGS-WRD	21	27		0.23	
06907300	Lamine River near Pilot Grove, MO	9/6/2006	USGS-WRD	12	50	4.4	1.36	
06907300	Lamine River near Pilot Grove, MO	11/6/2006	USGS	26	16	1.3	0.47	
06907300	Lamine River near Pilot Grove, MO	1/4/2007	USGS	245	78	1.6	0.38	
06907300	Lamine River near Pilot Grove, MO	2/14/2007	USGS-WRD	3330	183	3.6	0.75	
06907300	Lamine River near Pilot Grove, MO	3/7/2007	USGS	252	60	2.7	0.28	
06907300	Lamine River near Pilot Grove, MO	4/3/2007	USGS	482	80	1.6	0.22	
06907300	Lamine River near Pilot Grove, MO	5/3/2007	USGS-WRD	4820	460	3.6	0.87	
06907300	Lamine River near Pilot Grove, MO	6/6/2007	USGS-WRD	105	106	2.3	0.37	
06907300	Lamine River near Pilot Grove, MO	7/10/2007	USGS-WRD	171	42	1.4	0.19	
06907300	Lamine River near Pilot Grove, MO	9/11/2007	USGS-WRD	18	30		0.15	
06907300	Lamine River near Pilot Grove, MO	11/6/2007	USGS-WRD	28	31	1.9	0.33	
06907300	Lamine River near Pilot Grove, MO	1/9/2008	USGS-WRD	3300	310	3	0.77	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06907300	Lamine River near Pilot Grove, MO	3/6/2008	USGS-WRD	957	152	3	0.45	
06907300	Lamine River near Pilot Grove, MO	5/6/2008	USGS-WRD	485	28	1.7	0.25	
06907300	Lamine River near Pilot Grove, MO	7/9/2008	USGS-WRD	516	69	1.6	0.23	
06907300	Lamine River near Pilot Grove, MO	9/2/2008	USGS-WRD	62	22		0.16	
06907300	Lamine River near Pilot Grove, MO	10/21/2008	USGS-WRD	109	7.5 ¹	1.8	0.23	
06907300	Lamine River near Pilot Grove, MO	1/12/2009	USGS-WRD	106	7.5 ¹	2	0.3	
06907300	Lamine River near Pilot Grove, MO	3/9/2009	USGS-WRD	98	32	1.1	0.42	
06907300	Lamine River near Pilot Grove, MO	5/5/2009	USGS-WRD	1220	110	1.9	0.27	
06907300	Lamine River near Pilot Grove, MO	7/29/2009	USGS-WRD	109	45	1.8	0.23	
06907300	Lamine River near Pilot Grove, MO	9/2/2009	USGS-WRD	38	17		0.1	
06907300	Lamine River near Pilot Grove, MO	10/16/2009	USGS-WRD	3560	153	1.7	0.42	
06907300	Lamine River near Pilot Grove, MO	1/14/2010	USGS-WRD	E 220	7.5 ¹	1.7	0.06	
06907300	Lamine River near Pilot Grove, MO	3/2/2010	USGS-WRD	828	28	1.7	0.13	
06907300	Lamine River near Pilot Grove, MO	4/14/2010	USGS-WRD	71	41	1.4	0.17	
06907300	Lamine River near Pilot Grove, MO	5/26/2010	USGS	1450		3.2	0.71	
06907300	Lamine River near Pilot Grove, MO	6/15/2010	USGS-WRD		24	1.2	0.23	
06907300	Lamine River near Pilot Grove, MO	7/6/2010	USGS-WRD	1130		1.1	0.22	
06914990	Little Bull Creek	5/23/1994	USGS-WRD	2		2.7	0.172	
06914990	Little Bull Creek	8/15/1994	USGS-WRD	0.16		1.1 ¹	0.224	
06914990	Little Bull Creek	10/31/1994	USGS-WRD	31		5.8	0.714	
06914990	Little Bull Creek	3/9/1995	USGS-WRD	1.1		5.1	0.146	
06914990	Little Bull Creek	5/9/1995	USGS-WRD	14		2.7	0.093	
06914987	Little Bull Creek near Gardner, KS	5/23/1994	USGS-WRD	0.42		5.2	0.309	
06914987	Little Bull Creek near Gardner, KS	8/15/1994	USGS-WRD	0.2		6.5	0.28	
06914987	Little Bull Creek near Gardner, KS	10/31/1994	USGS-WRD	19		3.5	0.442	
06914987	Little Bull Creek near Gardner, KS	3/9/1995	USGS-WRD	0.86		6.9	0.333	
06914987	Little Bull Creek near Gardner, KS	5/9/1995	USGS-WRD	2.6		5	0.492	
06917000	Little Osage River at Fulton, KS	5/9/1980	USGS	25				36
06917000	Little Osage River at Fulton, KS	5/12/1980	USGS	22				22
06917000	Little Osage River at Fulton, KS	5/16/1980	USGS	16				88

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	5/19/1980	USGS	16				30
06917000	Little Osage River at Fulton, KS	5/23/1980	USGS	10				32
06917000	Little Osage River at Fulton, KS	5/26/1980	USGS	9.4				61
06917000	Little Osage River at Fulton, KS	5/30/1980	USGS	8				40
06917000	Little Osage River at Fulton, KS	6/2/1980	USGS	6.1				24
06917000	Little Osage River at Fulton, KS	6/6/1980	USGS	3.6				15
06917000	Little Osage River at Fulton, KS	6/9/1980	USGS	2.1				17
06917000	Little Osage River at Fulton, KS	6/13/1980	USGS	0.65				15
06917000	Little Osage River at Fulton, KS	6/16/1980	USGS	0.21				127
06917000	Little Osage River at Fulton, KS	6/20/1980	USGS	77				37
06917000	Little Osage River at Fulton, KS	6/21/1980	USGS	302				1030
06917000	Little Osage River at Fulton, KS	6/22/1980	USGS	147				259
06917000	Little Osage River at Fulton, KS	6/26/1980	USGS	15		1.4	0.17	114
06917000	Little Osage River at Fulton, KS	6/27/1980	USGS	8.3				67
06917000	Little Osage River at Fulton, KS	6/30/1980	USGS	2.6				47
06917000	Little Osage River at Fulton, KS	7/4/1980	USGS	1.9				26
06917000	Little Osage River at Fulton, KS	7/7/1980	USGS	0.76				25
06917000	Little Osage River at Fulton, KS	7/11/1980	USGS	0.33				18
06917000	Little Osage River at Fulton, KS	7/14/1980	USGS	0.17				77
06917000	Little Osage River at Fulton, KS	7/18/1980	USGS	0.09				15
06917000	Little Osage River at Fulton, KS	7/21/1980	USGS	0.02				15
06917000	Little Osage River at Fulton, KS	7/22/1980	USGS	0.2		1.4	0.14	
06917000	Little Osage River at Fulton, KS	7/25/1980	USGS	0.08				68
06917000	Little Osage River at Fulton, KS	7/28/1980	USGS	0.15				46
06917000	Little Osage River at Fulton, KS	8/1/1980	USGS	0.04				78
06917000	Little Osage River at Fulton, KS	8/11/1980	USGS	0.15				30
06917000	Little Osage River at Fulton, KS	8/15/1980	USGS	3				33
06917000	Little Osage River at Fulton, KS	8/18/1980	USGS	6.1				29
06917000	Little Osage River at Fulton, KS	8/19/1980	USGS	4		1.8	0.12	40
06917000	Little Osage River at Fulton, KS	8/22/1980	USGS	2.8				56

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	8/25/1980	USGS	1.7				65
06917000	Little Osage River at Fulton, KS	8/29/1980	USGS	1.1				55
06917000	Little Osage River at Fulton, KS	9/1/1980	USGS	0.98				93
06917000	Little Osage River at Fulton, KS	9/5/1980	USGS	0.33				29
06917000	Little Osage River at Fulton, KS	9/8/1980	USGS	0.04				21
06917000	Little Osage River at Fulton, KS	10/27/1980	USGS	0.03				42
06917000	Little Osage River at Fulton, KS	11/1/1980	USGS	0.02				29
06917000	Little Osage River at Fulton, KS	11/4/1980	USGS	0.02				363
06917000	Little Osage River at Fulton, KS	11/24/1980	USGS	0.05				44
06917000	Little Osage River at Fulton, KS	11/28/1980	USGS	0.06				36
06917000	Little Osage River at Fulton, KS	12/5/1980	USGS	0.05				32
06917000	Little Osage River at Fulton, KS	12/8/1980	USGS	0.07				30
06917000	Little Osage River at Fulton, KS	12/12/1980	USGS	0.05				16
06917000	Little Osage River at Fulton, KS	12/15/1980	USGS	0.05				21
06917000	Little Osage River at Fulton, KS	12/19/1980	USGS	0.05				18
06917000	Little Osage River at Fulton, KS	12/22/1980	USGS	0.04				30
06917000	Little Osage River at Fulton, KS	12/26/1980	USGS	0.04				27
06917000	Little Osage River at Fulton, KS	12/29/1980	USGS	0.04				42
06917000	Little Osage River at Fulton, KS	1/2/1981	USGS	0.03				7
06917000	Little Osage River at Fulton, KS	1/5/1981	USGS	0.02				16
06917000	Little Osage River at Fulton, KS	1/9/1981	USGS	0.03				12
06917000	Little Osage River at Fulton, KS	1/12/1981	USGS	0.08				26
06917000	Little Osage River at Fulton, KS	1/16/1981	USGS	0.12				43
06917000	Little Osage River at Fulton, KS	1/19/1981	USGS	0.11				20
06917000	Little Osage River at Fulton, KS	1/23/1981	USGS	0.16				15
06917000	Little Osage River at Fulton, KS	1/26/1981	USGS	0.16				9
06917000	Little Osage River at Fulton, KS	1/30/1981	USGS	0.12				25
06917000	Little Osage River at Fulton, KS	2/2/1981	USGS	0.16				23
06917000	Little Osage River at Fulton, KS	2/5/1981	USGS	0.18		1.1	0.1	
06917000	Little Osage River at Fulton, KS	2/6/1981	USGS	0.18				16

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	2/9/1981	USGS	0.14				14
06917000	Little Osage River at Fulton, KS	2/13/1981	USGS	0.3				5
06917000	Little Osage River at Fulton, KS	2/16/1981	USGS	0.49				3
06917000	Little Osage River at Fulton, KS	2/20/1981	USGS	0.98				2
06917000	Little Osage River at Fulton, KS	2/23/1981	USGS	0.86				4
06917000	Little Osage River at Fulton, KS	2/27/1981	USGS	0.57				22
06917000	Little Osage River at Fulton, KS	3/2/1981	USGS	0.88				25
06917000	Little Osage River at Fulton, KS	3/6/1981	USGS	1.7				37
06917000	Little Osage River at Fulton, KS	3/9/1981	USGS	1.2				16
06917000	Little Osage River at Fulton, KS	3/12/1981	USGS	0.87				34
06917000	Little Osage River at Fulton, KS	3/16/1981	USGS	1.2				22
06917000	Little Osage River at Fulton, KS	3/18/1981	USGS	1.5		0.93	0.07	
06917000	Little Osage River at Fulton, KS	3/19/1981	USGS	1				23
06917000	Little Osage River at Fulton, KS	3/22/1981	USGS	0.76				22
06917000	Little Osage River at Fulton, KS	3/26/1981	USGS	0.92				28
06917000	Little Osage River at Fulton, KS	3/29/1981	USGS	2.7				32
06917000	Little Osage River at Fulton, KS	4/22/1981	USGS	1.2		1.1	0.11	
06917000	Little Osage River at Fulton, KS	5/18/1981	USGS	2390				2390
06917000	Little Osage River at Fulton, KS	5/18/1981	USGS	2580				1770
06917000	Little Osage River at Fulton, KS	5/19/1981	USGS	1400				819
06917000	Little Osage River at Fulton, KS	5/19/1981	USGS	636				815
06917000	Little Osage River at Fulton, KS	5/20/1981	USGS	297				284
06917000	Little Osage River at Fulton, KS	5/23/1981	USGS	69				62
06917000	Little Osage River at Fulton, KS	5/24/1981	USGS	2700				1960
06917000	Little Osage River at Fulton, KS	5/24/1981	USGS	480				507
06917000	Little Osage River at Fulton, KS	5/25/1981	USGS	195				500
06917000	Little Osage River at Fulton, KS	5/29/1981	USGS	41				76
06917000	Little Osage River at Fulton, KS	6/1/1981	USGS	62				68
06917000	Little Osage River at Fulton, KS	6/2/1981	USGS	620				1050
06917000	Little Osage River at Fulton, KS	6/3/1981	USGS	176				571

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	6/6/1981	USGS	112				342
06917000	Little Osage River at Fulton, KS	6/8/1981	USGS	78				320
06917000	Little Osage River at Fulton, KS	6/12/1981	USGS	167				380
06917000	Little Osage River at Fulton, KS	6/15/1981	USGS	2660				1730
06917000	Little Osage River at Fulton, KS	6/15/1981	USGS	2940				1810
06917000	Little Osage River at Fulton, KS	6/16/1981	USGS	1800				860
06917000	Little Osage River at Fulton, KS	6/17/1981	USGS	369				453
06917000	Little Osage River at Fulton, KS	6/18/1981	USGS	195				183
06917000	Little Osage River at Fulton, KS	6/21/1981	USGS	95				101
06917000	Little Osage River at Fulton, KS	6/24/1981	USGS	59				103
06917000	Little Osage River at Fulton, KS	6/25/1981	USGS	870				1440
06917000	Little Osage River at Fulton, KS	6/25/1981	USGS	3060				1280
06917000	Little Osage River at Fulton, KS	6/26/1981	USGS	332				473
06917000	Little Osage River at Fulton, KS	6/27/1981	USGS	171				204
06917000	Little Osage River at Fulton, KS	6/27/1981	USGS	2180				1290
06917000	Little Osage River at Fulton, KS	6/28/1981	USGS	1770				465
06917000	Little Osage River at Fulton, KS	6/28/1981	USGS	640				277
06917000	Little Osage River at Fulton, KS	6/29/1981	USGS	278				287
06917000	Little Osage River at Fulton, KS	6/30/1981	USGS	500				159
06917000	Little Osage River at Fulton, KS	6/30/1981	USGS	2220				862
06917000	Little Osage River at Fulton, KS	7/1/1981	USGS	1150				486
06917000	Little Osage River at Fulton, KS	7/1/1981	USGS	720				481
06917000	Little Osage River at Fulton, KS	7/2/1981	USGS	311				221
06917000	Little Osage River at Fulton, KS	7/3/1981	USGS	195				84
06917000	Little Osage River at Fulton, KS	7/6/1981	USGS	114				79
06917000	Little Osage River at Fulton, KS	7/10/1981	USGS	70				80
06917000	Little Osage River at Fulton, KS	7/13/1981	USGS	26				45
06917000	Little Osage River at Fulton, KS	7/17/1981	USGS	9.5				53
06917000	Little Osage River at Fulton, KS	7/20/1981	USGS	17				54
06917000	Little Osage River at Fulton, KS	7/24/1981	USGS	6.1				26

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	7/27/1981	USGS	3.8				24
06917000	Little Osage River at Fulton, KS	7/31/1981	USGS	51				69
06917000	Little Osage River at Fulton, KS	8/3/1981	USGS	20				22
06917000	Little Osage River at Fulton, KS	8/7/1981	USGS	21				41
06917000	Little Osage River at Fulton, KS	8/10/1981	USGS	7.5				68
06917000	Little Osage River at Fulton, KS	8/14/1981	USGS	25				118
06917000	Little Osage River at Fulton, KS	8/17/1981	USGS	19				126
06917000	Little Osage River at Fulton, KS	8/21/1981	USGS	6.5				91
06917000	Little Osage River at Fulton, KS	8/24/1981	USGS	0.33				46
06917000	Little Osage River at Fulton, KS	8/27/1981	USGS	0.25				56
06917000	Little Osage River at Fulton, KS	8/31/1981	USGS	0.21				60
06917000	Little Osage River at Fulton, KS	9/1/1981	USGS	112				1090
06917000	Little Osage River at Fulton, KS	9/2/1981	USGS	1130				1240
06917000	Little Osage River at Fulton, KS	9/2/1981	USGS	506				307
06917000	Little Osage River at Fulton, KS	9/3/1981	USGS	149				243
06917000	Little Osage River at Fulton, KS	9/5/1981	USGS	227				263
06917000	Little Osage River at Fulton, KS	9/8/1981	USGS	26				117
06917000	Little Osage River at Fulton, KS	9/11/1981	USGS	7.5				77
06917000	Little Osage River at Fulton, KS	9/14/1981	USGS	3				45
06917000	Little Osage River at Fulton, KS	9/18/1981	USGS	0.76				25
06917000	Little Osage River at Fulton, KS	9/21/1981	USGS	0.65				49
06917000	Little Osage River at Fulton, KS	9/25/1981	USGS	0.21				96
06917000	Little Osage River at Fulton, KS	9/28/1981	USGS	0.21				34
06917000	Little Osage River at Fulton, KS	10/12/1981	USGS	98				808
06917000	Little Osage River at Fulton, KS	10/14/1981	USGS	716				321
06917000	Little Osage River at Fulton, KS	10/15/1981	USGS	680				309
06917000	Little Osage River at Fulton, KS	10/16/1981	USGS	974				973
06917000	Little Osage River at Fulton, KS	10/17/1981	USGS	692				962
06917000	Little Osage River at Fulton, KS	10/17/1981	USGS	1760				762
06917000	Little Osage River at Fulton, KS	10/18/1981	USGS	1490				523

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	10/18/1981	USGS	866				502
06917000	Little Osage River at Fulton, KS	10/19/1981	USGS	297				149
06917000	Little Osage River at Fulton, KS	10/23/1981	USGS	77				35
06917000	Little Osage River at Fulton, KS	10/26/1981	USGS	51				23
06917000	Little Osage River at Fulton, KS	10/30/1981	USGS	76				49
06917000	Little Osage River at Fulton, KS	11/1/1981	USGS	800				81
06917000	Little Osage River at Fulton, KS	11/1/1981	USGS	60				347
06917000	Little Osage River at Fulton, KS	11/2/1981	USGS	1840				711
06917000	Little Osage River at Fulton, KS	11/2/1981	USGS	848				370
06917000	Little Osage River at Fulton, KS	11/3/1981	USGS	402				369
06917000	Little Osage River at Fulton, KS	11/5/1981	USGS	398				86
06917000	Little Osage River at Fulton, KS	11/6/1981	USGS	233				90
06917000	Little Osage River at Fulton, KS	11/10/1981	USGS	395				30
06917000	Little Osage River at Fulton, KS	11/11/1981	USGS	286				61
06917000	Little Osage River at Fulton, KS	11/14/1981	USGS	166				19
06917000	Little Osage River at Fulton, KS	11/16/1981	USGS	123				96
06917000	Little Osage River at Fulton, KS	11/20/1981	USGS	98				128
06917000	Little Osage River at Fulton, KS	11/23/1981	USGS	67				198
06917000	Little Osage River at Fulton, KS	11/27/1981	USGS	65				86
06917000	Little Osage River at Fulton, KS	11/30/1981	USGS	1690				1320
06917000	Little Osage River at Fulton, KS	11/30/1981	USGS	1730				1660
06917000	Little Osage River at Fulton, KS	12/1/1981	USGS	1700				252
06917000	Little Osage River at Fulton, KS	12/1/1981	USGS	1330				273
06917000	Little Osage River at Fulton, KS	12/2/1981	USGS	453				315
06917000	Little Osage River at Fulton, KS	12/3/1981	USGS	259				67
06917000	Little Osage River at Fulton, KS	12/6/1981	USGS	126				60
06917000	Little Osage River at Fulton, KS	12/9/1981	USGS	114				81
06917000	Little Osage River at Fulton, KS	12/12/1981	USGS	107				61
06917000	Little Osage River at Fulton, KS	12/14/1981	USGS	85				84
06917000	Little Osage River at Fulton, KS	12/18/1981	USGS	75				48

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	12/21/1981	USGS	48				42
06917000	Little Osage River at Fulton, KS	12/28/1981	USGS	40				28
06917000	Little Osage River at Fulton, KS	1/1/1982	USGS	27				74
06917000	Little Osage River at Fulton, KS	1/4/1982	USGS	29				34
06917000	Little Osage River at Fulton, KS	1/9/1982	USGS	25				17
06917000	Little Osage River at Fulton, KS	1/29/1982	USGS	68				808
06917000	Little Osage River at Fulton, KS	1/30/1982	USGS-WRD	3480				1930
06917000	Little Osage River at Fulton, KS	1/30/1982	USGS-WRD	3910				1990
06917000	Little Osage River at Fulton, KS	1/31/1982	USGS	2750				657
06917000	Little Osage River at Fulton, KS	1/31/1982	USGS	1930				194
06917000	Little Osage River at Fulton, KS	2/1/1982	USGS	640				195
06917000	Little Osage River at Fulton, KS	2/2/1982	USGS	308				962
06917000	Little Osage River at Fulton, KS	2/14/1982	USGS	372				87
06917000	Little Osage River at Fulton, KS	2/15/1982	USGS	744				378
06917000	Little Osage River at Fulton, KS	2/16/1982	USGS	1180				381
06917000	Little Osage River at Fulton, KS	2/16/1982	USGS	1340				363
06917000	Little Osage River at Fulton, KS	2/17/1982	USGS	604				377
06917000	Little Osage River at Fulton, KS	2/18/1982	USGS	438				40
06917000	Little Osage River at Fulton, KS	2/19/1982	USGS	262				37
06917000	Little Osage River at Fulton, KS	2/22/1982	USGS	178				48
06917000	Little Osage River at Fulton, KS	2/26/1982	USGS	107				10
06917000	Little Osage River at Fulton, KS	3/1/1982	USGS	92				13
06917000	Little Osage River at Fulton, KS	3/5/1982	USGS	69				14
06917000	Little Osage River at Fulton, KS	3/8/1982	USGS	56				8
06917000	Little Osage River at Fulton, KS	3/12/1982	USGS	34				53
06917000	Little Osage River at Fulton, KS	3/14/1982	USGS	1180				2570
06917000	Little Osage River at Fulton, KS	3/14/1982	USGS	2580				2480
06917000	Little Osage River at Fulton, KS	3/15/1982	USGS	3110				1390
06917000	Little Osage River at Fulton, KS	3/15/1982	USGS	2020				1350
06917000	Little Osage River at Fulton, KS	3/16/1982	USGS	744				150

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	3/17/1982	USGS	438				155
06917000	Little Osage River at Fulton, KS	3/18/1982	USGS	286				310
06917000	Little Osage River at Fulton, KS	3/22/1982	USGS	138				28
06917000	Little Osage River at Fulton, KS	3/27/1982	USGS	109				31
06917000	Little Osage River at Fulton, KS	3/30/1982	USGS	72				10
06917000	Little Osage River at Fulton, KS	4/2/1982	USGS	59				10
06917000	Little Osage River at Fulton, KS	4/5/1982	USGS	48				56
06917000	Little Osage River at Fulton, KS	4/9/1982	USGS	52				6
06917000	Little Osage River at Fulton, KS	4/12/1982	USGS	41				2
06917000	Little Osage River at Fulton, KS	4/15/1982	USGS	31				30
06917000	Little Osage River at Fulton, KS	4/18/1982	USGS	26				36
06917000	Little Osage River at Fulton, KS	4/22/1982	USGS	22				29
06917000	Little Osage River at Fulton, KS	4/25/1982	USGS	25				20
06917000	Little Osage River at Fulton, KS	4/30/1982	USGS	24				19
06917000	Little Osage River at Fulton, KS	5/3/1982	USGS	27				37
06917000	Little Osage River at Fulton, KS	5/7/1982	USGS	82				131
06917000	Little Osage River at Fulton, KS	5/14/1982	USGS	1090				26
06917000	Little Osage River at Fulton, KS	5/14/1982	USGS	1140				867
06917000	Little Osage River at Fulton, KS	5/15/1982	USGS	1000				348
06917000	Little Osage River at Fulton, KS	5/16/1982	USGS	378				209
06917000	Little Osage River at Fulton, KS	5/17/1982	USGS	277				197
06917000	Little Osage River at Fulton, KS	5/21/1982	USGS	484				612
06917000	Little Osage River at Fulton, KS	5/22/1982	USGS	358				267
06917000	Little Osage River at Fulton, KS	5/23/1982	USGS	151				119
06917000	Little Osage River at Fulton, KS	5/26/1982	USGS	908				589
06917000	Little Osage River at Fulton, KS	5/27/1982	USGS	311				114
06917000	Little Osage River at Fulton, KS	5/29/1982	USGS	3710				623
06917000	Little Osage River at Fulton, KS	5/29/1982	USGS	4460				338
06917000	Little Osage River at Fulton, KS	5/30/1982	USGS	4790				326
06917000	Little Osage River at Fulton, KS	5/30/1982	USGS	3950				727

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	5/31/1982	USGS	5270				4300
06917000	Little Osage River at Fulton, KS	5/31/1982	USGS	6360				343
06917000	Little Osage River at Fulton, KS	6/1/1982	USGS	7700				541
06917000	Little Osage River at Fulton, KS	6/1/1982	USGS	7880				323
06917000	Little Osage River at Fulton, KS	6/2/1982	USGS	2420				223
06917000	Little Osage River at Fulton, KS	6/2/1982	USGS	1350				231
06917000	Little Osage River at Fulton, KS	6/3/1982	USGS	560				564
06917000	Little Osage River at Fulton, KS	6/4/1982	USGS	3450				1650
06917000	Little Osage River at Fulton, KS	6/4/1982	USGS	4380				1690
06917000	Little Osage River at Fulton, KS	6/5/1982	USGS	3110				210
06917000	Little Osage River at Fulton, KS	6/5/1982	USGS	4410				248
06917000	Little Osage River at Fulton, KS	6/6/1982	USGS	732				182
06917000	Little Osage River at Fulton, KS	6/7/1982	USGS	1250				1070
06917000	Little Osage River at Fulton, KS	6/7/1982	USGS	1180				2010
06917000	Little Osage River at Fulton, KS	6/8/1982	USGS	568				159
06917000	Little Osage River at Fulton, KS	6/9/1982	USGS	342				83
06917000	Little Osage River at Fulton, KS	6/10/1982	USGS	223				79
06917000	Little Osage River at Fulton, KS	6/11/1982	USGS	964				570
06917000	Little Osage River at Fulton, KS	6/12/1982	USGS	1490				516
06917000	Little Osage River at Fulton, KS	6/12/1982	USGS	964				268
06917000	Little Osage River at Fulton, KS	6/13/1982	USGS	488				27
06917000	Little Osage River at Fulton, KS	6/14/1982	USGS	275				84
06917000	Little Osage River at Fulton, KS	6/18/1982	USGS	133				94
06917000	Little Osage River at Fulton, KS	6/21/1982	USGS	86				39
06917000	Little Osage River at Fulton, KS	6/25/1982	USGS	54				54
06917000	Little Osage River at Fulton, KS	6/28/1982	USGS	62				50
06917000	Little Osage River at Fulton, KS	7/1/1982	USGS	3090				686
06917000	Little Osage River at Fulton, KS	7/1/1982	USGS	640				621
06917000	Little Osage River at Fulton, KS	7/2/1982	USGS	414				228
06917000	Little Osage River at Fulton, KS	7/3/1982	USGS	294				221

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06917000	Little Osage River at Fulton, KS	7/6/1982	USGS	191				100
06917000	Little Osage River at Fulton, KS	7/9/1982	USGS	21				73
06917000	Little Osage River at Fulton, KS	7/12/1982	USGS	19				57
06917000	Little Osage River at Fulton, KS	7/15/1982	USGS	13				121
06917000	Little Osage River at Fulton, KS	7/18/1982	USGS	6.8				61
06917000	Little Osage River at Fulton, KS	7/22/1982	USGS	3.4				52
06917000	Little Osage River at Fulton, KS	7/25/1982	USGS	1.7				32
06917000	Little Osage River at Fulton, KS	7/29/1982	USGS	3.2				59
06917000	Little Osage River at Fulton, KS	8/1/1982	USGS	1.1				113
06917000	Little Osage River at Fulton, KS	8/5/1982	USGS	0.57				95
06917000	Little Osage River at Fulton, KS	8/8/1982	USGS	0.49				73
06917000	Little Osage River at Fulton, KS	8/12/1982	USGS	520				4980
06917000	Little Osage River at Fulton, KS	8/13/1982	USGS	1480				5060
06917000	Little Osage River at Fulton, KS	10/24/1983	USGS-WRD	28				58
06916600	Marais de Cygnes River near KS-MO State Line	7/23/1980	USGS	28		1.1	0.13	
06916600	Marais de Cygnes River near KS-MO State Line	8/18/1980	USGS	66		1.2	0.12	44
06916600	Marais de Cygnes River near KS-MO State Line	9/24/1980	USGS	2			0.12	50
06916600	Marais de Cygnes River near KS-MO State Line	12/31/1980	USGS	1			0.07	
06916600	Marais de Cygnes River near KS-MO State Line	2/6/1981	USGS	1		2.3	0.05	
06916600	Marais de Cygnes River near KS-MO State Line	3/18/1981	USGS	5			0.05	
06916600	Marais de Cygnes River near KS-MO State Line	4/23/1981	USGS	19			0.07	
06916600	Marais de Cygnes River near KS-MO State Line	6/17/1981	USGS	29300		2	0.58	329
3845250942233	Muddy Creek near Harrisonville, MO	4/30/1992	USGS	0.14	31		0.01	
3845250942233	Muddy Creek near Harrisonville, MO	5/20/1992	USGS	0.24	40	2.3	0.04	
3845250942233	Muddy Creek near Harrisonville, MO	8/27/1992	USGS-WRD	0.01		2.5	0.47	408
3845250942233	Muddy Creek near Harrisonville, MO	11/22/1992	USGS-WRD		1030	2.3	0.45	
3845250942233	Muddy Creek near Harrisonville, MO	11/22/1992	USGS-WRD	48				
3845250942233	Muddy Creek near Harrisonville, MO	12/8/1992	USGS-WRD	0.11		1.8	0.06	13
3845250942233	Muddy Creek near Harrisonville, MO	1/27/1993	USGS-WRD	1.7		2.7	0.22	42
3845250942233	Muddy Creek near Harrisonville, MO	2/24/1993	USGS-WRD	0.12		1.4	0.02	56

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
3845250942233	Muddy Creek near Harrisonville, MO	3/24/1993	USGS	0.13		1	0.03	22
3845250942233	Muddy Creek near Harrisonville, MO	4/13/1993	USGS-WRD	10				
3845250942233	Muddy Creek near Harrisonville, MO	4/13/1993	USGS		1690	4.2	0.41	
3845250942233	Muddy Creek near Harrisonville, MO	4/13/1993	USGS-WRD	27				
3845250942233	Muddy Creek near Harrisonville, MO	4/13/1993	USGS-WRD	16				
3845250942233	Muddy Creek near Harrisonville, MO	7/1/1993	USGS-WRD	105				
3845250942233	Muddy Creek near Harrisonville, MO	7/1/1993	USGS-WRD		23100	5.2	0.1	
3845250942233	Muddy Creek near Harrisonville, MO	7/1/1993	USGS-WRD	35				
3845250942233	Muddy Creek near Harrisonville, MO	7/1/1993	USGS-WRD	13				
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	3/14/1980	USGS	1.4			0.13	
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	10/16/1980	USGS	29				49
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	10/29/1980	USGS	23				25
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	2/4/1981	USGS	0.05		1.2	0.06	
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	5/17/1981	USGS	55		3	0.69	1360
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	5/18/1981	USGS	215		2.4	0.37	1320
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	6/4/1981	USGS	0.27		1.8	0.15	167
381916094391200	North Sugar Creek 2 Mi. Bl La Cygne Lake, KS	7/13/1981	USGS	0.8				
06915977	North Sugar Creek Bl La Cygne Lake, KS	3/14/1980	USGS	0.1			0.05	
06915977	North Sugar Creek Bl La Cygne Lake, KS	10/16/1980	USGS	25				8
06915977	North Sugar Creek Bl La Cygne Lake, KS	10/29/1980	USGS	25				8
06915977	North Sugar Creek Bl La Cygne Lake, KS	2/5/1981	USGS	0.05		1.7	0.05	
06915977	North Sugar Creek Bl La Cygne Lake, KS	5/18/1981	USGS	64		1.8	0.08	26
06915977	North Sugar Creek Bl La Cygne Lake, KS	5/18/1981	USGS	366			0.06	30
06915977	North Sugar Creek Bl La Cygne Lake, KS	6/4/1981	USGS	0.04			0.05	
06915988	North Sugar Creek near Trading Post, KS	3/14/1980	USGS	9.2			0.21	
06915988	North Sugar Creek near Trading Post, KS	6/25/1980	USGS	0.13		1.2	0.26	
06915988	North Sugar Creek near Trading Post, KS	10/16/1980	USGS	25				62
06915988	North Sugar Creek near Trading Post, KS	10/30/1980	USGS	23				16
06915988	North Sugar Creek near Trading Post, KS	11/28/1980	USGS	0.5				8
06915988	North Sugar Creek near Trading Post, KS	12/31/1980	USGS	0.05		1.5	0.04	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06915988	North Sugar Creek near Trading Post, KS	2/5/1981	USGS	0.3		1.1	0.06	
06915988	North Sugar Creek near Trading Post, KS	3/18/1981	USGS	0.08		1.4	0.1	
06915988	North Sugar Creek near Trading Post, KS	4/23/1981	USGS	0.02		1.6	0.08	
06915988	North Sugar Creek near Trading Post, KS	5/18/1981	USGS	295		3.4	0.55	1360
06915988	North Sugar Creek near Trading Post, KS	6/4/1981	USGS	3.9		2	0.13	43
3846130942231	North Trib Muddy Creek near Harrisonville, MO	4/29/1992	USGS	0.48	9		0.03	54
3846130942231	North Trib Muddy Creek near Harrisonville, MO	5/20/1992	USGS	0.15	6	1.1	0.02	7
3846130942231	North Trib Muddy Creek near Harrisonville, MO	6/17/1992	USGS-WRD	0.03	9	0.88	0.03	8
3846130942231	North Trib Muddy Creek near Harrisonville, MO	8/27/1992	USGS-WRD	0.03		0.6	0.06	98
3846130942231	North Trib Muddy Creek near Harrisonville, MO	11/4/1992	USGS	0.27		2.6	0.8	76
3846130942231	North Trib Muddy Creek near Harrisonville, MO	11/19/1992	USGS-WRD		266	3.1	0.41	339
3846130942231	North Trib Muddy Creek near Harrisonville, MO	12/8/1992	USGS-WRD	0.77		3.1	0.1	14
3846130942231	North Trib Muddy Creek near Harrisonville, MO	1/27/1993	USGS-WRD	3.5		2.6	0.25	43
3846130942231	North Trib Muddy Creek near Harrisonville, MO	2/24/1993	USGS-WRD	0.52		3.3	0.16	15
3846130942231	North Trib Muddy Creek near Harrisonville, MO	3/24/1993	USGS	0.56		2.8	0.08	
3846130942231	North Trib Muddy Creek near Harrisonville, MO	4/13/1993	USGS-WRD		5740		1.4	4530
3846130942231	North Trib Muddy Creek near Harrisonville, MO	6/18/1993	USGS		1230	6.5	0.16	638
06918070	Osage River above Schell City, MO	3/6/1979	USGS	13700		5.1	0.17	741
06918070	Osage River above Schell City, MO	4/3/1979	USGS	4000		3	0.21	248
06918070	Osage River above Schell City, MO	5/9/1979	USGS	2000		1.6	0.17	165
06918070	Osage River above Schell City, MO	6/5/1979	USGS	4200		9.7	0.87	4400
06918070	Osage River above Schell City, MO	7/25/1979	USGS	590		1.3	0.15	440
06918070	Osage River above Schell City, MO	8/14/1979	USGS	356		1.1	0.1	230
06918070	Osage River above Schell City, MO	9/13/1979	USGS	200		1.9	0.17	191
06918070	Osage River above Schell City, MO	10/2/1979	USGS	80		0.86	0.1	56
06918070	Osage River above Schell City, MO	11/13/1979	USGS	200		1.3	0.09	325
06918070	Osage River above Schell City, MO	12/4/1979	USGS	330		2	0.14	323
06918070	Osage River above Schell City, MO	2/7/1980	USGS	300		0.9	0.13	66
06918070	Osage River above Schell City, MO	3/13/1980	USGS	5750		4.3	0.62	1110
06918070	Osage River above Schell City, MO	4/17/1980	USGS	5360		2.1	0.15	1160

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06918070	Osage River above Schell City, MO	5/22/1980	USGS	328		0.95	0.11	125
06918070	Osage River above Schell City, MO	6/9/1980	USGS	1030		3.7	0.55	1080
06918070	Osage River above Schell City, MO	8/5/1980	USGS	16		1.2	0.13	68
06918070	Osage River above Schell City, MO	9/4/1980	USGS	35		0.9	0.09	105
06918070	Osage River above Schell City, MO	11/18/1980	USGS	25		1.1	0.09	27
06918070	Osage River above Schell City, MO	5/14/1981	USGS	15		1.8	0.06	35
06918070	Osage River above Schell City, MO	7/14/1981	USGS	3000		1.7	0.12	163
06918070	Osage River above Schell City, MO	9/10/1981	USGS	681		2.7	0.15	95
06918070	Osage River above Schell City, MO	11/25/1981	USGSNWQL	2500		1.8	0.1	11
06918070	Osage River above Schell City, MO	1/21/1982	USGSNWQL	880		1.7	0.08	74
06918070	Osage River above Schell City, MO	3/3/1982	USGSNWQL	2760		2.3	0.06	115
06918070	Osage River above Schell City, MO	5/5/1982	USGSNWQL	960		2.1	0.16	231
06918070	Osage River above Schell City, MO	7/7/1982	USGSNWQL	3400		2.2	0.2	331
06918070	Osage River above Schell City, MO	1/12/1983	USGSNWQL	500		2.7	0.12	73
06918070	Osage River above Schell City, MO	3/16/1983	USGS-WRD	1800		2.2	0.12	75
06918070	Osage River above Schell City, MO	5/4/1983	USGS-WRD	23500		2.5	0.5	499
06918070	Osage River above Schell City, MO	7/7/1983	USGS-WRD	4600		2.5	0.34	358
06918070	Osage River above Schell City, MO	11/8/1983	USGS-WRD	1250		3.4	0.2	208
06918070	Osage River above Schell City, MO	1/5/1984	USGS-WRD	E 200		2.8	0.07	94
06918070	Osage River above Schell City, MO	3/7/1984	USGS-WRD	8300		3	0.29	402
06918070	Osage River above Schell City, MO	5/11/1984	USGS-WRD	3040		2.1	0.08	157
06918070	Osage River above Schell City, MO	7/13/1984	USGS-WRD	2400		3.3	0.25	426
06918070	Osage River above Schell City, MO	9/14/1984	USGS-WRD	300		1.7	0.15	115
06918070	Osage River above Schell City, MO	11/8/1984	USGS-WRD	1170		2.2	0.21	189
06918070	Osage River above Schell City, MO	1/9/1985	USGS-WRD	7190		2.3	0.14	103
06918070	Osage River above Schell City, MO	3/20/1985	USGS-WRD	7490		1.6	0.15	118
06918070	Osage River above Schell City, MO	5/23/1985	USGS-WRD	1640		1.9	0.13	338
06918070	Osage River above Schell City, MO	9/11/1985	USGS-WRD	620		1.2	0.11	40
06918070	Osage River above Schell City, MO	11/13/1985	USGS-WRD	7030		0.95	0.15	98
06918070	Osage River above Schell City, MO	1/9/1986	USGS-WRD	1000		1.4	0.07	1

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06918070	Osage River above Schell City, MO	3/19/1986	USGS-WRD	1310		0.89	0.08	29
06918070	Osage River above Schell City, MO	5/14/1986	USGS-WRD	7460		3.1	0.14	3000
06918070	Osage River above Schell City, MO	7/8/1986	USGS-WRD	13200		1.6	0.29	1260
06918070	Osage River above Schell City, MO	9/16/1986	USGS-WRD	470		0.94	0.19	95
06918070	Osage River above Schell City, MO	1/7/1987	USGS-WRD	1500		1.2	0.02	42
06918070	Osage River above Schell City, MO	3/4/1987	USGS-WRD	39800		0.95	0.35	345
06918070	Osage River above Schell City, MO	5/21/1987	USGS-WRD	3100		3.8	0.59	773
06918070	Osage River above Schell City, MO	7/7/1987	USGS-WRD	6050		2.2	0.28	1130
06918070	Osage River above Schell City, MO	9/3/1987	USGS-WRD	506		0.91	0.08	131
06918070	Osage River above Schell City, MO	1/6/1988	USGS-WRD	3700		1.2	0.12	27
06918070	Osage River above Schell City, MO	7/12/1988	USGS-WRD	1090		2.1	0.11	119
06918070	Osage River above Schell City, MO	11/3/1988	USGS-WRD	211		0.75	0.06	38
06918070	Osage River above Schell City, MO	1/5/1989	USGS-WRD	1130		1.1	0.12	37
06918070	Osage River above Schell City, MO	7/19/1989	USGS-WRD	2970		1.4	0.26	342
06918070	Osage River above Schell City, MO	9/8/1989	USGS-WRD	5470		2	0.2	300
06918070	Osage River above Schell City, MO	3/8/1990	USGS-WRD	8470		3	0.14	610
06918070	Osage River above Schell City, MO	5/8/1990	USGS-WRD	5360		1.4	0.15	121
06918070	Osage River above Schell City, MO	7/12/1990	USGS-WRD	1080		1	0.09	218
06918070	Osage River above Schell City, MO	9/6/1990	USGS-WRD	1.4		1	0.1	63
06918070	Osage River above Schell City, MO	5/8/1991	USGS-WRD	1210		2	0.22	400
06918070	Osage River above Schell City, MO	7/18/1991	USGS-WRD	540		0.39	0.17	27
06918070	Osage River above Schell City, MO	9/5/1991	USGS-WRD	500		2.3	0.16	96
06918070	Osage River above Schell City, MO	11/5/1991	USGS-WRD	200		0.66	0.07	40
06918070	Osage River above Schell City, MO	1/9/1992	USGS-WRD	720		2.3	0.1	63
06918070	Osage River above Schell City, MO	11/19/1992	USGS	13700		1.5	0.34	232
06918070	Osage River above Schell City, MO	1/12/1993	USGS-WRD	4160		1.3	0.07	143
06918070	Osage River above Schell City, MO	3/10/1993	USGS-WRD	6440		1.5	0.13	591
06918070	Osage River above Schell City, MO	5/5/1993	USGS-WRD	7740		1.6	0.14	616
06918070	Osage River above Schell City, MO	7/27/1993	USGS-WRD	45300		1.2	0.26	93
06918070	Osage River above Schell City, MO	9/28/1993	USGS-WRD	48200		0.78	0.15	158

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06918070	Osage River above Schell City, MO	11/29/1994	USGS-WRD	13900	270	1.7	0.28	
06918070	Osage River above Schell City, MO	6/27/1995	USGS-WRD	45400	140	1.6	0.14	
06918070	Osage River above Schell City, MO	8/22/1995	USGS-WRD	822	82	1.5	0.15	
06918070	Osage River above Schell City, MO	6/19/1996	USGS-WRD	5960	480	2.8	0.46	
06918070	Osage River above Schell City, MO	6/19/1996	USGS-WRD	5960	480	2.8	0.46	
06918070	Osage River above Schell City, MO	11/5/1996	USGS-WRD	2110	50	0.82	0.08	
06918070	Osage River above Schell City, MO	11/5/1996	USGS-WRD	2110	50	0.82	0.08	
06918070	Osage River above Schell City, MO	6/24/1997	USGS-WRD	2480	190	1.8	0.18	
06918070	Osage River above Schell City, MO	6/24/1997	USGS-WRD	2480	190	1.8	0.18	
06918070	Osage River above Schell City, MO	6/7/1999	USGS-WRD	7920	195	1.6	0.25	
06918070	Osage River above Schell City, MO	6/7/1999	USGS-WRD	7920	195	1.6	0.25	
06918070	Osage River above Schell City, MO	5/22/2000	USGS-WRD	300	61	0.91	0.13	
06918070	Osage River above Schell City, MO	5/22/2000	USGS-WRD	300	61	0.91	0.13	
06918070	Osage River above Schell City, MO	11/27/2000	USGS-WRD	177	11	0.86	0.07	
06918070	Osage River above Schell City, MO	11/27/2000	USGS-WRD	177	11	0.86	0.07	
06918070	Osage River above Schell City, MO	3/11/2002	USGS-WRD	621	50	0.82	0.09	
06918070	Osage River above Schell City, MO	3/11/2002	USGS-WRD	621	50	0.82	0.09	
06918070	Osage River above Schell City, MO	4/15/2002	USGS-WRD	949	183	1.1	0.26	
06918070	Osage River above Schell City, MO	4/15/2002	USGS-WRD	949	183	1.1	0.26	
06918070	Osage River above Schell City, MO	5/22/2002	USGS-WRD	6400	49	1.5	0.16	
06918070	Osage River above Schell City, MO	5/22/2002	USGS-WRD	6400	49	1.5	0.16	
06918070	Osage River above Schell City, MO	6/17/2002	USGS-WRD	5600	252	1.8	0.35	
06918070	Osage River above Schell City, MO	6/17/2002	USGS-WRD	5600	252	1.8	0.35	
06918070	Osage River above Schell City, MO	7/24/2002	USGS-WRD	229	E 90	1.2	0.17	
06918070	Osage River above Schell City, MO	7/24/2002	USGS-WRD	229	E 90	1.2	0.17	
06918070	Osage River above Schell City, MO	3/17/2003	USGS-WRD	538	75	1.3	0.13	
06918070	Osage River above Schell City, MO	3/17/2003	USGS-WRD	538	75	1.3	0.13	
06918070	Osage River above Schell City, MO	5/13/2003	USGS-WRD	2700	426	2.6	0.47	
06918070	Osage River above Schell City, MO	5/13/2003	USGS-WRD	2700	426	2.6	0.47	
06918070	Osage River above Schell City, MO	6/17/2003	USGS-WRD	1220	188	2	0.3	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06918070	Osage River above Schell City, MO	6/17/2003	USGS-WRD	1220	188	2	0.3	
06918070	Osage River above Schell City, MO	7/9/2003	USGS-WRD	524	120	1.3	0.2	
06918070	Osage River above Schell City, MO	7/9/2003	USGS-WRD	524	120	1.3	0.2	
06918070	Osage River above Schell City, MO	3/9/2004	USGS-WRD	44000	164	2.5	0.56	
06918070	Osage River above Schell City, MO	3/9/2004	USGS-WRD	44000	164	2.5	0.56	
06918070	Osage River above Schell City, MO	5/11/2004	USGS-WRD	783	62	0.97	0.12	
06918070	Osage River above Schell City, MO	5/11/2004	USGS-WRD	783	62	0.97	0.12	
06918070	Osage River above Schell City, MO	7/21/2004	USGS-WRD	2310	130	1.2	0.22	
06918070	Osage River above Schell City, MO	7/21/2004	USGS-WRD	2310	130	1.2	0.22	
06918070	Osage River above Schell City, MO	11/15/2004	USGS-WRD	5000	109	1.5	0.31	
06918070	Osage River above Schell City, MO	11/15/2004	USGS-WRD	5000	109	1.5	0.31	
06914960	Rock Creek near Wellsville, KS	5/25/1994	USGS-WRD	0.92		1.6	0.084	
06914960	Rock Creek near Wellsville, KS	5/25/1994	USGS-WRD			1.8	0.109	
06914960	Rock Creek near Wellsville, KS	11/2/1994	USGS-WRD	1.3		1.7	0.377	
06914960	Rock Creek near Wellsville, KS	11/2/1994	USGS-WRD	1.3		1.6	0.422	
06914960	Rock Creek near Wellsville, KS	3/10/1995	USGS-WRD	0.34		1.3	0.074	
06914960	Rock Creek near Wellsville, KS	5/11/1995	USGS-WRD	7.2		2.2	0.142	
06914960	Rock Creek near Wellsville, KS	5/25/1994	USGS-WRD	0.92		1.6	0.084	
06914960	Rock Creek near Wellsville, KS	11/2/1994	USGS-WRD	1.3		1.7	0.377	
06914960	Rock Creek near Wellsville, KS	11/2/1994	USGS-WRD	1.3		1.6	0.422	
06914960	Rock Creek near Wellsville, KS	3/10/1995	USGS-WRD	0.34		1.3	0.074	
06914960	Rock Creek near Wellsville, KS	5/11/1995	USGS-WRD	7.2		2.2	0.142	
06914970	Smith Branch near Spring Hill, KS	5/26/1994	USGS-WRD	0.4			0.087	
06914970	Smith Branch near Spring Hill, KS	11/2/1994	USGS-WRD	0.03		1.9	0.35	
06914970	Smith Branch near Spring Hill, KS	3/8/1995	USGS-WRD	0.4		0.78	0.077	
06914970	Smith Branch near Spring Hill, KS	5/12/1995	USGS-WRD	2.1		0.57	0.012 ¹	
06921590	South Grand River at Archie, MO	7/23/2008	USGS-WRD	14	17	1	0.09	
06921590	South Grand River at Archie, MO	9/11/2008	USGS-WRD	11	27	0.92	0.17	
06921590	South Grand River at Archie, MO	10/9/2008	USGS-WRD	14	7.5 ¹	0.71	0.09	
06921590	South Grand River at Archie, MO	1/6/2009	USGS-WRD	140	7.5 ¹	1.3	0.06	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06921590	South Grand River at Archie, MO	3/27/2009	USGS-WRD	207	130	1.3	0.17	
06921590	South Grand River at Archie, MO	5/19/2009	USGS-WRD	117	40	1.4	0.14	
06921590	South Grand River at Archie, MO	7/8/2009	USGS-WRD	20	27	1.3	0.09	
06921590	South Grand River at Archie, MO	9/23/2009	USGSMOLS	17	75	2	0.34	
06921590	South Grand River at Archie, MO	10/27/2009	USGS-WRD	604	91	1.4	0.28	
06921590	South Grand River at Archie, MO	1/21/2010	USGS-WRD	1430	210	2	0.33	
06921590	South Grand River at Archie, MO	3/10/2010	USGS-WRD	253	36	0.84	0.1	
06921590	South Grand River at Archie, MO	5/27/2010	USGSMOLS	655		2.4	0.49	
06921590	South Grand River at Archie, MO	7/22/2010	USGS-WRD	319				
06921582	South Grand River below Freeman, MO	11/19/1997	USGS-WRD	6.8	0.5 ¹			
06921582	South Grand River below Freeman, MO	1/14/1998	USGS-WRD	95	10			
06921582	South Grand River below Freeman, MO	6/1/1998	USGS-WRD	112	1			
06921582	South Grand River below Freeman, MO	8/20/1998	USGS-WRD	3.6	23			
06921582	South Grand River below Freeman, MO	11/18/1998	USGS-WRD	76	14	1.1	0.07	
06921582	South Grand River below Freeman, MO	12/3/1998	USGS-WRD	150		0.81	0.19	
06921582	South Grand River below Freeman, MO	1/26/1999	USGS-WRD	56	12	1.3	0.07	
06921582	South Grand River below Freeman, MO	2/24/1999	USGS-WRD	84		0.97	E 0.05	
06921582	South Grand River below Freeman, MO	3/24/1999	USGS-WRD	56		0.46	E 0.04	
06921582	South Grand River below Freeman, MO	4/14/1999	USGS-WRD	60		E 0.33	0.025 ¹	
06921582	South Grand River below Freeman, MO	5/17/1999	USGS-WRD	995		3	0.7	
06921582	South Grand River below Freeman, MO	6/16/1999	USGS-WRD	27	92	2	0.2	
06921582	South Grand River below Freeman, MO	7/28/1999	USGS-WRD	4.4			0.1	
06921582	South Grand River below Freeman, MO	8/11/1999	USGS-WRD	4.2	22	0.69	0.1	
06921582	South Grand River below Freeman, MO	9/15/1999	USGS-WRD	6.3		0.58	0.07	
06921582	South Grand River below Freeman, MO	10/21/1999	USGS-WRD	4			0.09	
06921582	South Grand River below Freeman, MO	11/8/1999	USGS-WRD	3.5	12		0.18	
06921582	South Grand River below Freeman, MO	12/8/1999	USGS-WRD	34		1.2	0.17	
06921582	South Grand River below Freeman, MO	1/5/2000	USGS-WRD	11	3	1.2	0.09	
06921582	South Grand River below Freeman, MO	2/16/2000	USGS-WRD	5.8		0.94	0.08	
06921582	South Grand River below Freeman, MO	3/14/2000	USGS-WRD	12		0.6	0.09	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06921582	South Grand River below Freeman, MO	4/11/2000	USGS-WRD	11		0.5	0.07	
06921582	South Grand River below Freeman, MO	5/23/2000	USGS-WRD	16	75	1	0.14	
06921582	South Grand River below Freeman, MO	6/13/2000	USGS-WRD	15		0.99	0.17	
06921582	South Grand River below Freeman, MO	7/18/2000	USGS-WRD	4.2	37		0.14	
06921582	South Grand River below Freeman, MO	8/17/2000	USGS-WRD	0.89			0.12	
06921582	South Grand River below Freeman, MO	9/13/2000	USGS-WRD	0.53			0.14	
06921582	South Grand River below Freeman, MO	10/19/2000	USGS-WRD	2.1		2.7	0.36	
06921582	South Grand River below Freeman, MO	11/20/2000	USGS-WRD	2.4	5 ¹	0.83	0.13	
06921582	South Grand River below Freeman, MO	12/12/2000	USGS-WRD	1.7		1.4	0.15	
06921582	South Grand River below Freeman, MO	1/16/2001	USGS-WRD	10	22	4.1	0.54	
06921582	South Grand River below Freeman, MO	3/1/2001	USGS-WRD	94		3.9	0.12	
06921582	South Grand River below Freeman, MO	3/21/2001	USGS-WRD	84		3	0.12	
06921582	South Grand River below Freeman, MO	4/11/2001	USGS-WRD	648		3.4	0.81	
06921582	South Grand River below Freeman, MO	5/9/2001	USGS-WRD	32	73	1.4	0.18	
06921582	South Grand River below Freeman, MO	6/21/2001	USGS-WRD	952		3.6	1.12	
06921582	South Grand River below Freeman, MO	7/18/2001	USGS-WRD	8.3	56	0.94	0.13	
06921582	South Grand River below Freeman, MO	8/14/2001	USGS-WRD	1.8		0.69	0.12	
06921582	South Grand River below Freeman, MO	9/6/2001	USGS	1.1		1.4	0.17	
06921582	South Grand River below Freeman, MO	10/17/2001	USGS-WRD	46	61	1.3	0.23	
06921582	South Grand River below Freeman, MO	11/13/2001	USGS-WRD	3.7	16	E 0.62	0.15	
06921582	South Grand River below Freeman, MO	12/18/2001	USGS-WRD	4.9	20	1.2	0.11	
06921582	South Grand River below Freeman, MO	1/23/2002	USGS-WRD	3.8	12	2.3	0.21	
06921582	South Grand River below Freeman, MO	2/20/2002	USGS-WRD	125	82	1.4	0.19	
06921582	South Grand River below Freeman, MO	3/4/2002	USGS-WRD	22	5 ¹	0.94	0.08	
06921582	South Grand River below Freeman, MO	4/23/2002	USGS-WRD	120	160	2	0.24	
06921582	South Grand River below Freeman, MO	5/15/2002	USGS-WRD	239	108	1.7	0.2	
06921582	South Grand River below Freeman, MO	6/11/2002	USGS-WRD	19	40	0.98	0.1	
06921582	South Grand River below Freeman, MO	7/10/2002	USGS-WRD	1.6	40		0.11	
06921582	South Grand River below Freeman, MO	8/13/2002	USGS-WRD	8.2	41	0.9	0.16	
06921582	South Grand River below Freeman, MO	9/25/2002	USGS-WRD	0.62	23	1.1	0.09	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06921582	South Grand River below Freeman, MO	10/21/2002	USGS-WRD	1.3	10	E 0.47	0.07	
06921582	South Grand River below Freeman, MO	11/14/2002	USGS-WRD	0.95	5 ¹	E 0.58	0.12	
06921582	South Grand River below Freeman, MO	12/13/2002	USGS-WRD	1.4	5 ¹		0.08	
06921582	South Grand River below Freeman, MO	1/7/2003	USGS-WRD	1.5	22		0.13	
06921582	South Grand River below Freeman, MO	2/11/2003	USGS-WRD	1.5	28	2	0.41	
06921582	South Grand River below Freeman, MO	3/5/2003	USGS-WRD	1.9	24	4.5	0.6	
06921582	South Grand River below Freeman, MO	4/10/2003	USGS-WRD	2.8	28	1.1	0.15	
06921582	South Grand River below Freeman, MO	5/30/2003	USGS-WRD	2.8	36		0.15	
06921582	South Grand River below Freeman, MO	6/19/2003	USGS-WRD	3.8	43	1.1	0.17	
06921582	South Grand River below Freeman, MO	7/23/2003	USGS-WRD	0.35	17		0.17	
06921582	South Grand River below Freeman, MO	8/22/2003	USGS-WRD	0.12	12		0.18	
06921582	South Grand River below Freeman, MO	9/23/2003	USGS-WRD	1.2	12	1	0.13	
06921582	South Grand River below Freeman, MO	11/10/2003	USGS-WRD	2.9	11		0.09	
06921582	South Grand River below Freeman, MO	1/13/2004	USGS-WRD	8.3	5 ¹	1.9	0.13	
06921582	South Grand River below Freeman, MO	3/10/2004	USGS-WRD	107	44	2.5	0.13	
06921582	South Grand River below Freeman, MO	5/7/2004	USGS-WRD	24	30		0.11	
06921582	South Grand River below Freeman, MO	7/20/2004	USGS-WRD	17	44	1.2	0.17	
06921582	South Grand River below Freeman, MO	9/22/2004	USGS-WRD	18	60	1.5	0.23	
06921582	South Grand River below Freeman, MO	11/3/2004	USGS-WRD	105	38	1.2	0.21	
06921582	South Grand River below Freeman, MO	1/11/2005	USGS-WRD	412	56	1.6	0.16	
06921582	South Grand River below Freeman, MO	3/22/2005	USGS-WRD	39	13		0.1	
06921582	South Grand River below Freeman, MO	5/6/2005	USGS-WRD	16	16	E 0.51	0.07	
06921582	South Grand River below Freeman, MO	7/22/2005	USGS-WRD	12	44	0.69	0.11	
06921582	South Grand River below Freeman, MO	9/30/2005	USGS-WRD	8	25	1.4	0.16	
06921582	South Grand River below Freeman, MO	11/15/2005	USGS-WRD	3.8	15		0.24	
06921582	South Grand River below Freeman, MO	1/13/2006	USGS-WRD	3.6	5 ¹	1.8	0.19	
06921582	South Grand River below Freeman, MO	3/17/2006	USGS-WRD	14	37	0.79	0.18	
06921582	South Grand River below Freeman, MO	5/17/2006	USGS-WRD	15	29	0.94	0.1	
06921582	South Grand River below Freeman, MO	7/14/2006	USGS-WRD	28	92	1.6	0.29	
06921582	South Grand River below Freeman, MO	9/11/2006	USGS-WRD	2.1	39	1	0.17	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06921582	South Grand River below Freeman, MO	11/27/2006	USGS	1.5	17	0.6	0.18	
06921582	South Grand River below Freeman, MO	1/12/2007	USGS	12	11	1.7	0.16	
06921582	South Grand River below Freeman, MO	2/9/2007	USGS	31	14	2.9	0.29	
06921582	South Grand River below Freeman, MO	3/28/2007	USGS-WRD	33	42	1	0.15	
06921582	South Grand River below Freeman, MO	4/17/2007	USGS-WRD	194	90	1.8	0.15	
06921582	South Grand River below Freeman, MO	5/4/2007	USGS-WRD	1380	600	3.1	0.75	
3844410942043	South Trib Muddy Creek near Harrionsville, MO	4/29/1992	USGS	0.19	20		0.02	
3844410942043	South Trib Muddy Creek near Harrionsville, MO	5/20/1992	USGS	0.03	32	1.1	0.05	
3844410942043	South Trib Muddy Creek near Harrionsville, MO	8/27/1992	USGS-WRD	0.03		1.7	0.12	
3844410942043	South Trib Muddy Creek near Harrionsville, MO	9/29/1992	USGS-WRD	0.05			0.07	72
3844410942043	South Trib Muddy Creek near Harrionsville, MO	10/22/1992	USGS-WRD	0.03				2
3844410942043	South Trib Muddy Creek near Harrionsville, MO	11/4/1992	USGS	0.1		1.2	0.08	51
3844410942043	South Trib Muddy Creek near Harrionsville, MO	11/18/1992	USGS-WRD	18				
3844410942043	South Trib Muddy Creek near Harrionsville, MO	12/8/1992	USGS-WRD	0.13		0.9	0.13	8
3844410942043	South Trib Muddy Creek near Harrionsville, MO	1/27/1993	USGS-WRD	1.6		1.1	0.24	17
3844410942043	South Trib Muddy Creek near Harrionsville, MO	2/24/1993	USGS-WRD	0.2		0.7	0.08	9
3844410942043	South Trib Muddy Creek near Harrionsville, MO	3/24/1993	USGS	0.5		1.1	0.05	18
06922200	Tebo Creek at Leesville	10/11/1977	USGS	50		0.89	0.14	
06922200	Tebo Creek at Leesville	11/17/1977	USGS	44		0.48	0.07	
06922200	Tebo Creek at Leesville	12/12/1977	USGS	26		0.63	0.02	
06922200	Tebo Creek at Leesville	2/24/1978	USGS	12		0.96	0.02	
06922200	Tebo Creek at Leesville	3/14/1978	USGS	1300		3.7	0.62	
06922200	Tebo Creek at Leesville	4/4/1978	USGS	20		1.2	0.05	
06922200	Tebo Creek at Leesville	5/2/1978	USGS	123		1	0.11	
06922200	Tebo Creek at Leesville	6/6/1978	USGS	44		2.2	0.05	
06922200	Tebo Creek at Leesville	7/11/1978	USGS	3500		5	0.73	
06922200	Tebo Creek at Leesville	8/1/1978	USGS	13		0.62	0.05	
06922200	Tebo Creek at Leesville	9/5/1978	USGS	61		1.3	0.11	
06922200	Tebo Creek at Leesville	10/12/1978	USGS	20		0.72	0.06	
06922200	Tebo Creek at Leesville	11/7/1978	USGS	3.6		0.61	0.04	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06922200	Tebo Creek at Leesville	12/5/1978	USGS	29		0.61	0.05	
06922200	Tebo Creek at Leesville	1/9/1979	USGS	5		0.21	0.04	
06922200	Tebo Creek at Leesville	2/12/1979	USGS	21		1.1	0.04	
06914980	Wade Branch near Wellsville, KS	5/26/1994	USGS-WRD	0.73		0.39	0.889	
06914980	Wade Branch near Wellsville, KS	11/3/1994	USGS-WRD	0.04		1.1	0.261	
06914980	Wade Branch near Wellsville, KS	3/10/1995	USGS-WRD	0.49		0.56	0.261	
06914980	Wade Branch near Wellsville, KS	5/26/1994	USGS-WRD	0.73		0.39	0.889	
06914980	Wade Branch near Wellsville, KS	11/3/1994	USGS-WRD	0.04		1.1	0.261	
06914980	Wade Branch near Wellsville, KS	3/10/1995	USGS-WRD	0.49		0.56	0.261	
06922190	West Fork Tebo Creek Near Lewis, MO	10/20/1983	USGS-WRD	5		1.1	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	11/7/1983	USGS-WRD	2.7		1.9	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	12/9/1983	USGS-WRD	3		2.1	0.02	
06922190	West Fork Tebo Creek near Lewis, MO	1/6/1984	USGS-WRD	3		2.6	0.08	
06922190	West Fork Tebo Creek near Lewis, MO	2/9/1984	USGS-WRD	3		0.7	0.01	
06922190	West Fork Tebo Creek near Lewis, MO	3/8/1984	USGS-WRD	4		1.8	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	4/5/1984	USGS-WRD	28		1.6	0.05	
06922190	West Fork Tebo Creek near Lewis, MO	5/11/1984	USGS-WRD	20			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	6/8/1984	USGS-WRD	17		1.4	0.27	
06922190	West Fork Tebo Creek near Lewis, MO	7/13/1984	USGS-WRD	2		0.7	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	8/9/1984	USGS-WRD	0.2			0.06	
06922190	West Fork Tebo Creek near Lewis, MO	9/14/1984	USGS-WRD	1		0.8	0.05	
06922190	West Fork Tebo Creek near Lewis, MO	10/5/1984	USGS-WRD	0.5			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	11/8/1984	USGS-WRD	6.8		0.7	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	12/7/1984	USGS-WRD	6		0.4	0.02	
06922190	West Fork Tebo Creek near Lewis, MO	1/8/1985	USGS-WRD	22		1.5	0.07	
06922190	West Fork Tebo Creek near Lewis, MO	2/20/1985	USGS-WRD	20		2.3	0.06	
06922190	West Fork Tebo Creek near Lewis, MO	3/20/1985	USGS-WRD	15		0.7	0.02	
06922190	West Fork Tebo Creek near Lewis, MO	4/18/1985	USGS-WRD	7			0.05	
06922190	West Fork Tebo Creek near Lewis, MO	5/23/1985	USGS-WRD	3		0.6	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	6/14/1985	USGS-WRD	7		1.1	0.03	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06922190	West Fork Tebo Creek near Lewis, MO	7/9/1985	USGS-WRD	3		0.6	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	8/8/1985	USGS-WRD	3		0.7	0.05	
06922190	West Fork Tebo Creek near Lewis, MO	9/12/1985	USGS-WRD	4.4			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	10/11/1985	USGS-WRD	4.3			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	11/13/1985	USGS-WRD	694		3.5	0.44	
06922190	West Fork Tebo Creek near Lewis, MO	12/3/1985	USGS-WRD	22		0.9	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	1/10/1986	USGS-WRD	3		0.5	0.01	
06922190	West Fork Tebo Creek near Lewis, MO	2/13/1986	USGS-WRD	4		1.1	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	3/18/1986	USGS-WRD	2			0.01	
06922190	West Fork Tebo Creek near Lewis, MO	4/10/1986	USGS-WRD	2.1		0.5	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	5/15/1986	USGS-WRD	5		0.9	0.08	
06922190	West Fork Tebo Creek near Lewis, MO	6/4/1986	USGS-WRD	3.8		0.9	0.06	
06922190	West Fork Tebo Creek near Lewis, MO	7/7/1986	USGS-WRD	1		1.1	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	8/7/1986	USGS-WRD	2		0.6	0.09	
06922190	West Fork Tebo Creek near Lewis, MO	9/16/1986	USGS-WRD	0.2		0.4	0.07	
06922190	West Fork Tebo Creek near Lewis, MO	10/16/1986	USGS-WRD	5			0.12	
06922190	West Fork Tebo Creek near Lewis, MO	11/7/1986	USGS-WRD	13			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	12/2/1986	USGS-WRD	4		1.9	0.21	
06922190	West Fork Tebo Creek near Lewis, MO	1/8/1987	USGS-WRD	3			0.005 ¹	
06922190	West Fork Tebo Creek near Lewis, MO	2/5/1987	USGS-WRD	3		0.9	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	3/5/1987	USGS-WRD	18		0.8	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	4/9/1987	USGS-WRD	1.5			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	5/21/1987	USGS-WRD	1		0.8	0.05	
06922190	West Fork Tebo Creek near Lewis, MO	6/11/1987	USGS-WRD	1		0.8	0.06	
06922190	West Fork Tebo Creek near Lewis, MO	7/7/1987	USGS-WRD	1.8		2.8	0.08	
06922190	West Fork Tebo Creek near Lewis, MO	8/6/1987	USGS-WRD	0.5			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	9/3/1987	USGS-WRD	0.5			0.01	
06922190	West Fork Tebo Creek near Lewis, MO	10/5/1987	USGS-WRD	0.15			0.05	
06922190	West Fork Tebo Creek near Lewis, MO	11/5/1987	USGS-WRD	1			0.06	
06922190	West Fork Tebo Creek near Lewis, MO	12/8/1987	USGS-WRD	1.5			0.03	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06922190	West Fork Tebo Creek near Lewis, MO	1/6/1988	USGS-WRD	3		1	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	2/2/1988	USGS-WRD	2.3		1.3	0.05	
06922190	West Fork Tebo Creek near Lewis, MO	3/1/1988	USGS-WRD	2.5			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	4/7/1988	USGS-WRD	21		0.8	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	5/10/1988	USGS-WRD	2.5			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	6/14/1988	USGS-WRD	0.5			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	7/12/1988	USGS-WRD	0.2			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	8/4/1988	USGS-WRD	0.2			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	9/6/1988	USGS-WRD	0.1			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	10/6/1988	USGS-WRD	0.1			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	11/3/1988	USGS-WRD	0.5			0.07	
06922190	West Fork Tebo Creek near Lewis, MO	12/20/1988	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	1/5/1989	USGS-WRD	1		0.8	0.02	
06922190	West Fork Tebo Creek near Lewis, MO	2/7/1989	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	3/7/1989	USGS-WRD	1		0.7	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	4/5/1989	USGS-WRD	6			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	5/11/1989	USGS-WRD	1			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	6/8/1989	USGS-WRD	1		1.4	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	7/19/1989	USGS-WRD	0.5			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	8/1/1989	USGS-WRD	0.5		0.7	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	9/8/1989	USGS-WRD	0.5		0.6	0.06	
06922190	West Fork Tebo Creek near Lewis, MO	10/13/1989	USGS-WRD	1			0.07	
06922190	West Fork Tebo Creek near Lewis, MO	11/9/1989	USGS-WRD	1			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	12/7/1989	USGS-WRD	1			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	1/11/1990	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	2/8/1990	USGS-WRD	2.7			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	3/8/1990	USGS-WRD	9.3		0.6	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	4/4/1990	USGS-WRD	9.6			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	5/7/1990	USGS-WRD	9.6		1	0.04	
06922190	West Fork Tebo Creek near Lewis, MO	6/7/1990	USGS-WRD	9.5		0.7	0.03	

USGS Gage No	Site Location	Sample Date	Agency	Q (cfs)	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Suspended Sediment (mg/L)
06922190	West Fork Tebo Creek near Lewis, MO	7/12/1990	USGS-WRD	9.6		1.8	0.07	
06922190	West Fork Tebo Creek near Lewis, MO	8/10/1990	USGS-WRD	9			0.04	
06922190	West Fork Tebo Creek near Lewis, MO	9/6/1990	USGS-WRD	1		0.8	0.06	
06922190	West Fork Tebo Creek near Lewis, MO	10/16/1990	USGS-WRD	1			0.005 ¹	
06922190	West Fork Tebo Creek near Lewis, MO	11/7/1990	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	12/5/1990	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	1/9/1991	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	2/4/1991	USGS-WRD	10				
06922190	West Fork Tebo Creek near Lewis, MO	3/6/1991	USGS-WRD	1			0.02	
06922190	West Fork Tebo Creek near Lewis, MO	4/17/1991	USGS-WRD	1			0.03	
06922190	West Fork Tebo Creek near Lewis, MO	5/7/1991	USGS-WRD	8		1.4	0.08	
06922190	West Fork Tebo Creek near Lewis, MO	6/4/1991	USGS-WRD	1		1.5	0.03	
06922190	West Fork Tebo Creek near Lewis, MO	7/18/1991	USGS-WRD	0.1			0.07	

¹ value listed is one half the limit of detection

E = value is estimated

Trib = Tributary

Bl = below

Appendix F - Supplemental Implementation Plan

States are not required under Section 303(d) of the Clean Water Act to develop TMDL implementation plans and EPA does not approve or disapprove them. However, the Missouri Department of Natural Resources (MDNR) included an implementation plan in this TMDL to provide information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL. Therefore, this informational plan is included to be used by local professionals, watershed managers and citizens for decision-making support and planning purposes. It should not be considered to be a part of the established Long Branch TMDL.

The pollutants targeted by the TMDL to address the unknown water quality impairment of Long Branch are TSS, TN and TP. Potential sources of these pollutants include regulated point sources as well as inputs from agricultural nonpoint sources. Therefore, any practices used to implement this TMDL will focus on these sources.

Point Sources

This part of the TMDL will be implemented through permit action. Effluent limits and monitoring requirements for existing operating permits will be reevaluated to reflect the water quality targets set by the TMDL as the permits approach renewal. This includes effluent limits for TSS and nutrients using the WLAs developed for this TMDL and instream monitoring of TSS and nutrients using the WLAs developed for this TMDL and instream monitoring of TSS or turbidity, nitrogen and phosphorus. Future inspections of the permitted facilities by MDNR will determine the extent and nature of input from these sites. Discharge permits may need to be amended to include additional measures (e.g., a storm water pollution prevention plan) that ensure the facilities do not continue to cause or contribute to the impairment of Long Branch. Additionally, permitted facilities identified to contribute to the pollutant loading of the impaired segment shall adopt appropriate BMPs to reduce such loading from their storm water outfalls. BMPs are recommended methods, structures and practices designed to prevent or reduce water pollution. These facilities must also regularly measure instream pollutant concentrations to determine the efficacy of the control measures.

Nonpoint Sources

Nonpoint sources of sediment and nutrients are not regulated in Missouri. However, with cropland and grassland accounting for a significant portion of the land area in the watershed, agricultural runoff is likely a major component of nonpoint source contributions to the impaired segment. Contributions of sediment and nutrients from agricultural areas should be reduced to meet the TMDL targets.

To reduce the loading and effect of sediment on Long Branch, efforts should be made to encourage agricultural producers in the watershed to adopt erosion control BMPs. The concept

of BMPs is one of a voluntary and site specific approach to water quality problems. In the Long Branch watershed, agricultural BMPs should focus on erosion control measures such as grassy swales, contour farming, the expansion or enhancement of riparian zones, off-stream watering of livestock and rotational grazing practices.

To reduce the loading and effect of nutrients on Long Branch, efforts should be made to encourage agricultural producers in the watershed to adopt nutrient management practices. Management practices should focus on the proper management of nutrients from manure, previous crops and commercial fertilizers. Soil testing of croplands prior to fertilizer applications should be encouraged and education on cultural techniques such as identifying signs of plant need should be provided. Education on proper manure storage and timing of manure applications may also provide benefits for restoring the impaired water body.

In an effort to most effectively implement voluntary BMPs, MDNR may work with the NRCS, local university extension offices and the local Soil and Water Conservation District to encourage area land owners to implement these practices. An additional approach may be to work with these agencies to form a watershed group comprised of local stakeholders to promote the use of erosion control practices.