United States Environmental Protection Agency

Region 7

Total Maximum Daily Load

For Total Suspended Solids and Dissolved Iron

Sandy Creek (MO_0652)

Putnam County, Missouri

for William A. Spratlin
Director
Water, Wetlands and Pesticides Division

12-20-10
Date

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Total Maximum Daily Load (TMDL)
For Sandy Creek
303(d) Listed Pollutant: Unknown

Name: Sandy Creek

Location: Putnam County near Unionville, Missouri

Hydrologic Unit Code (HUC): 10280201-0304

Water Body Identification (WBID): 0652

Missouri Stream Classification: C[1]

Designated Beneficial Uses:[2]
- Protection of Warm Water Aquatic Life
- Whole Body Contact Recreation – Category B
- Livestock and Wildlife Watering
- Human Health Protection (Fish Consumption)

Impaired Beneficial Use: Protection of Warm Water Aquatic Life (General Criteria, 1G)

Size of Classified Segment: 3.0 miles

Location of Classified Segment: Segment begins at the mouth of the creek at its confluence with Shoal Creek and ends at Township 66 North, Range 17 West, Section 19

Size of Impaired Segment: 3.0 miles[3]

Identified Pollutant on 303(d) List: Unknown

Identified Source on 303(d) List: Unknown

TMDL Priority Ranking: Medium

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[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] According to Missouri WQS Table H (CSR, 2009)

[3] The stream length listed corresponds to the EPA approved 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. 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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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per Liter
1G	General Criteria Pertaining to Protection of Aquatic Life
AFO	Animal Feeding Operation
AML	Abandoned Mine Lands
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
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
LA	Load Allocation
LC	Loading Capacity
LDC	Load Duration Curve
LRP	Land Reclamation Program
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
MSWDC	Missouri Soil and Water Districts Commission
N	North
NA	Not Applicable
NASS	National Agricultural Statistics Service
NFR	Non-Filterable Residue
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service

ACRONYMS AND ABBREVIATIONS cont.

PCS	Permit Compliance System
PSF	Premium Standard Farms
RAM	Resource Assessment and Monitoring
SWPPP	Storm Water Pollution Prevention Plan
TBELs	Technology Based Effluent Limitations
TKN	Total Kjeldahl Nitrogen
Temp	Temperature
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
URS	URS Group
U.S.	United States
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geological Survey
WBID	Water Body Identification
WLA	Wasteload Allocation
WQBELs	Water Quality Based Effluent Limitations
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The Sandy Creek 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 (U.S.) Environmental Protection Agency (EPA) approved 2008 Missouri 303(d) List and is identified as impaired due to unknown pollutants and sources. Data analyses and field investigations conducted to support the listing and TMDL development have identified total suspended solids (TSS) and dissolved iron concentrations in Sandy Creek as contributors to the impairment. These pollutants have been shown to be present at elevated levels and can be linked to the impaired beneficial use of the water body. This report addresses the Sandy Creek impairment by establishing a TSS TMDL and a dissolved iron TMDL in accordance with Section 303(d) of the CWA.

Section 303(d) of the CWA and Chapter 40 of the Code of Federal Regulations (CFR) Part 130 requires states to 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 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 exceeding 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 regulated (point) sources. The LA is the portion of the allowable load that is allocated to nonregulated (nonpoint) sources. The MOS accounts for the uncertainty associated with linking pollutant load to the water quality impairment. This is often associated with model assumptions and data limitations.

The goal of the TMDL program is to restore designated beneficial uses to 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 Sandy Creek. In addition to establishing a TMDL for Sandy Creek, 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, sediment data, toxicity data, flow data and comparison to a reference stream condition in the same ecological drainage unit (EDU) in which Sandy Creek is located.

Section 2 of this report provides background information on the Sandy Creek watershed and Section 3 describes potential sources of concern. Section 4 presents the applicable WQS and Section 5 describes the modeling that was done to support 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 Sandy Creek and its watershed.

2.1 THE SETTING

Sandy Creek is an 8.1-mile intermittent stream (classified, 3 miles; unclassified, 5.1 miles)[4] located in the Grand River/Chariton EDU. Sandy Creek originates in Putnam County (T66N R18W Section 3) and flows southeast to its confluence with Shoal Creek, a tributary of the Chariton River. The Sandy Creek watershed covers an area of approximately 17.43 square miles with the total river distance of 8.1 miles of Sandy Creek. The topographic relief along the impaired segment is generally 20 to 40 feet along the valley bottom and adjoining gently sloping upland ridges. The elevation of the impaired segment ranges from 860 feet (upstream) to 820 feet (downstream). The watershed was defined using the ten digit watershed hydrologic unit code (HUC) labeled Sandy Creek-Shoal Creek and further specified for Sandy Creek in particular using contours based on the United States Geological Survey (USGS) topographic maps and National Hydrography Dataset.

Sandy Creek was placed on the 2002 Missouri 303(d) List for unknown pollutants. EPA based these listings on the Missouri Department of Natural Resources' (MDNR) revised "Monitoring Report on 26 Waters" and Visual/Benthic Low Flow Surveys. Specific reasons cited included indications of daily oxygen sag; anoxic sediments; overall reduced biodiversity; and high specific conductance (indicating excessive dissolved minerals) (MDNR, 2006a).

All classified waters of the state, as per Missouri WQS, must protect aquatic life. A combination of natural geology and land use in the prairie portions of the state where Sandy Creek is located is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major water quality problems are 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. Total suspended solids (TSS) can contribute to the impairment of aquatic life at elevated levels. Excessive sedimentation affects the aquatic plant community by clouding the water and reducing the amount of sunlight reaching aquatic plants. Sedimentation impacts aquatic invertebrates and fish by covering spawning areas, foraging habitat and food supplies rendering them useless, while also clogging the gills of fish. Another impact of excessive sedimentation is the loss of habitat and species diversity. Streams affected by sedimentation lose the hard-bottomed, erosional areas used by several species of benthic invertebrates and small foraging fish. These erosional areas are replaced by uniform soft-bottomed, sedimentary habitat, normally occurring only near the stream banks. Consequently,

[4] The stream length listed in Table H is the length of classified stream. The calculation of TMDL loads is based on the outlet of the watershed that includes all of its unclassified segments located upstream.

entire species of invertebrates and fish can be extirpated[5] from the stream. 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 pollutants, this TMDL targets dissolved iron concentrations and TSS. 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.

Additionally, a TMDL for dissolved iron will also be developed using high quality field data and Missouri's WQS numeric criterion. Elevated levels of heavy metals like iron can be toxic to fish and aquatic invertebrates. Iron can change the pH of a stream with widespread consequences and can precipitate out in several forms, which can smother fish eggs, clog fish gills and cover the stream substrate making it unsuitable for benthic invertebrates.

2.2 PHYSIOGRAPHIC LOCATION, GEOLOGY AND SOILS

Sandy Creek is located within the Northern Plains; a region within the Dissected Till Plains. The Dissected Till Plains are a physiographic region of the Central Lowlands Province, which are in turn part of the Interior Plains physiographic division of the United States (MDC, 2010). The Dissected Till Plains are characterized by moderately dissected, glaciated, flat-to-rolling terrain that slopes gently toward the Missouri and Mississippi River Valleys. Sandy Creek is a tributary to Shoal Creek in the Chariton River Watershed. The Sandy Creek watershed is located in the Marmaton and Cherokee geologic groups of the Middle Pennsylvanian Middle Series-Desmonian Stage. Predominant rock types include shale, limestone and sandstone (USDI, 2005).

The soils hydrologic group 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. Figure 1 and Table 1 provide details of soil types within the impaired Sandy Creek watershed. The dominant soil type, Group C, covers approximately 67.2 percent of the watershed. 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. Approximately 28.1 percent of soils in the impaired watershed are categorized as Group D. Group D soils include clay loam, silty clay loam, sandy clay, silty clay or clay. This hydrologic soil group has the highest runoff potential. They 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 (Purdue Research Foundation, 2009). 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. Approximately 3.9 percent of the soils are categorized as Group B.

[5] Local extinction is the condition of a species which ceases to exist in the chosen area of study, but still exists elsewhere. This phenomenon is also known as extirpation.

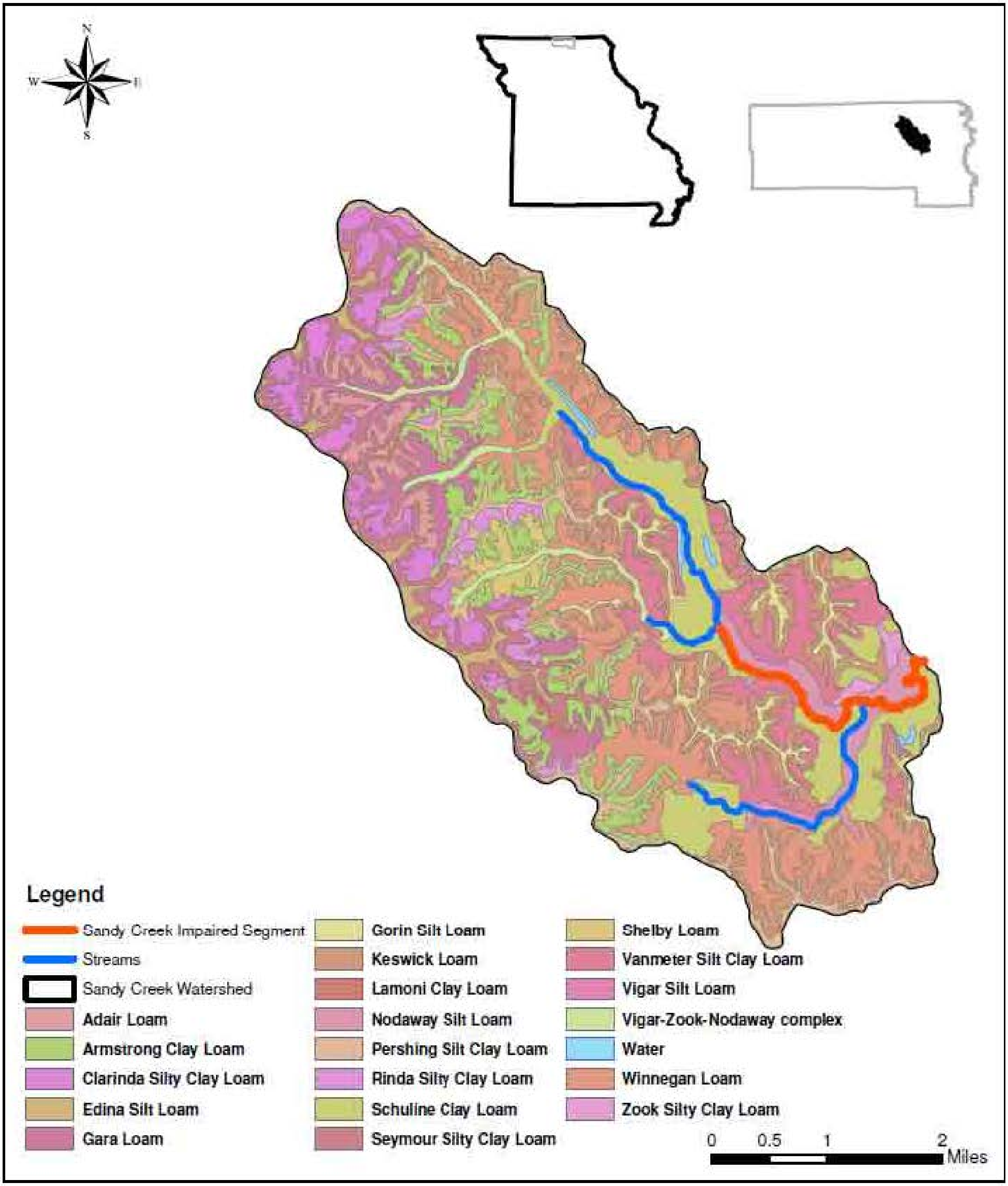

Figure 1. Sandy Creek Watershed Soil Types (NRCS, 2009)

Table 1. Sandy Creek Watershed Soils Summary (NRCS, 2009)

Soil Type	Hydrologic Soil Group	Acres	Percent (%)
Nodaway Silt Loam	B	434.6	3.9
Subtotal	**B**	**434.6**	**3.9**
Adair Loam	C	296.4	2.7
Armstrong Clay Loam	C	1,075.9	9.6
Gara Loam	C	616.6	5.5
Gorin Silt Loam	C	309	2.8
Keswick Loam	C	1,551.4	13.9
Lamoni Clay Loam	C	28.6	0.3
Schuline Clay Loam	C	1,339.4	12
Shelby Loam	C	175.7	1.6
Vigar Silt Loam	C	7.8	0.1
Vigar-Zook-Nodaway Complex	C	261.7	2.3
Winnegan Loam	C	1,833.3	16.4
Subtotal	**C**	**7,495.8**	**67.2**
Clarinda Silty Clay Loam	D	570.3	5.1
Edina Silt Loam	D	228.3	2
Pershing Silty Clay Loam	D	595.1	5.3
Rinda Silty Clay Loam	D	195.6	1.8
Seymour Silty Clay Loam	D	635.6	5.7
Vanmeter Silt Clay Loam	D	911.7	8.2
Subtotal	**D**	**3,136.6**	**28.1**
Zook Silty Clay Loam	C/D	54.3	0.48
Subtotal	**C/D**	**54.3**	**0.48**
Water		36.3	0.3
Subtotal		**36.3**	**0.3**

2.3 RAINFALL AND CLIMATE

The Unionville Weather Station is the closest source of recent and available weather and climate data. It is located in Putnam County, approximately 8.5 miles west of the Sandy Creek watershed (Figure 2). It records daily precipitation, maximum and minimum temperature, snowfall and snow depth. Figure 3 provides a summary of rainfall and climate data for the Unionville Station based on 30 years of data (1971 – 2000) (NOAA, 2010). The annual average precipitation and temperature over the 30 year period is 37.5 inches and 49.8 degrees Fahrenheit, respectively. 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. Thus, an understanding of annual and monthly precipitation patterns is useful when considering the load duration curve (LDC) approach to TMDLs.

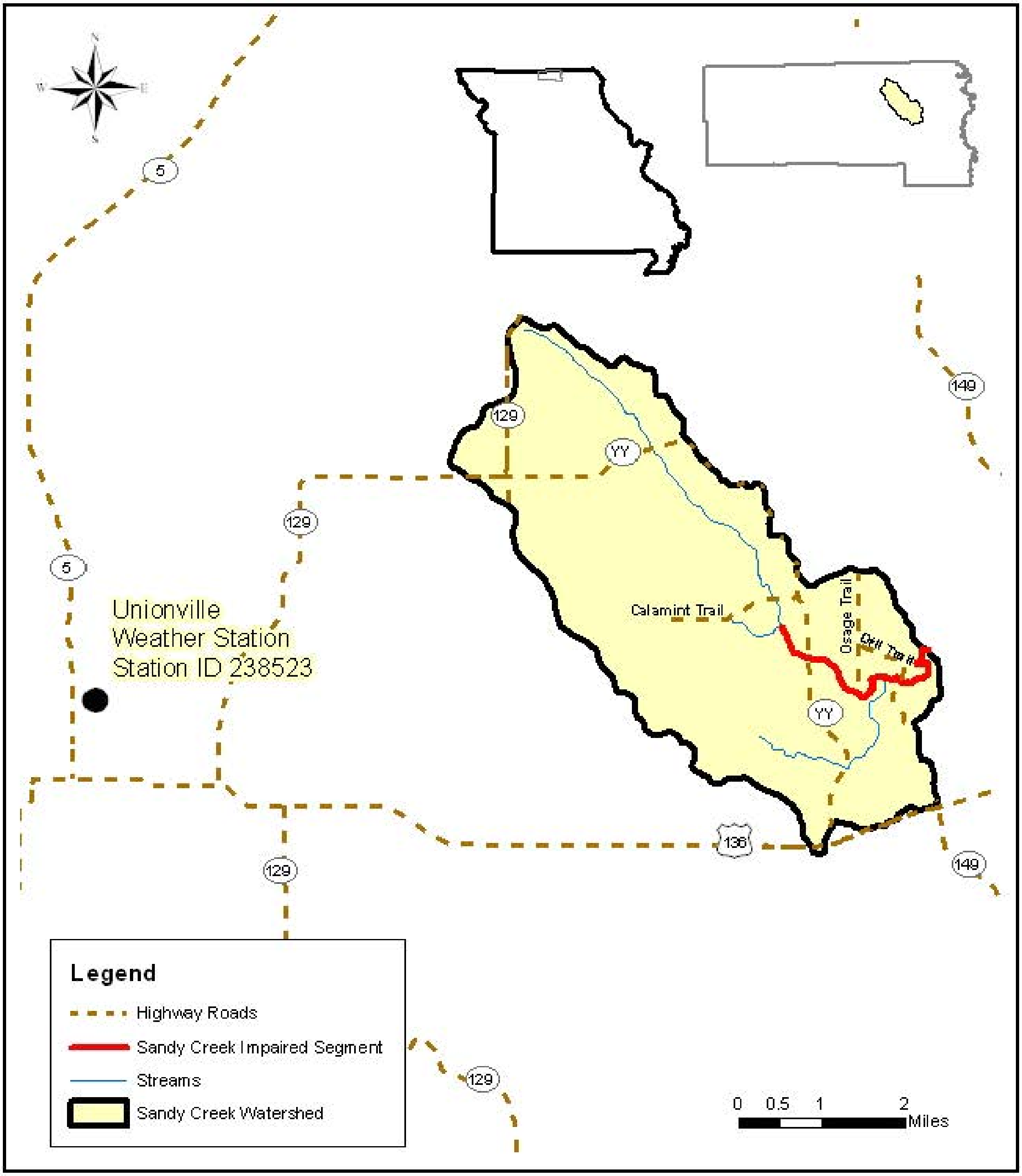

Figure 2. Location of Sandy Creek Watershed with Weather Station

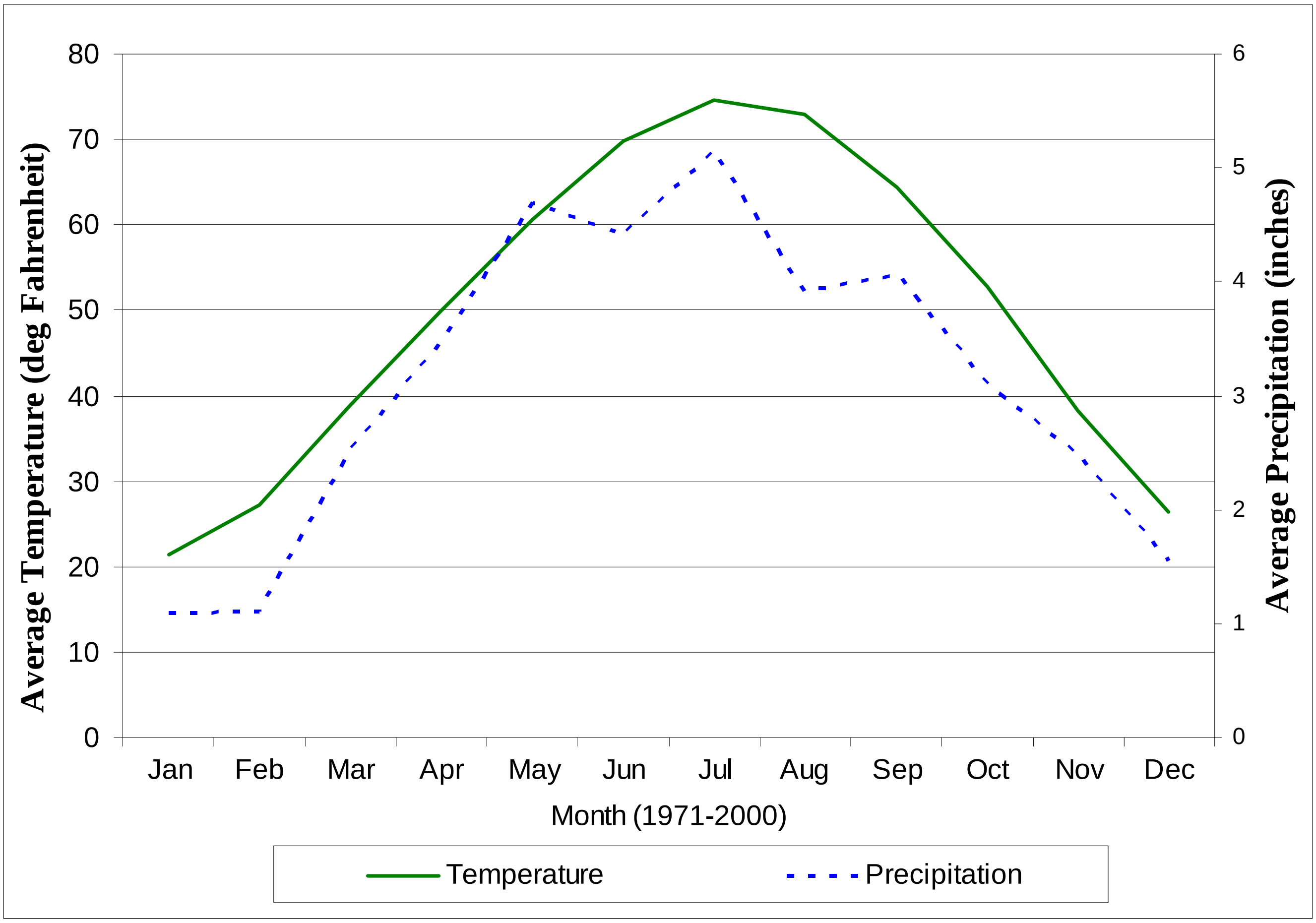

Figure 3. Thirty Year Monthly Temperature and Precipitation Averages for Unionville Station (Station ID 238523)

2.4 POPULATION

The census reports that the 2000 population (in Putnam County) for all areas was 24,977 (U.S. Census Bureau, 2000). The population of the Sandy Creek watershed is not directly available. However, the population of the watershed can be estimated based on the total number of people per census block points located within the watershed. The points represent the centroids of census blocks, the smallest division for which the census provides population data. The Sandy Creek watershed population was estimated to be 105 persons; calculated using a Geographic Information System (GIS) by selecting the census block points located within the watershed area (17.43 square miles). An overall population density for the Sandy Creek watershed was calculated to be 6 persons per square mile (105 persons divided by 17.43 square miles).

2.5 LAND USE AND LAND COVER

The land use and land cover of the Sandy Creek watershed is shown in Figure 4 and summarized in Table 2 (MoRAP, 2005). The primary land uses and land covers are grassland (54.2 percent), forest (23.2 percent) and cropland (12.8 percent). Herbaceous, wetlands, impervious, low intensity urban, barren and water occupy the remaining 9.8 percent of the watershed area.

Table 2. Land Use and Land Cover in the Sandy Creek Watershed (MoRAP, 2005)

	Watershed Area		
Land Use/Land Cover	**Acres**	**Square Miles**	**Percent (%)**
Impervious[1]	135.46	0.21	1.21
Low Intensity Urban[2]	28.75	0.04	0.26
Barren or Sparsely Vegetated	2.00	0.003	0.02
Cropland	1,429.96	2.23	12.82
Grassland	6,052.41	9.46	54.24
Forest	2,585.65	4.04	23.17
Herbaceous[3]	676.70	1.10	6.10
Wetland	94.69	0.15	0.85
Open Water	152.10	0.24	1.40
Total	**11,157.72**	**17.47**	**100**

[1] Impervious land use includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings (MoRAP, 2005)
[2] Low intensity urban is defined as vegetated urban environments with a low density of buildings (MoRAP, 2005)
[3] Herbaceous land uses include open and young woodlands with less than 60 percent cover of deciduous trees (MoRAP, 2005)

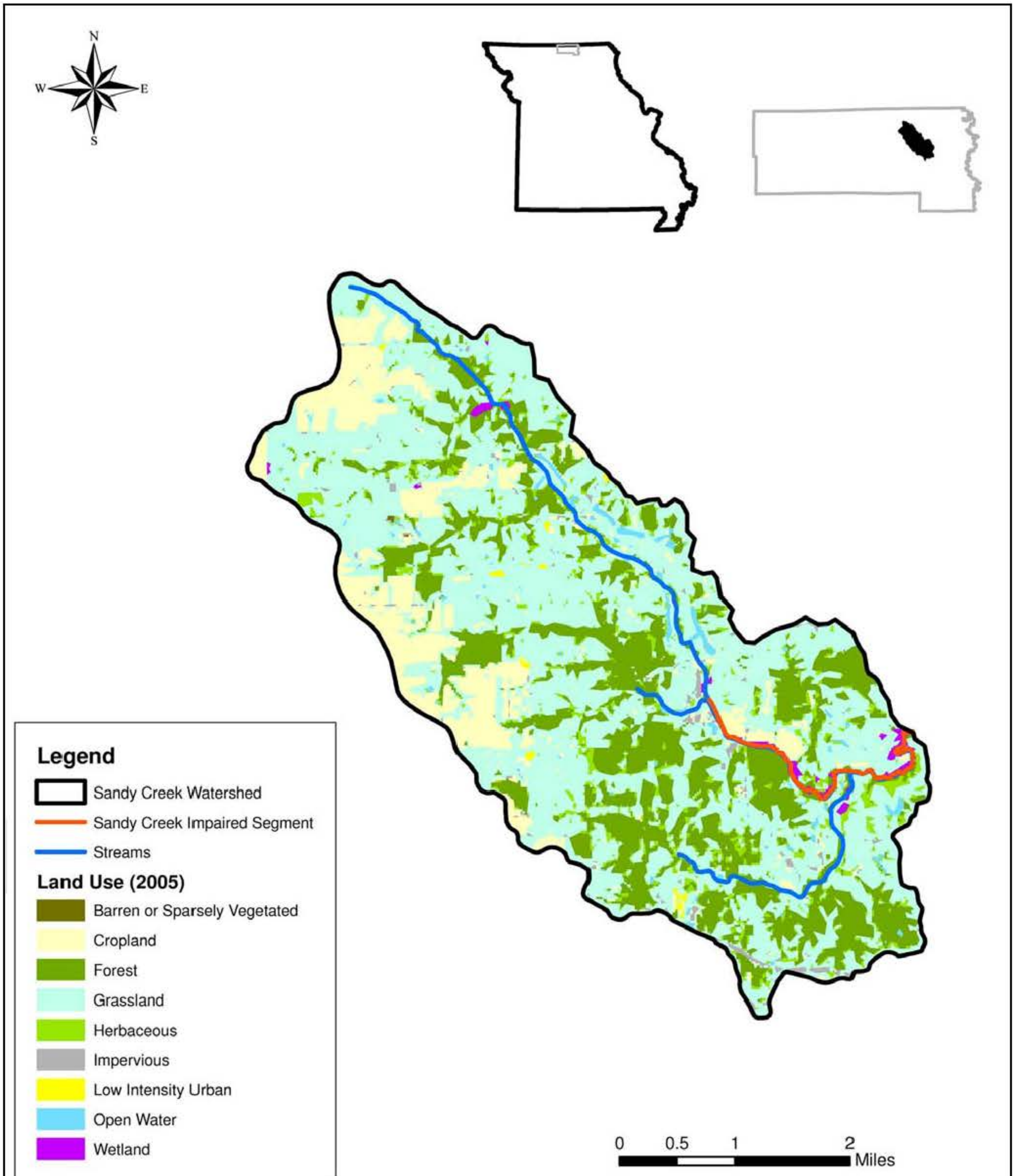

Figure 4. Land Use/Land Cover in the Sandy Creek Watershed (MoRAP, 2005)

2.6 DEFINING THE PROBLEM

Sandy Creek is identified as impaired due to unknown pollutants and sources. Recent water quality data has shown high levels of iron that exceeds the WQS criterion of 1,000 micrograms per liter (µg/L) (see Figure 5 for the locations of all sampling points within Sandy Creek). Additionally, water quality monitoring has revealed elevated levels of TSS in Sandy Creek. In the absence of Missouri numeric standards for TSS, a target derived from the Grand/Chariton EDU is used (see Appendix C for a list of sites and data). The TSS target is 11.0 milligrams per liter (mg/L) and is derived by targeting the 25th percentile base load concentration of TSS measurements collected by the USGS in the Grand/Chariton EDU (12) where Sandy Creek is located (see Appendix B for full description). Water quality monitoring data provided by MDNR has shown that TSS and dissolved iron have been present at elevated levels and are linked to the impaired beneficial use of the water body. Table 3 summarizes water quality data collected from Sandy Creek by MDNR from 2001-2009. Eleven of 33 measurements of TSS were elevated with a majority of the measurements being taken downstream of the Premium Standard Farms' (PSF) Whitetail finishing facility. Additionally, one of four dissolved iron samples taken in the water column was above the numeric target.

Sandy Creek was sampled in September 2009 and April 2010 to assess the impairment due to unknown pollutants. Surface water chemistry parameters, interstitial water chemistry parameters, in-situ water quality parameters and stream physical characteristics were collected. Three locations in Sandy Creek established by MDNR were monitored; see Figure 5 for sampling locations. Results from the September 2009 Sandy Creek assessment (Table 4) identified that dissolved iron was noticeably high in interstitial[6] water at upstream location #3 (3,600 µg/L) as compared to all remaining interstitial and surface water samples (32 µg/L to 110 µg/L). Sample location #3 is located directly upstream of the Calamint Trail crossing of Sandy Creek. Dissolved manganese concentrations were also consistently higher in interstitial water, when compared to surface water. The highest concentrations of manganese also occurred at upstream location #3 (interstitial water #3 = 10,000 µg/L and surface water #3 = 2,200 µg/L) in September 2009.

The majority of Missouri's numeric criteria can be found in Tables A and B in the Code of State Regulations (CSR), Title 10 – Department of Natural Resources, Division 20 – Clean Water Commission, Chapter 7 - Water Quality (10 CSR 20-7.031). The state of Missouri no longer has instream numeric criteria for manganese. The applicable water quality criterion for the protection of aquatic life for iron is 1,000 µg /L. The higher levels of these heavy metals may be due to past discharges to Sandy Creek from nearby mining facilities. Consequently, a TMDL for dissolved iron will be developed.

A Biological Assessment and Habitat Study Report, performed by MDNR in 2007 - 2008, concluded that Sandy Creek is biologically impaired by unknown sources. The water quality parameters tested were under Missouri's water quality criteria and the study concluded that limited habitat and small stream size are a likely source of biological impairment. Unfortunately, heavy metals were not sampled during the MDNR assessment. The report does

[6] Interstitial water is water found between sediment particles in the stream bottom.

suggest that historic coal mining activity may still affect the watershed in Sandy Creek. Although now ceased, the most recent mining activities occurred in the Sandy Creek watershed in the early to mid 1990s. The formerly mined land has either been reclaimed or is in the final stages of reclamation. According to MDNR, mining in the Sandy Creek watershed was extensive. It was conducted up to and along the stream bank for a considerable distance, starting at approximately Calamint Road and continuing upstream along the northeast bank. Coal mining can not only disturb stream banks, but can also be a source of acid mine drainage, metals and sulfates (MDNR 2008). These historic point sources are likely contributors to elevated iron concentrations in the surface water of Sandy Creek.

Table 3. Sandy Creek Water Quality Data (MDNR, 2009b)

Upstream of PSF Whitetail (2001-2002)[1]									
Parameter[2]	**Sampling Events**	**Mean (mg/L)**	**Median (mg/L)**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Lower Quartile (mg/L)**	**Upper Quartile (mg/L)**	**Criteria[3] (mg/L)**	**Number of Exceedances**
TN	-	-	-	-	-	-	-	0.855	-
TP	-	-	-	-	-	-	-	0.092	-
TSS	10	149.8	15.0	10.0	1224.0	12.23	85.0	11.0	3
DO	2	13.1	13.1	12.6	13.6	NA	NA	5 minimum	0
SC (µS/cm)	2	85.0	85.0	70.0	100.0	NA	NA	NA	-
NH_3	10	0.699	0.99	0.0499*	0.99	0.335	0.99	5.0 chronic[4] 17.0 acute	0
NO_3	8	0.425	0.155	0.01499*	1.2	0.099	0.915	NA	-
TKN	-	-	-	-	-	-	-	NA	-
PO_4	2	0.0499*	0.0499*	0.0499*	0.0499*	NA	NA	NA	-
SO_4	-	-	-	-	-	-	-	NA	-
Cl	2	15.2	15.2	14.3	16.0	NA	NA	230 chronic 860 acute	0
DFe	2	1.51	1.51	0.22	2.80	NA	NA	1.0	1
Downstream of PSF Whitetail (2001-2002)[1]									
Parameter[2]	**Sampling Events**	**Mean (mg/L)**	**Median (mg/L)**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Lower Quartile (mg/L)**	**Upper Quartile (mg/L)**	**Criteria[3]**	**Number of Exceedances**
TN	-	-	-	-	-	-	-	0.855	-
TP	-	-	-	-	-	-	-	0.092	-

TSS	18	43.22	13.0	2.5	431.0	5.0	37.0	11.0	6
DO	2	11.9	11.9	11.6	12.2	NA	NA	5 minimum	0
SC (µS/cm)	1	70.0	70.0	70.0	70.0	NA	NA	NA	-
NH_3	17	0.604	0.99	0.0499*	0.99	0.0499*	0.99	5.0 chronic[4] 17.0 acute	0
NO_3	16	0.578	0.265	0.01499*	1.8	0.099	1.2	NA	-
TKN	-	-	-	-	-	-	-	NA	-
PO_4	7	0.0514	0.0499*	0.0299*	0.08	0.0499*	0.05	NA	-
SO_4	-	-	-	-	-	-	-	NA	-
Cl	2	9.05	9.05	8.1	10.0	NA	NA	230 chronic 860 acute	0
DFe	2	0.16	0.16	0.05	0.27	NA	NA	1.0	0
Calamint Road (2007-2008)									
Parameter[2]	**Sampling Events**	**Mean (mg/L)**	**Median (mg/L)**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Lower Quartile (mg/L)**	**Upper Quartile (mg/L)**	**Criteria[3]**	**Number of Exceedances**
TN	2	0.4	0.4	0.4	0.4	NA	NA	0.855	0
TP	2	0.00499*	0.00499*	0.00499*	0.00499*	NA	NA	0.092	0
TSS	0	-	-	-	-	-	-	11.0	-
DO	2	10.8	10.8	9.1	12.5	NA	NA	5 minimum	0
SC (µS/cm)	2	1027.0	1027.0	714.0	1340.0	NA	NA	NA	-
NH_3	2	0.01499*	0.01499*	0.01499*	0.01499*	NA	NA	5.0 chronic[4] 17.0 acute	0
NO_3	2	0.00499*	0.00499*	0.00499*	0.00499*	NA	NA	NA	-
TKN	-	-	-	-	-	-	-	NA	-

PO_4	-	-	-	-	-	-	-	NA	-
SO_4	2	348.0	348.0	202.0	494.0	NA	NA	NA	-
Cl	2	8.85	8.85	6.0	11.7	NA	NA	230 chronic 860 acute	0
DFe	-	-	-	-	-	-	-	1.0	-
Highway YY (2005-2009)									
Parameter[2]	**Sampling Events**	**Mean (mg/L)**	**Median (mg/L)**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Lower Quartile (mg/L)**	**Upper Quartile (mg/L)**	**Criteria[3]**	**Number of Exceedances**
TN	6	0.565	0.445	0.32	1.06	0.335	0.85	0.855	1
TP	6	0.0292	0.0225	0.00499*	0.07	0.00499*	0.055	0.092	0
TSS	5	62.7	13.0	2.5	206.0	4.25	146.0	11.0	2
DO	11	8.74	8.6	6.1	11.2	7.3	11.1	5 minimum	0
SC (µS/cm)	11	1004.9	860.0	360.0	2200.0	703.0	1260.0	NA	-
NH_3	6	0.0542	0.0325	0.01499*	0.17	0.01499*	0.0875	5.0 chronic[4] 17.0 acute	0
NO_3	6	0.967	0.02	0.00499*	0.33	0.00499*	0.233	NA	-
TKN	4	0.545	0.485	0.35	0.86	0.375	0.775	NA	-
PO_4	-	-	-	-	-	-	-	NA	-
SO_4	6	466.8	447.5	205.5	756.0	349.8	599.3	NA	-
Cl	6	8.45	7.36	7.0	12.0	7.0	10.5	230 chronic 860 acute	0
DFe	-	-	-	-	-	-	-	1.0	-

All Sites (2001-2009)									
Parameter[2]	**Sampling Events**	**Mean (mg/L)**	**Median (mg/L)**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Lower Quartile (mg/L)**	**Upper Quartile (mg/L)**	**Criteria[3]**	**Number of Exceedances**
TN	8	0.524	0.4	0.32	1.06	0.343	0.72	0.855	1
TP	8	0.0231	0.00499*	0.00499*	0.07	0.00499*	0.048	0.092	0
TSS	33	78.5	13.0	2.50	1224.0	8.5	25.5	11.0	11
DO	17	9.86	10.6	6.1	13.6	7.5	11.9	5 minimum	0
SC (µS/cm)	16	834.3	757.0	70.0	2200.0	380.8	1250.0	NA	-
NH_3	35	0.503	0.43	0.01499*	0.99	0.0499*	0.99	5.0 chronic[4] 17.0 acute	0
NO_3	32	0.414	0.125	0.00499*	1.8	0.02	0.613	NA	-
TKN	4	0.545	0.485	0.35	0.86	0.375	0.775	NA	-
PO_4	9	0.051	0.0499*	0.0299*	0.08	0.0499*	0.04995	NA	-
SO_4	8	437.1	447.5	202.0	756.0	253.3	533.8	NA	-
Cl	12	9.73	9.05	6.0	16.0	7.0	11.9	230 chronic 860 acute	0
DFe	4	0.84	0.25	0.05	2.80	0.09	2.18	1.0	1

[1] PSF = Premium Standard Farms, NA = Not applicable
[2] DO = Dissolved Oxygen, NH_3 = Ammonia, Cl = Chloride, TKN= Total Kjeldahl Nitrogen, TP = Total Phosphorus, NO_3 = Nitrate, TSS = Total Suspended Solids, SC = Specific Conductance, PO_4 = Phosphate, SO_4 = Sulfate, DFe = Dissolved Iron
[3] Criteria based on reference conditions for TN and TP in Level III Ecoregion 40 streams and the measured TSS concentrations adjusted so that their median is equal to the 25th percentile base load concentration of TSS measurements in the Grand/Chariton EDU. This is accomplished by adjusting the measured data using the ratio between the 25th percentile target and the median from the measured data.
[4] Criteria based on average pH and temperatures at the stream during sampling events
* Value is a reportable detection limit or method detection limit
- Parameter not recorded

Table 4. Sandy Creek Water Quality Data (URS, 2010)[1]

Location[2]	DO (mg/L)	SC (µS/cm)	Cl (mg/L)	DAl (µg/L)	DCa (µg/L)	DFe (µg/L)	DMg (µg/L)	SO_4 (mg/L)
September 2009								
1 SW	6.36	0.941	5.62	<50	150,000	32	930	320
2 SW	5.51	1.10	5.78	<50	160,000	32	1,200	380
3 SW	5.96	1.19	6.09	<50	160,000	41	2,200	440
1 IW	9.45	0.627	6.18	<50	130,000	110	6,700	230
2 IW	9.76	0.677	6.16	<50	93,000	75	6,800	140
3 IW	10.02	0.887	4.60	<50	140,000	3,600	10,000	170
April 2010								
1 SW	10.79	0.643	5.8	<50	130,000	61	620	270
2 SW	7.45	0.671	5.7	<50	140,000	43	810	310
3 SW	8.39	0.725	6.2	<50	140,000	46	1,600	350
1 IW	6.50	0.598	5.7	<50	130,000	<10	1,600	240
2 IW	4.51	0.583	5.1	<50	120,000	<10	790	230
3 IW	5.28	0.614	5.0	<50	140,000	<10	8,800	230
Missouri WQS								
Criteria	5 minimum	NA	230 chronic 860 acute	750 acute	NA	1,000	NA	NA

[1] All sampling was performed on September 8-9, 2009, and April 19-20, 2010. DO = Dissolved Oxygen, NH_3 = Ammonia Nitrogen, Cl = Chloride, TP = Total Phosphorus, TSS = Total Suspended Solids, SC = Specific Conductance, SO_4 = Sulfate, DFe = Dissolved Iron, DMg = Dissolved Manganese, DAl = Dissolved Aluminum, DCa = Dissolved Calcium

[2] SW = Surface Water, IW = Interstitial Water, Location 1 =Dill Trail crossing, Location 2 = Downstream of Highway YY, Location 3 = Calamint Trail crossing, NA = Not applicable

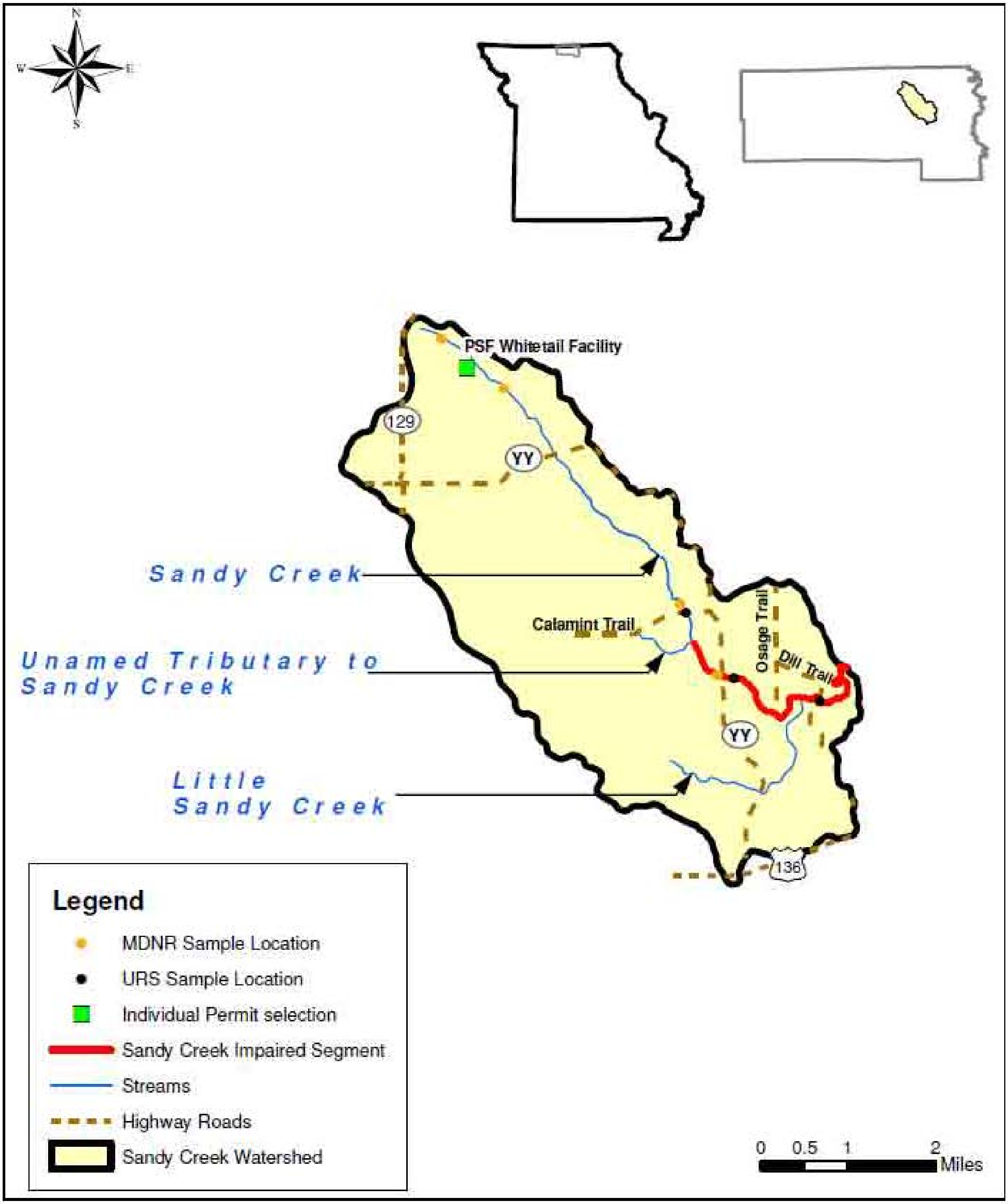

Figure 5. Sampling Locations in Sandy Creek (MDNR, 2009b and URS, 2010)

3 SOURCE INVENTORY

A source assessment is used to identify and characterize the known and suspected sources contributing to impairment in Sandy Creek. 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 sources, either constant or time transient, which occur at a fixed location in a watershed. Nonpoint sources are generally accepted to be diffuse sources not entering a water body at a specific location. Sediment and dissolved iron are considered to be the primary contributors to impairment of the aquatic communities in Sandy Creek.

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 NPDES-regulated entities are included in this source category:

- Municipal and industrial wastewater treatment plants (WWTP);
- Concentrated animal feeding operations (CAFOs);
- Storm water runoff from Municipal Separate Storm Sewer Systems (MS4s);
- General permitted facilities (e.g., including storm water runoff from construction and industrial sites);
- Abandoned mine lands (AML); and
- Illicit straight pipe discharges.

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 Sandy Creek watershed were identified by consulting EPA's Permit Compliance System (PCS) website[7] (EPA, 2009) and MDNR's GIS inventory[8] of NPDES permitted facilities covered under storm water or general permits.

Point sources in Sandy Creek watershed are listed in Table 5 and shown in Figure 6. Of the two permit numbers listed, one is a general permit and the other is a site specific permit. The NPDES permits in Sandy Creek watershed reflect the rural nature of the area. Both the general permit and the site specific permit are related to agricultural activities.

[7] www.epa.gov/enviro/html/pcs/index.html
[8] http://msdis.missouri.edu/datasearch/ThemeList.jsp; GIS layers updated May 2009 and June 2009 (MSDIS, 2009)

3.1.1 Concentrated Animal Feeding Operations

Both point source sites in Table 5 are certified CAFOs. Ronald Blankenship (MOG010426) operates small CAFOs that are covered by a general NPDES permit. A CAFO can be covered by the general permit if they have a design capacity of less than 7,000 animal units (7,000 beef, 17,500 swine, 4,900 dairy or 210,000 laying hens). Requirements of the general permit include no point source discharge except for storm events that exceed the system design capacity, required monitoring of flow estimates during any discharges to waters of the state and operational monitoring of land application systems (MDNR, 2006b). The other CAFO in the watershed holds a site specific permit - PSF, LLC; Whitetail Finishing Site (PSF Whitetail, MO0117421). PSF Whitetail includes a combined design flow of 0.145 million gallons per day (MGD). This is a hog finishing facility and is designed for finishing 79,488 hogs per year. It is a "no discharge" permit (e.g., effluent is land applied) and would only discharge in the event of an extreme storm event. Wastewater is stored in lagoons and land applied based on the available nitrogen approach. This facility has a waste management system designed to minimize runoff entering the facility and detain runoff emanating from the operation. In addition, it is designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with stream flow that occurs less than 1 to 5 percent of the time. Although the potential number of animals associated with the site specific CAFO is 79,488 head in the watershed, the actual number of animals at the operation is typically less than the number allowed by the facility's permit. Since these CAFOs are no discharge facilities, they are unlikely to impact water quality during critical low flow periods. The watershed has a significant amount of grassland and pasture, therefore the number of smaller animal feeding operations (AFO) that are not permitted is presumably high, particularly during seasonal feeding months in the winter.

Countywide data from the National Agricultural Statistics Service (NASS) (USDA, 2007) were combined with the land cover data for the Sandy Creek watershed to estimate approximately 1,220 cattle in the watershed.[9] The cattle are most likely located on the approximately 9.46 square miles of grassland/pastureland in the watershed. The density of cattle in the Sandy Creek watershed (129 cattle per square mile) suggests they are a potential source of TSS and nutrients to the stream. NASS also reports there were 964 sheep and lambs and 374 chickens (layers) in Putnam County in 2007. There was no county level data available for hogs and pigs in Putnam County; however, 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. In summary, animal feeding operations within the watershed have the potential to be a significant source of TSS to Sandy Creek. However, they are not considered to be a contributor of iron to the stream.

[9] According to the NASS there are approximately 46,700 head of cattle in Putnam County (USDA, 2007). According to the 2005 MoRAP there are 361 square miles of grasslands in Putnam County (MoRAP, 2005). These values result in a cattle density of approximately 129 cattle per square mile of grasslands in Putnam County. This density was multiplied by the number of grassland square miles in the Sandy Creek watershed to estimate the number of cattle in the watershed.

3.1.2 Abandoned Mine Lands

Active and abandoned mine land (AML) areas can be classified as point sources due to the nature of mining and milling activities, regardless if they are currently covered by a discharge permit (EPA 1993). Within the Sandy Creek watershed, there are two producing and two past producing coal mines (Table 6). All four mines are located near the impaired section of Sandy Creek. Two of the mines' area are situated along Sandy Creek and two along Little Sandy Creek, a tributary that flows into Sandy Creek within the impaired segment. Neither of the two producing mines listed in MDNR's database have an active NPDES permit associated with it; however, existing, historic and abandoned coal mines are a known source of pollutants. Other abandoned coal mines in Missouri have been identified by the USGS (Christensen, 2005) as contributing to increased conductivity, iron, manganese, aluminum and sulfate.

Both of the producing mines listed are associated with Missouri Mining, Inc. According to MDNR (Larsen, 2010), Missouri Mining, Inc. had a complex of mines in Putnam County that were active in the late 1970s through the 1980s and perhaps into the very early 1990s. These mines are no longer actively producing coal and have been reclaimed. No open pits remain. MDNR's Land Reclamation Program (LRP) is involved with these mines since the reclamation of some of these mines is not 100 percent completed. When Missouri Mining, Inc. declared bankruptcy in the early 1990s, the LRP ordered the reclamation bonds forfeited over to the MDNR so the money collected from the bonds could be used to complete the reclamation. Because this mining complex encompassed several thousands of acres, the project is still not 100 percent completed. Consequently, the mines are no longer under permit. Those mining permits were ordered revoked at the same time the reclamation bonds were ordered forfeit.

Historic mining activity has left abandoned mine workings and tailings piles throughout Missouri's primary mining areas and some likely exist in the Sandy Creek watershed based on its history of mining activity. These AMLs constitute discrete areas of point source delivery of iron, manganese and other heavy metals to the impaired segments. Seepage of dissolved metals from abandoned tailing piles represents another potential secondary source of metals contamination to the impaired water bodies. As precipitation infiltrates tailing piles and moves through the subsurface, metals may become dissolved and enter gaining streams within the watershed via the groundwater recharge pathway. At present the amount and extent of seepage as a secondary source of metals contamination is unknown.

The active and abandoned coal mines in the Sandy Creek watershed are a potential source of these pollutants, but is not a contributor of TSS. According to property owner information, Sampling Location #1 of the URS water quality sampling program was located on reclaimed mining land. Approximate locations of the coal mines are included in Figure 6.

3.1.3 Illicit Straight Pipe Discharges

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

3.1.4 Runoff from MS4 Urban Areas

There are no Phase I or Phase II regulated communities within the Sandy Creek watershed at this time.

Table 5. Permitted Facilities in the Sandy Creek Watershed

General Permit

Facility ID and Name	Receiving Stream	Number of Outfalls	Permit Expiration	Classification/Description[4]
MOG010426, Ronald Blankenship	Tributary of Sandy Creek	2	2011	CAFO IC, Hogs

Site Specific Permit

Facility ID and Name	Outfall Type	Receiving Stream[1]	Outfall Number	Design Flow (Gal/Year)[2]	Reporting Requirements[3]	Permit Expiration	Classification/ Description[4]
MO0117421, Premium Standard Farms, LLC; Whitetail Finishing Site	Anaerobic Lagoon/ Secondary Containment	N. Blackbird Ck.	001	6,162,660	Flow, DO, NH_3, BOD, pH, Cl, Temp., TKN, TP, $NO_3 + NO_2$, Solids	2009	CAFO IA, Hogs
			002	6,309,260			
			003	5,267,680			
			004	6,187,480			
			005	5,273,155			
			006	6,168,135			
			007	6,210,840			
			008	5,289,580			
		Little Shoal Ck.	010	6,177,990			
	Domestic Wastewater	N. Blackbird Ck.	013	NA	Flow, DO, NH_3, BOD, pH, Cl, Temp.		
	Fresh Water Lake Monitoring	Tributary to N. Blackbird Ck.	015		Flow, pH, NH_3, $NO_3 + NO_2$, TP, Temp, TSS		
			016				
	Stream Monitoring	N. Blackbird Ck.	017		Flow, pH, NH_3, $NO_3 + NO_2$, TP, Temp., TSS, DO		
			018				
		Shoal Creek	019				
		Little Shoal Ck.	020				

	Storm water	Sandy Ck.	021				
	Storm water	Little Shoal Ck.	022		pH, NH_3, NO_2+NO_3, TP, Cl, Temp.		
	Storm water	Little Shoal Ck.	023				

[1] Permit number MO0117421 lists multiple receiving streams, N = North, Ck. = Creek
[2] Gal/Year = Gallons per year. Total permitted flow = 53,046,780 gallons per year or 0.145 MGD. NA = Not Applicable (no design flow).
[3] DO = Dissolved Oxygen, NH_3 = Ammonia Nitrogen, BOD = Biochemical Oxygen Demand, Cl = Chloride, Temp = Temperature, TKN= Total Kjeldahl Nitrogen, TP = Total Phosphorus, NO_3 = Nitrate Nitrogen, NO_2 = Nitrite Nitrogen, TSS = Total Suspended Solids.
[4] CAFO IA 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).

Table 6. Coal Mining Locations in the Sandy Creek Watershed (MDNR, 2008c)

Location in Putnam County				Name/ Owner/ Operator	Type of Operation	Status
TWP	**RNG**	**SEC**	**Quarter**			
66N	17W	31	C N2S2	Eva Maria Mine; Gillum Mine #2 Strip; Gillum Mine #70; Eva Maria Strip / Missouri Mining Inc.	Surface	Producer
66N	17W	20	SESW	Loren Rowland Mine	Underground	Past Producer
66N	17W	31	C	No Data	Surface	Past Producer
66N	17W	30	NESENE	Missouri Mining Co.	No Data	Producer

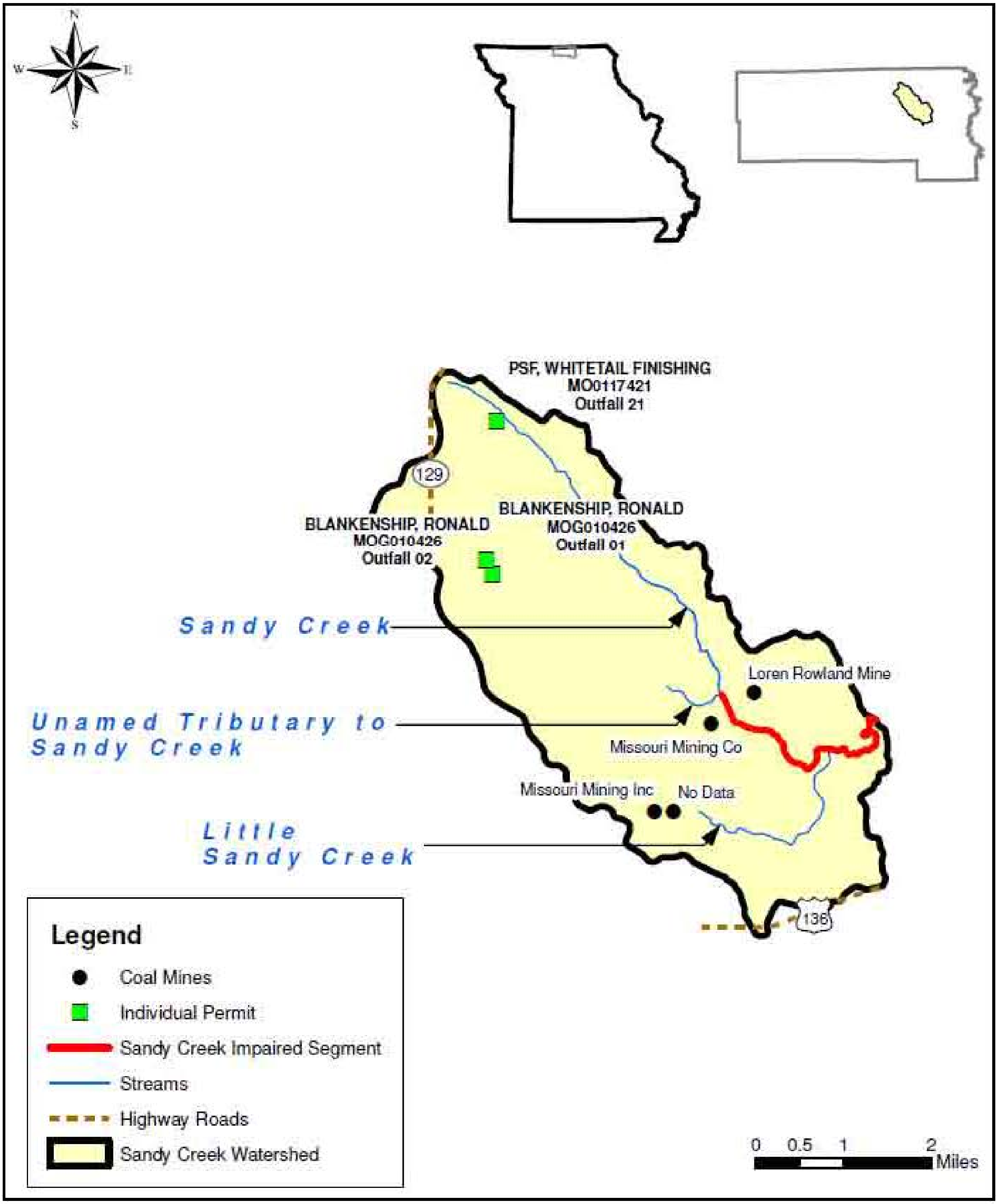

Figure 6. Location of Permitted and Unpermitted Facilities in the Sandy Creek Watershed (Note: MOG010426 is shown twice due to multiple outfalls)

3.2 NONPOINT SOURCES

Nonpoint sources are diffuse sources of pollutant loading that typically cannot be identified as entering a water body at a single location and they include all other categories not classified as point sources.

Based on the information before us, the decision to apply discharges associated with unpermitted sources to the LA, as opposed to the WLA for purposes of this TMDL, is acceptable. The decision to allocate these sources to the 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 approving 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 pollutant 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 WLA in this TMDL. WLA in addition to that allocated here is not available.

One exception is AMLs for the dissolved iron TMDL. AMLs are considered to be point sources regardless of their NPDES permit status and are applied to the WLA category. Potential nonpoint sources contributing to the impairment in Sandy Creek include runoff from agricultural areas, such as cropland and pasture, non-regulated animal feeding areas and onsite wastewater treatment systems. Each of these is discussed further in the following sections.

3.2.1 Runoff from Agriculture Areas

The 2005 land use and land cover data (MoRAP, 2005) indicates there are 1,430 cropland acres in the watershed, which comprises 12.8 percent of the entire watershed and 6,052 (54.2 percent) grassland acres in the watershed (Table 2). Additionally, cropland comprises approximately two percent of the riparian buffer, while 34.1 percent is classified as grassland (discussed in Section 3.2.4 and shown in Table 5). Lands used for agricultural purposes can be a source of sediment. Sediment can be dislodged from the soil matrix by agricultural animals in confined spaces and pastures and stream bank erosion can occur when cattle access streams for drinking water. Runoff from these areas can be potential sources of sediment. 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. In addition, when pasture land is not fenced off from the stream, cattle or other livestock may contribute sediment to the stream while walking in or adjacent to the water body. In summary, agricultural activities and runoff from these areas have the potential to be significant sources of TSS to Sandy Creek. Agricultural lands in the watershed are not expected to be a significant source of iron to Sandy Creek.

Permitted CAFOs identified in this TMDL are part of the assigned WLA. At this time, 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 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 man-made conveyance.

3.2.2 Runoff from Non-MS4 Urban Areas

Only a small portion (0.26 percent) of the Sandy Creek watershed is classified as low intensity urban and only 1.2 percent of the watershed is identified as impervious. 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, bacteria, 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 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 are very little impervious or urban areas in the watershed, it is unlikely that runoff from these sources is a significant contributor of TSS or iron to Sandy Creek.

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 septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsley and Witten, 1996). Failing septic systems are sources of nutrients and pathogens that can reach nearby streams through both runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the Sandy Creek watershed is unknown. However, the EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL)[10] reports there are 4,747 septic systems within the Upper Chariton Watershed, which is the eight digit HUC watershed that contains the Sandy Creek watershed. The Upper Chariton Watershed has an average population per septic system of 2.23. As discussed in Section 2.4, the estimated rural population of the Sandy Creek watershed is approximately 105 persons. Based on this population and an average density of 2.23 persons per septic system an estimate of approximately 47 systems in the watershed is obtained. An EPA study reports that the estimated failure rate of onsite wastewater systems in Missouri is 30 percent to 50 percent (EPA, 2010). At this failure rate there would be approximately 14 to 24 failing systems in the watershed. No information was identified that would suggest failing onsite wastewater systems are a significant problem in the Sandy Creek watershed. Based on the small numbers of onsite systems they are not considered a significant source of TSS or iron.

3.2.4 Riparian Corridor Conditions

Riparian[11] (streamside) corridor conditions can have a strong influence on instream water quality and habitat. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal and assimilation of pollutants from runoff. Therefore, a stream with good riparian cover is better able to moderate the impacts of high pollutant loads than a stream with poor riparian cover. Wooded riparian buffers can also provide shading that reduces stream temperatures and increases the dissolved oxygen saturation capacity of the stream.

As indicated in Table 7, 10.9 percent of the land in the Sandy Creek riparian corridor (defined as 30-meter buffer on either side of Sandy Creek) is classified as herbaceous, 30.3 percent is forested, 20.5 percent is wetlands and 34.1 percent is grassland (MoRAP, 2005). Compared to wooded areas or wetlands, grasslands (which may include pasture areas) generally provide less shading and higher pollutant loads due to livestock and related agricultural activity. Approximately, 34.1 percent of the riparian areas around Sandy Creek are grassland habitat. Consequently, the main land use in the riparian corridor is grassland, which comprises over a third of the riparian area. Agricultural activities within the riparian buffer of Sandy Creek could be a potential source of TSS, but not iron to the impaired segment.

Table 7. Percentage Land Use/Land Cover Within Riparian Buffer, 30-Meter

Land Use/Land Cover[1]	Acres	Square Miles	Percent (%)
Cropland	3.9	0.006	2.0
Forest	58.8	0.09	30.3
Herbaceous[2]	21.2	0.03	10.9
Grassland	66.2	0.10	34.1
Open Water	3.9	0.006	2.0
Wetlands	39.8	0.06	20.5
Impervious[3]	0.5	0.0007	0.2

[10] http://bering.tetratech-ffx.com/website/stepl/viewer.htm
[11] A riparian corridor (or zone or area) is the linear strip of land running adjacent to a stream bank.

Land Use/Land Cover[1]	Acres	Square Miles	Percent (%)
Total	**194.3**	**0.29**	**100**

[1] MoRAP, 2005
[2] Herbaceous land uses include open and young woodlands with less than 60 percent cover of deciduous trees (MoRAP, 2005)
[3] Impervious land uses includes non-vegetated, impervious surfaces including areas dominated by streets, parking lots and buildings (MoRAP, 2005)

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 applicable WQS. The purpose of developing a TMDL is to identify the maximum amount of a pollutant load that a water body can receive and still achieve WQS. 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 (US Code Title 33, Chapter 26, Subchapter III [US 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 (i.e., general and numeric) 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 beneficial 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 Sandy Creek segment (WBID 0652) is three miles in length and is classified as an intermittent stream (C). Designated beneficial uses include[12]:

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

The designated beneficial use that is impaired is the Protection of Warm Water Aquatic Life.

[12] According to Missouri WQS Table H (CSR, 2009)

4.2 CRITERIA

In the 2008 Missouri 303(d) List, Sandy Creek is listed as impaired due to unknown pollutants. Water quality monitoring has revealed an exceedance of the dissolved iron numeric criterion of 1,000 µg /L and elevated levels of TSS in Sandy Creek.

The TMDL for iron is based on attainment of the Missouri aquatic life standard for dissolved iron of 1,000 µg /L under all flow conditions, as stated in 10 CSR 20-7.031, Table A (CSR, 2009).

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. In the absence of Missouri numeric standards for TSS, a reference approach was used. The TSS target is 11.0 mg/L and is derived by targeting the 25th percentile base load concentration of TSS measurements collected by the USGS in Grand/Chariton EDU (12) where Sandy Creek is located.

All water bodies in Missouri are protected by the general criteria (standards) contained in Missouri's WQS, 10 CSR20-7.031(3). These criteria are also called narrative criteria, since they do not contain specific numeric limits. The narrative criteria not being met in Sandy Creek are (3)(A), (D) and (G):

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

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 antidegradation review consisting of: 1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; 2) full satisfaction of all intergovernmental coordination and public participation provisions; and 3) assurance that the highest statutory and regulatory requirements for point sources and best management practices (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 designated beneficial 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 LDC is useful in identifying and differentiating between storm-driven and steady-input sources (Cleland, 2002 and Cleland, 2003). For Sandy Creek, the LDC approach was used to: 1) provide a visual representation of stream flow conditions under which elevated levels of TSS and dissolved iron criteria exceedances have occurred, 2) assess critical conditions and 3) quantify the LC of the stream to meet the surface water quality targets for TSS and dissolved iron.

A limited amount of flow data is available in the Sandy Creek watershed (Appendix A), which was inadequate for developing a LDC. To address this issue, a synthetic flow analysis was used. To develop a synthetic flow based duration curve for Sandy Creek, flow records from seven USGS gaging stations (Table 8) in the same ecological region were used to establish a daily flow per square-mile estimate. Average daily flow per square-mile from the seven stations was calculated for each day of record and multiplied by the impaired watershed area (17.43 square miles). In the Sandy Creek watershed, no continuously discharging permitted wastewater facilities or separate storm water sewer systems (MS4) are present. To construct a LDC, the synthetic flow was estimated for the period from July 20, 1978 to July 14, 2010. A detailed discussion of methods used to develop the TSS and dissolved iron LDCs is presented in Appendix B and Appendix C.

Table 8. Stream Flow Stations Used to Estimate Flows in Sandy Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Discharge Record	Latitude/ Longitude
Medicine Creek near Laredo, MO	USGS	06900050	355	2000–2010	40°01'35.8", 93°26'10.4"
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220	1962-2010	39°27'17.7", 92°34'06.6"
East Fork Big Creek near Bethany, MO	USGS	06897000	95	1934–2010	40°17'50.0", 94°01'34.4"
Medicine Creek near Galt, MO	USGS	06900000	225	1918–2010	40°07'47.1", 93°21'45.2"
Mussel Fork near Mussel Fork, MO	USGS	06906000	267	1948–2010	39°31'24.7", 92°56'58.7"
South Fork Chariton River near Promise City, IA	USGS	06903700	168	1967-2010	40°48'02", 93°11'32"
Chariton River near Chariton, IA	USGS	06903400	182	1967-2010	40°57'06.8", 93°15'34.7"

5.1 CRITERION TO SUPPORT THE TMDL

In Sandy Creek, where narrative standards for TSS are targeted for the impaired segment, a reference stream approach was used to define the TSS TMDL target. The TSS target was developed to protect the aquatic life designated use of the stream. Missouri does not have a numeric criterion for TSS; therefore a statistical approach was used to develop a target for TSS. The dissolved iron target is 1,000 µg /L based on the Missouri WQS numeric criterion to protect aquatic life, as stated in 10 CSR 20-7.031, Table A (CSR, 2009). The methods used to establish the TSS target differ from the method used to establish the dissolved iron target and are described below.

The TSS target is 11.0 mg/L and was based on a reference approach by targeting the 25th percentile of TSS base load concentration data (USGS, non-filterable residue) available within the Grand/Chariton EDU (12) where Sandy Creek is located (see Appendix C for a list of sites and data). To develop the LDC for TSS, measured TSS concentrations are adjusted so that their median is equal to the 25th percentile base load concentration of TSS measurements collected by the USGS in the EDU. This is accomplished by adjusting the measured data using the ratio between the 25th percentile target and the median from the measured data and results in the data retaining most of its variability while having a median that meets the 25th percentile target. This adjusted data was then regressed as yield (pounds/day) versus instantaneous flow (cfs). The resultant regression equation was used to develop the load duration curve. A detailed discussion of the method used to develop the TSS target is provided in Appendix B.

6 CALCULATION OF LOADING CAPACITY

LC is defined as the maximum amount of a pollutant that a water body can assimilate without exceeding WQS. This load is then divided among the point source (WLA) and nonpoint source (LA) pollutant contributions to the stream, with an allowance for an explicit MOS. 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 the equation:

$$LC = \Sigma\ WLA + \Sigma\ LA + MOS$$ **Equation 1**

Where:

LC = Loading Capacity

WLA = Wasteload Allocation (point source)

LA = Load Allocation (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 achieve WQS. 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 Sandy Creek, TSS and dissolved iron TMDLs are expressed as pound per day (lb/day) using a LDC (Figure 7, Figure 8, Table 9 and Table 10). The LDC represents the LC as a solid red line over the range of flow conditions present in the creek. Water quality measurements, shown as points, are loads calculated from TSS and dissolved iron concentrations collected in Sandy Creek.

As presented in Figure 7, excursions to the TSS TMDL occurred under all flow conditions. A minimal amount of data is available for dissolved iron (Figure 8); however, of the data available, one of ten water column measurements and one of six interstitial water measurements were found to be above the numeric criterion of 1,000 µg /L.

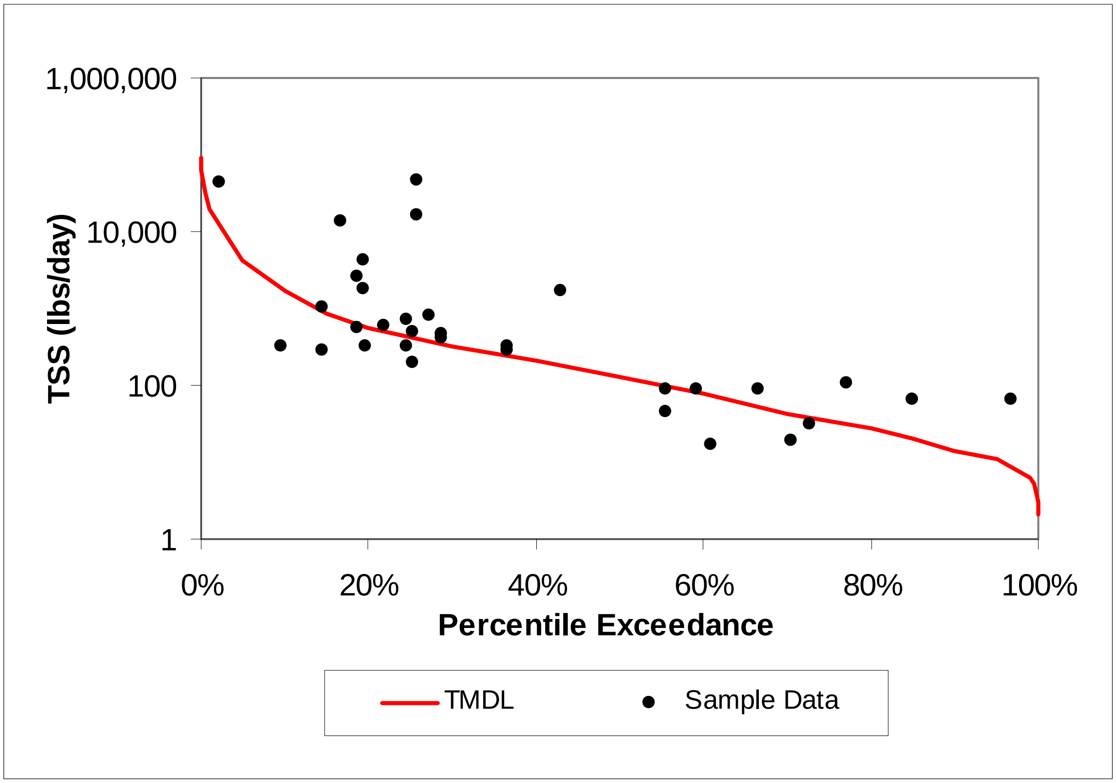

Figure 7. TSS LDC for Sandy Creek

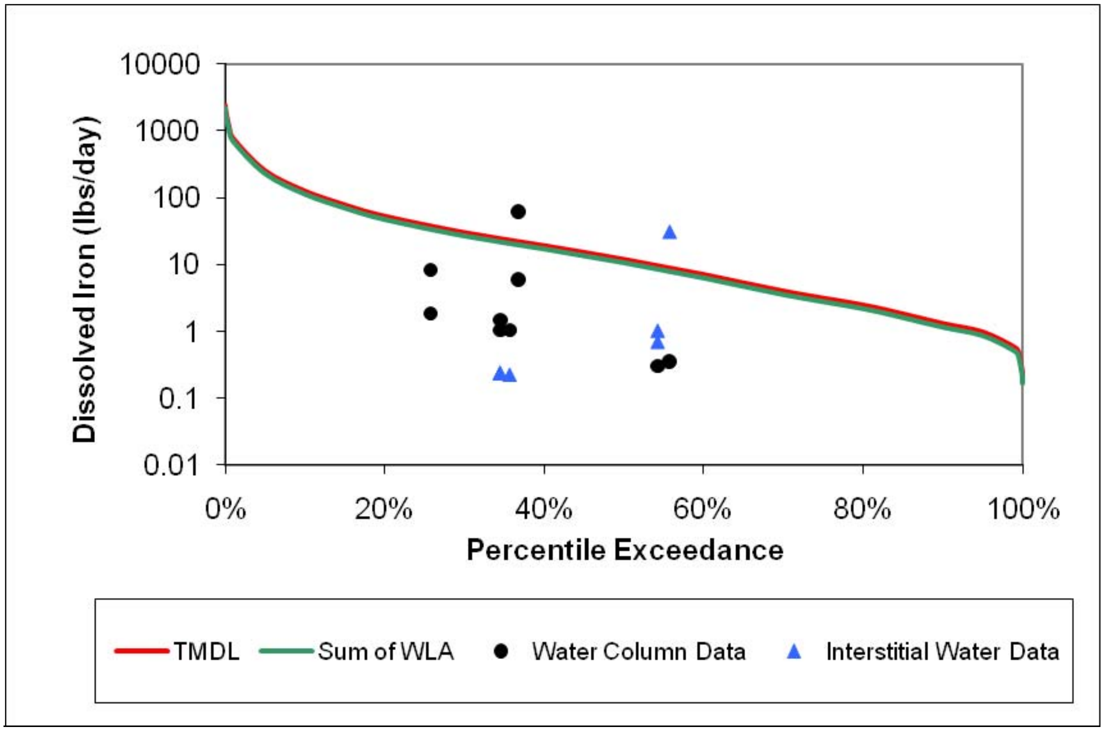

Figure 8. Dissolved Iron LDC for Sandy Creek

Table 9. TSS TMDL Under a Range of Flow Conditions in Sandy Creek

Percent Flow Exceedance	Estimated Flow (cfs)	TSS TMDL (lb/day)	TSS LA (lb/day)	TSS WLA (lb/day)	MOS[1] (lb/day)
95	0.18	10.68	10.68	0	--
90	0.24	14.26	14.26	0	--
70	0.73	43.60	43.60	0	--
50	2.19	129.99	129.99	0	--
30	5.51	326.72	326.72	0	--
10	23.08	1,668.37	1,668.37	0	--
5	46.51	4,302.98	4,302.98	0	--

[1] The MOS for TSS is implicit.

Table 10. Dissolved Iron TMDL Under a Range of Flow Conditions in Sandy Creek

Percent Flow Exceedance	Estimated Flow (cfs)	Dissolved Iron TMDL (lb/day)	Dissolved Iron LA (lb/day)	Dissolved Iron WLA (lb/day)	MOS (lb/day)
95	0.18	0.97	0	0.87	0.10
90	0.24	1.30	0	1.17	0.13
70	0.73	3.97	0	3.57	0.40
50	2.19	11.82	0	10.64	1.18
30	5.51	29.70	0	26.73	2.97
10	23.08	124.53	0	112.08	12.45
5	46.51	250.93	0	225.84	25.09

7 WASTELOAD ALLOCATION (POINT SOURCE LOADS)

The WLA is the allowable amount of the pollutant that can be assigned to point sources. The WLA is set to the current permit limits or technology based effluent limits (TBELs). NPDES permit limits can be either TBELs or water quality-based effluent limitations (WQBELs) for a given pollutant. TBELs are based upon the expected capability of a treatment method to reduce the pollutant to a certain concentration. WQBELs represent the most stringent concentration of a pollutant that a receiving stream can assimilate without exceeding applicable WQS or criteria at a specific location. The permitted facilities in the watershed are all "no discharge" facilities. Thus, the waste generated onsite is not directly discharged to the stream, instead it is land applied. The "no discharge" permits only discharge in the event of a large storm event that exceeds the wastewater storage capacity of the facility.

PSF operates the White Tail Finishing Site under permit MO0117421. The facility is classified as a CAFO with multiple outfalls associated with nine anaerobic lagoons with secondary containment structures, domestic wastewater, storm water and lake and stream monitoring (see Table 5). One storm water outfall discharges directly to Sandy Creek.

However, this is a no discharge facility for process waste. Wastewater is stored in the lagoons and land applied based on the available nitrogen approach. The PSF facilities are "no discharge" permits and would only discharge in the event of an extreme storm event. A general permit (MOG10426) is also issued to Ronald Blankenship covering operations of a small CAFO. This facility has two registered outfalls discharging to Sandy Creek, however, it is also a “no discharge” facility and would not cause or contribute to the TSS and dissolved iron impairments. Since both of these facilities are no discharge and would not cause or contribute to the TSS and dissolved iron impairments, WLAs for these facilities are set to zero (Table 11).

Table 11. TSS and Iron WLAs for Permitted Facilities in the Sandy Creek Watershed

Facility ID	Facility Name [1]	Permit Type	Outfall Number[2]	Receiving Stream	WLA for TSS and Iron (lb/day)
MO0117421	PSF, Whitetail Finishing	Site Specific	021	Sandy Creek	0.0
MOG010426	Ronald Blankenship	General	01, 02	Sandy Creek Tributary	0.0

[1] PSF = “Premium Standard Farms”
[2] Only outfalls within the Sandy Creek watershed are listed

The dissolved iron impairment is most likely due to dissolved iron from AMLs. Active and abandoned mine areas can be classified as point sources due to the nature of mining and milling activities, regardless if they are currently covered by a discharge permit (EPA 1993). None of the four producing or past producing mines in the Sandy Creek watershed are covered under an active discharge permit. Consequently, there is no wastewater or storm water discharge information available. Since there is no other reasonable source of iron present in the watershed, these AMLs are most likely responsible for the dissolved iron entering Sandy Creek. This is reflected in the dissolved iron WLA, which was calculated by subtracting an explicit MOS from the total LC of iron in Sandy Creek and allocating the remainder to the WLA.

It should be noted, that while a WLA has been calculated for the point sources of the dissolved iron impairment, including any unpermitted abandoned mines, any allocation does not reflect an authorization to discharge from an unpermitted point source. Discharging pollutants to waters of the state without a permit is a violation of both state and federal clean water law. Should it become necessary to permit currently unpermitted abandoned mines or tailings piles, those areas must follow MDNR’s permit application and antidegradation processes and will be evaluated in light of this TMDL.

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, a Storm Water Pollution Prevention Plan (SWPPP) ensures the design, implementation and maintenance of BMPs. Compliance with the SWPPP should result in sediment loading from construction sites at or below applicable targets.

The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment loading in the watershed. Any future point sources should be evaluated in light of the TMDL established and the range of flows into which any additional load will impact.

8 LOAD ALLOCATION (NONPOINT SOURCE LOADS)

The LA includes all existing and future nonpoint sources and natural background contributions (40 CFR § 130.2(g)) of the pollutants of concern. LA is the allowable amount of the pollutant that can be assigned to nonpoint sources. The LA is set at the remainder for the TMDL loading curve after removing allowances for the point source WLA and MOS. Because all point sources for TSS in the watershed received a zero WLA and the MOS is implicit, the total LC is allocated to nonpoint sources as LA. For dissolved iron, the total LC is allocated to the WLA and the explicit MOS because the LA is set to zero. TSS and dissolved iron LAs are provided in Tables 9 and 10.

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 TSS TMDL based on conservative assumptions used in the development of the TSS LDC. In the case of TSS, a reference approach used was to target the 25th percentile of all concentration data available in the EDU in which Sandy Creek is located (see Appendix B and C). The use of this EDU specific data ensures that all local geologic and landscape conditions are addressed in this TMDL. An explicit MOS of 10 percent was incorporated into the dissolved iron TMDL.

10 CRITICAL CONDITIONS AND SEASONAL VARIATION

Although there were insufficient water quality data to determine any seasonal pattern that may be occurring in the Sandy Creek watershed, exceedances to the water quality criteria were present under both low and high flow conditions (Figure 7 and Figure 8). The TMDL LDC for TSS represents flow under all conditions. Because the WLA, LA and TMDL are applicable at all flow conditions, they are also applicable and protective over all seasons. One 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.

11 MONITORING PLANS

A stressor study was conducted on Sandy Creek in 2009 - 2010 by Versar, Inc. (published 2010). No future monitoring has been scheduled for Sandy Creek at this time. In general, future stream monitoring is scheduled and conducted by MDNR approximately three years after the approval of a 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 (RAM) 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 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 Sandy Creek 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 Sandy Creek in Putnam County, 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 is 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 Sandy Creek TMDL has been assembled and is being kept on file with EPA.

APPENDICES

Appendix A – Sandy Creek Water Quality Data
Appendix B – Development of TSS Targets Using Reference LDCs
Appendix C – Stream Flow and Water Quality Stations Used to Develop TMDLs in Sandy Creek
Appendix D – Supplemental Implementation Plan

REFERENCES

Athayde, D., P. Shelley, E. Driscoll, D. Gaboury and G. Boyd, 1983. *Results of the Nationwide Urban Runoff Program, Volume I – Final Report*. Water Planning Division, EPA, Washington D.C.

Christensen, E.D., 2005. Assessment, water-quality trends and options for remediation of acidic drainage from abandoned coal mines near Huntsville, Missouri, 2003–2004: U.S. Geological Survey Scientific Investigations Report 2005 – 5202. USGS, Reston, VA.

Cleland, B.R., 2002. TMDL Development From the "Bottom Up" – Part II: Using Load Duration Curves to Connect the Pieces. Proceedings from the WEF National TMDL Science and Policy 2002 Conference. America's Clean Water Foundation, Washington, D.C.

Cleland, B.R., 2003. TMDL Development From the "Bottom Up" – Part III: Duration Curves and Wet-Weather Assessments. America's Clean Water Foundation, Washington, D.C.

CSR (Code of State Regulations), 2009. Missouri Secretary of State Web page. Title 10 - Department of Natural Resources, Division 20 – Clean Water Commission, Chapter 7 – Water Quality. 10 CSR 20-7.031 - Water Quality Standards. Jefferson City, MO. http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

EPA (United States Environmental Protection Agency), 1993. Memo: NPDES Permit Issues and Hard Rock Mines. EPA Region VIII, Denver, CO.

EPA, 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX. EPA 822-B-00-019. Washington, D.C.

EPA, 2006. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA-822-R-06-001. Washington, D.C.

EPA, 2009. Water Discharge Permits (PCS). Accessed July 17, 2009. http://www.epa.gov/enviro/html/pcs/index.html

EPA, 2010. Region 5 STEPL Online Database. 2003. Accessed March 29, 2010. http://bering.tetratech-ffx.com/website/stepl/viewer.htm

Horsley & Witten, Inc., 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick and Freeport, Maine. Casco Bay Estuary Project. Portland, ME.

Larsen, Michael, 2010. Personal Correspondence. Missouri Department of Natural Resources – Land Reclamation Program. May 2010.

MDC (Missouri Department of Conservation), 2010. *Chariton River Watershed – Geology/Geomorphology, Physiographic Region/Geology/Soils.* Accessed February 16, 2010. http://mdc.mo.gov/fish/watershed/chariton/geology/

MSWDC (Missouri Soil and Water Districts Commission), 2003. *Needs Assessment, Plan to Address Identified Needs & A Summary to Date*, Accessed February 16, 2010. http://www.dnr.mo.gov/env/swcp/2003%20needs%20assessment.pdf

MDNR (Missouri Department of Natural Resources), 2006a. *Total Maximum Daily Load Information Sheet For Streams Where the Pollutant is Unknown*. Accessed April 16, 2010. http://www.dnr.mo.gov/env/wpp/tmdl/info/unknowns-info.pdf

MDNR, 2006b. *Missouri State Operating Permit – General Permit (MOG010000)*. Jefferson City, MO. http://www.dnr.mo.gov/env/wpp/permits/issued/G010000.pdf

MDNR, 2008a. *Final Consolidated 2008 Missouri 303(d)*. Jefferson City, MO. http://www.dnr.mo.gov/env/wpp/waterquality/303d/2008/2008-303d-final.pdf

MDNR, 2008b. *Biological Assessment and Habitat Study Report – Sandy Creek, Putnam County*. Jefferson City, MO.

MDNR, 2008c. *Inventory of Mines, Occurrences and Prospects in Missouri*. Prepared by Missouri Department of Natural Resources, Division of Geology and Land Survey (DGLS), Geological Survey Program (GSP). Prepared on January 10, 2008. ftp://msdis.missouri.edu/pub/state/st_imop.zip

MDNR, 2009a. Agricultural Nonpoint Source, Special Area Land Treatment Program, NPS Problems. http://www.dnr.mo.gov/env/swcp/service/Salt/nps_problems.htm#improper%20animal%20waste%20management

MDNR, 2009b. Sandy Creek Water Quality Data 2000-2009.

MDNR, 2010. *How to Obtain a Concentrated Animal Feeding Operations Permit in Missouri*. Jefferson City, MO. http://www.dnr.mo.gov/pubs/pub2351.pdf

MoRAP (Missouri Resource Assessment Partnership), 2005. Land Use/Land Cover Data. Accessed April 26, 2007. http://www.msdis.missouri.edu

MSDIS (Missouri Spatial Data Information Service), 2009. GIS Layers Downloaded May 2009. http://msdis.missouri.edu/datasearch/ThemeList.jsp

NOAA (National Oceanic and Atmospheric Administration). NNDC Climate Data Online. Accessed March 29, 2010. http://cdo.ncdc.noaa.gov/climatenormals/clim20/mo/234544.pdf

NRCS (Natural Resources Conservation Service), 2009 Soil Data Mart. Accessed July 17, 2009. http://soildatamart.nrcs.usda.gov/Survey.aspx?County=MO001

Purdue Research Foundation, 2009. Hydrologic Soil Groups. Accessed July 17, 2009. http://www.ecn.purdue.edu/runoff/documentation/hsg.html

Reckhow, K. H., M. N. Beaulac and J. R. Simpson, 1980. *Modeling Phosphorous Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients.* EPA-440/5-8-011, U.S. Environmental Protection Agency, Washington, D.C.

United States Census Bureau, 2000. 2000 Population Estimates. Accessed November 6, 2008, http://www.census.gov/

URS Corporation, 2010. *Sampling Collection and Data Report*. Sampling for Consent Decree Waters in Missouri – Sandy Creek.

USDA (United States Department of Agriculture), 2007. National Agriculture Statistics Service. Accessed February 19, 2009. http://www.nass.usda.gov/

USDI (United States Department of the Interior) - US Geological Survey, 1997. Standards for Digital Raster Graphics. Reston, VA.

USDI - US Geological Survey, 2005. Mineral Resources On-line Spatial Data. Accessed April 16, 2010. http://mrdata.usgs.gov/sgmc/mo.html

Appendix A

MDNR Sandy Creek Water Quality Data

Project Name	Agency	Site	Site Name	Year	Month	Day	Flow (cfs)	Iron (µg/L)	TSS (mg/L)	TSS Method
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2005	11	9	0.2499			
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2007	9	1				
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2009	2	27	5		206	SM 2540D
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2009	5	26	3		2.499	SM 2540D
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2006	2	17	0.05			
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2008	3	27	2.2			
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2009	3	11	10		86	SM 2540D
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2006	5	26	0.2			
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2005	7	14	0.1			
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2009	5	6	1.5		13	SM 2540D
Sandy Cr.	MDNR	652/2.4	Sandy Cr. @ Hwy YY	2009	4	20	2		6	SM 2540D
Sandy Cr.	MDNR	652/3.1/0.4	Sandy Cr. @Calamint Rd.	2008	4	1	0.77			
Sandy Cr.	MDNR	652/3.1/0.4	Sandy Cr. @Calamint Rd.	2007	9	1				
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	5	23		50	431	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	1	23	0.02		37	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	6	26			18	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	9	25			76	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	3	18	0.07		5	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	4	25	0.62		8	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	2	7	1.01		13	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	3	27	3.01		34	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	2	26	0.03		12	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	10	29	0.31		2.499	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	4	23	0.11		5	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	11	28	0.11		5	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	1	31	0.02		3.499	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2002	5	30	0.14		23	

Project Name	Agency	Site	Site Name	Year	Month	Day	Flow (cfs)	Iron (µg/L)	TSS (mg/L)	TSS Method
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	6	26	0.25		46	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	5	23		270	13	
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	8	27	0.11		8.9	
Sandy Cr.	MDNR	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2001	5	31				
	PSF	652/3.0/3.9	Sandy Cr. DS of PSF Whitetail (Site 35)	2000	5	30	0.02		37	
Sandy Cr.	MDNR	652/3.0/4.5	Sandy Cr. US of PSF Whitetail (Site 36)	2001	5	31				
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	5	29	0.02		100	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2002	3	18	0.01		10	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	3	27	0.23		80	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	6	26	0.03		10	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	4	25	0.37		18	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2002	5	23		220	1224	
Sandy Cr.	MDNR	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	5	31				
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	5	23		2800	15	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	1	31	0.43		13	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2001	2	7	2.09		15	
	PSF	652/3.0/4.6	Sandy Cr. US of PSF Whitetail (Site 37)	2002	4	23	0.16		13	

Cr. = creek
cfs = cubic feet per second
PSF = Premium Standard Farms
µg/L = microgram per liter
mg/L = milligram per liter
TSS = total suspended solids
MDNR = Missouri Department of Natural Resources

Appendix B

Development of TSS Targets Using Reference LDCs

Overview

This procedure is used when a lotic[13] 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. For sediment, the target was derived by targeting the 25th percentile base load concentration of TSS measurements collected by the USGS in the EDU in which the water body is located.

If a flow record for the impaired stream is not available a synthetic flow record is needed. 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 (Table B-1). Selection of these gages is based on location, land use/soil/topography similarities to the Sandy Creek watershed and the availability of flow data of sufficient age and duration. From this synthetic record develop flow duration from which to build a LDC for the pollutant within the EDU.

Methodology

The first step in this procedure is to locate available TSS data within the EDU of interest (Appendix C). 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 curve. Both the date and TSS 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 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). Figure B-1 shows the application of the approach in the Sandy Creek EDU (Grand River/Chariton 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).

[13] Lotic = pertaining to moving water

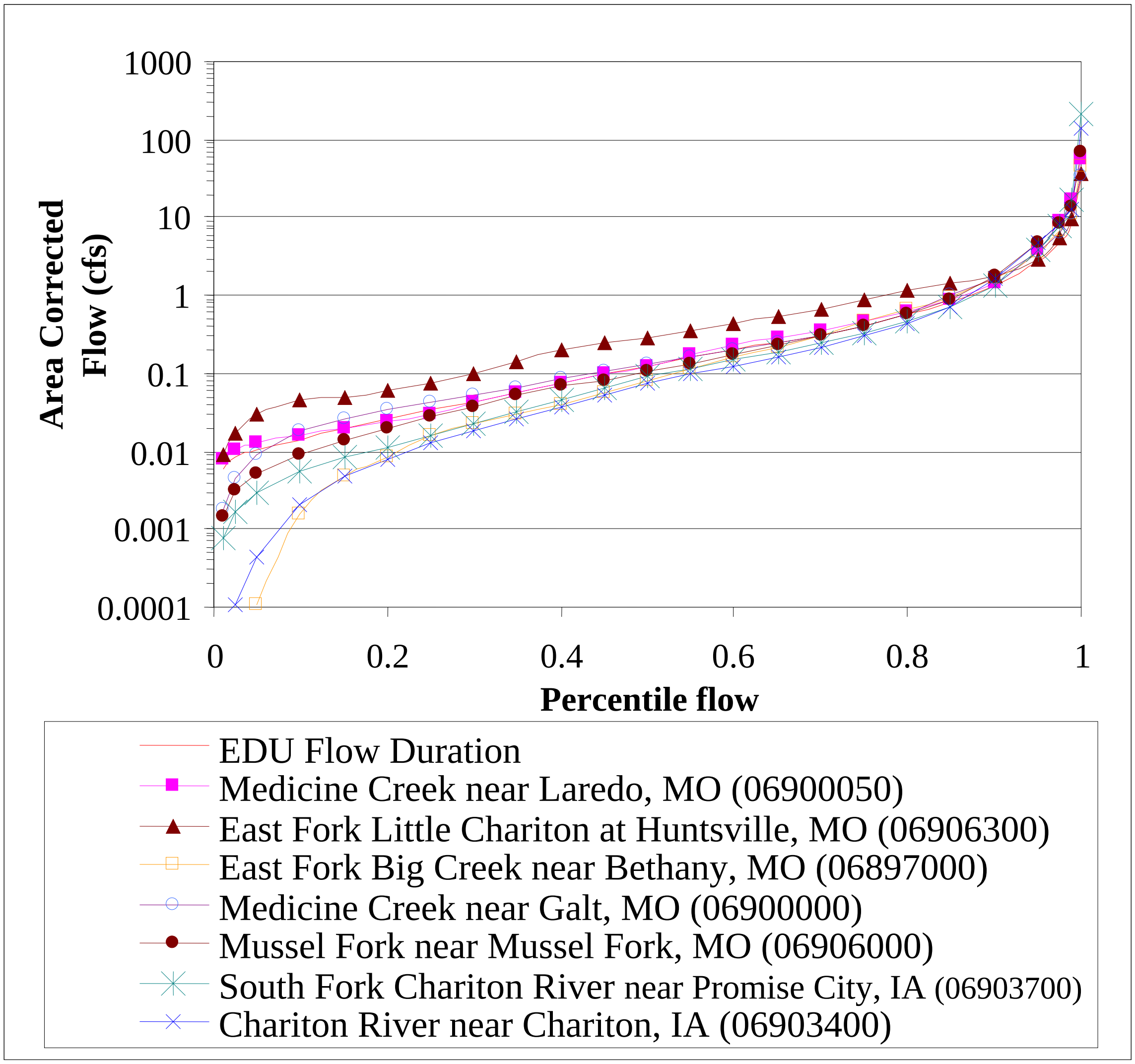

Figure B-1. Synthetic Flow Development in the Grand River/Chariton EDU

Table B-1. Stream Flow Stations Used to Estimate Flows in Sandy Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)	Lognormal Nash-Sutcliffe
Medicine Creek near Laredo, MO	USGS	06900050	355	79%
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220	98%
East Fork Big Creek near Bethany, MO	USGS	06897000	95	89%
Medicine Creek near Galt, MO	USGS	06900000	225	99%
Mussel Fork near Musselfork, MO	USGS	06906000	267	70%
South Fork Chariton River near Promise City, IA	USGS	06903700	168	25%
Chariton River near Chariton, IA	USGS	06903400	182	38%

mi^2 = square miles

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

The next step was to collect previously measured water quality data from within the EDU. Measured TSS concentrations are adjusted so that their median is equal to the 25th percentile base load concentration of total suspended solids measurements collected by the USGS in the EDU. This is accomplished by adjusting the measured data using the ratio between the 25th percentile target and the median from the measured data and results in the data retaining most of its variability while having a median that meets the 25th percentile target. Figure B-2 shows an example of this process where the solid line is the measured distribution of the natural log TSS concentration with the natural log flow and the dashed line represents a data distribution (the adjusted data) which would comply with the 25th percentile TSS target.

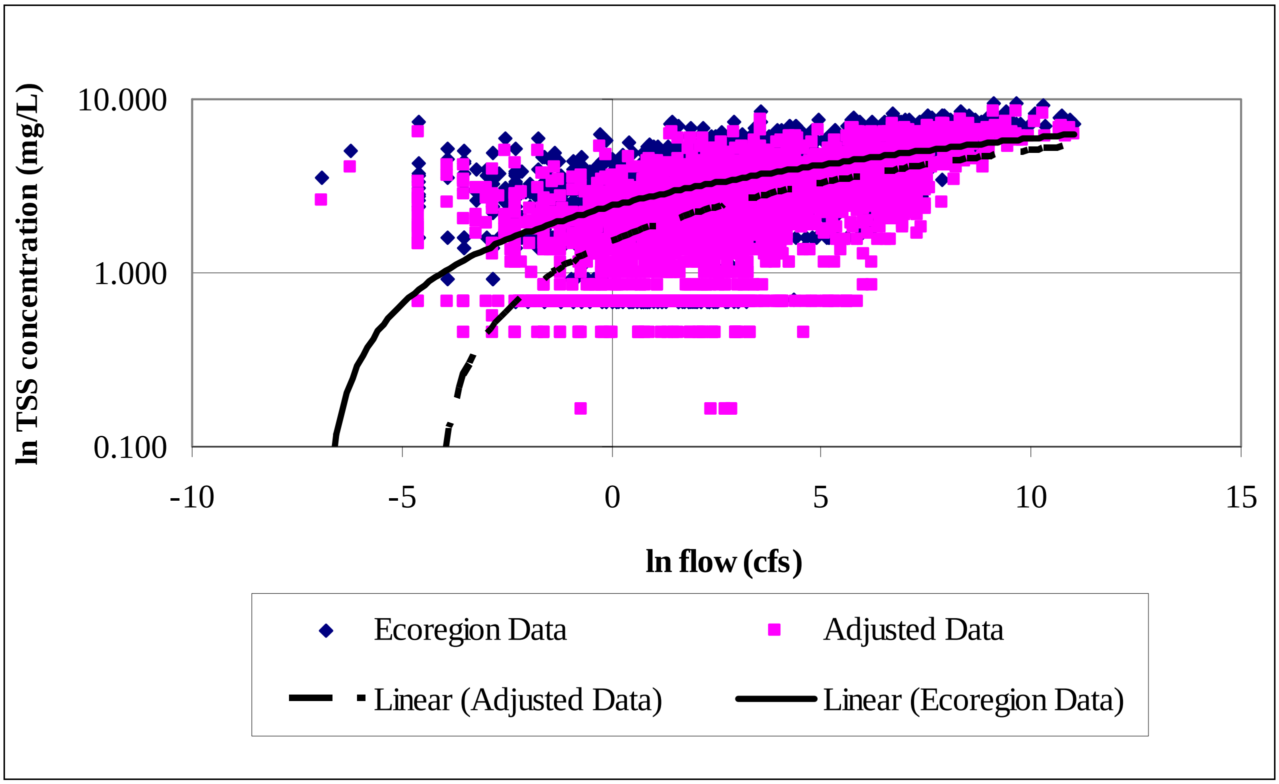

Figure B-2. Graphic Representation of Data Adjustment in the Grand River/Chariton EDU

The next step was to calculate the TSS-discharge relationship for the EDU using the adjusted data; this is natural log transformed data for the TSS yield (pound/day) and the instantaneous flow (cfs). Figure B-3 shows this relationship for this TMDL.

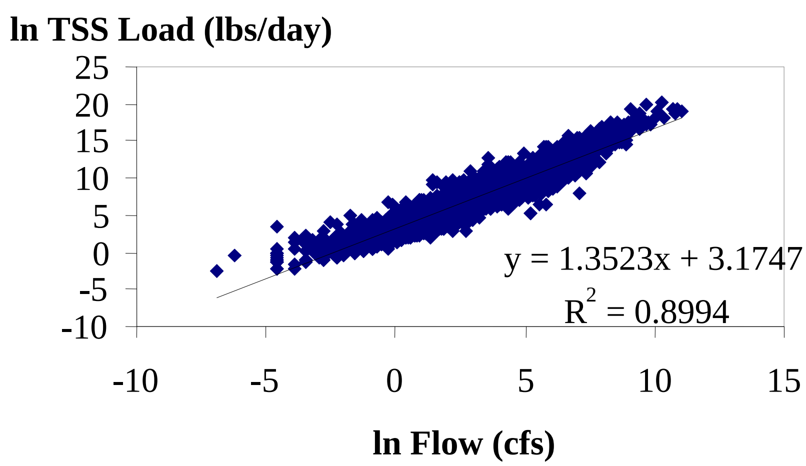

Figure B-3. Load / Flow Relationship Used to Set LDC TMDL

This relationship was used to develop a LDC for which the relationship between flow and TSS 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 25th percentile of data collected in the EDU.

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 B-4).

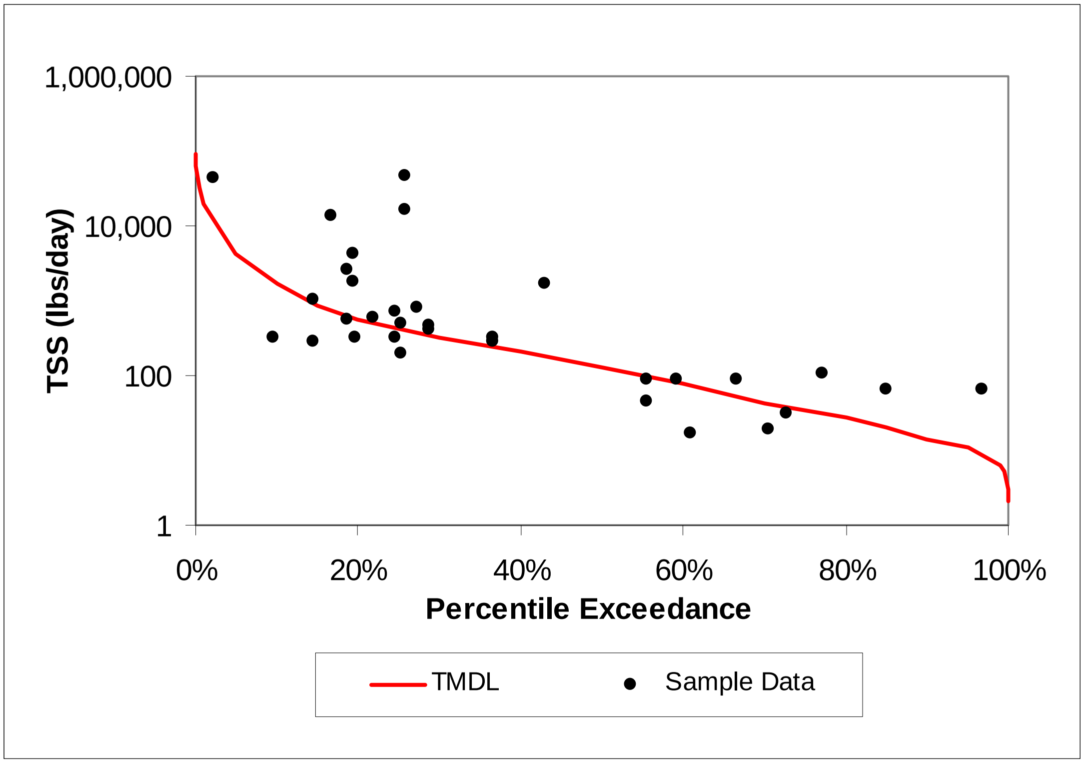

Figure B-4. Example of TMDL LDC Using This Method

The resulting LDC with plotted site specific measured data can now be used to target implementation by identifying flows in which TSS concentrations are higher than would be expected in a stream meeting the 25th percentile target value.

For more information contact:

United States 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

Stream Flow and Water Quality Stations Used to Develop TMDLs in Sandy Creek

Table C-1. Stream Flow Stations Used to Estimate Flows in Sandy Creek

River/Station Name	Data Source	Station Number	Drainage Area (mi^2)
Medicine Creek near Laredo, MO	USGS	06900050	355
East Fork Little Chariton River near Huntsville, MO	USGS	06906300	220
East Fork Big Creek near Bethany, MO	USGS	06897000	95
Medicine Creek near Galt, MO	USGS	06900000	225
Mussel Fork near Musselfork, MO	USGS	06906000	267
South Fork Chariton River near Promise City, IA	USGS	06903700	168
Chariton River near Chariton, IA	USGS	06903400	182

mi^2 = square miles

Table C-2. Stations Used to Develop Water Quality Data Targets in Sandy Creek

USGS Gage Number	Station Name	Drainage Area (mi^2)
06898100	Thompson River at Mount Moriah, MO	891
06898800	Weldon River near Princeton, MO	452
06899580	No Creek near Dunlap, MO	34
06899585	No Creek at Farmersville, MO	67.4
06899950	Medicine Creek near Harris, MO	192
06900100	Little Medicine Creek near Harris, MO	66.5
06901500	Locust Creek near Linneus, MO	550
06902000	Grand River near Sumner, MO	6880
06905725	Mussel Fork near Mystic, MO	24
06898000	Thompson River at Davis City, IA	701
06896187	Middle Fork Grand River near Grant City, MO	82.4
06900900	Locust Creek near Unionville, MO	77.5
640/IOWAa	Chariton River at Centerville, IA	708[1]
06904000	Chariton River near Centerville, IA	708
06906300	East Fork Little Chariton River at Huntsville, MO	220

[1] Specific drainage area was unavailable, value estimated using drainage area of nearby USGS Gage (06904000).
mi^2 = square miles

Table C-3. Water Quality Data Used in TMDL Development

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898100 - Thompson River at Mount Moriah, MO			
06898100	11/9/1999	22	527
06898100	1/13/2000	8.6	
06898100	3/23/2000	33	
06898100	5/18/2000	19	27
06898100	7/13/2000	49	
06898100	9/6/2000	10	
06898100	11/28/2000	15	< 10
06898100	1/3/2001	7.5	
06898100	3/15/2001	4860	
06898100	5/2/2001	276	156
06898100	7/13/2001	126	
06898100	9/20/2001	53	
06898100	11/8/2001	41	14
06898100	1/17/2002	14	< 10
06898100	3/14/2002	91	43
06898100	5/9/2002	223	347
06898100	8/1/2002	26	30
06898100	9/3/2002	17	176
06898100	11/7/2002	18	< 10
06898100	1/15/2003	15	< 10
06898100	3/28/2003	50	11
06898100	5/22/2003	196	107
06898100	7/15/2003	76	66
06898100	8/29/2003	6.1	< 10
06898100	9/4/2003	10	146
06898100	11/4/2003	325	644
06898100	1/23/2004	23	< 10
06898100	3/25/2004	268	186
06898100	5/20/2004	E 837	593
06898100	7/9/2004	118	17
06898100	9/10/2004	259	82
06898100	11/8/2004	70	132
06898100	1/21/2005	31	< 10
06898100	3/3/2005	144	42

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898100	5/25/2005	342	292
06898100	7/8/2005	96	67
06898100	9/16/2005	23	< 10
06898100	11/10/2005	12	< 10
06898100	1/20/2006	23	< 10
06898100	3/31/2006	23	< 10
06898100	5/25/2006	81	100
06898100	7/27/2006	15	23
06898100	9/8/2006	44	28
06898100	11/9/2006	23	< 10
06898100	1/4/2007	381	333
06898100	2/14/2007	24	< 10
06898100	3/21/2007	291	218
06898100	4/6/2007	394	192
06898100	5/23/2007	298	63
06898100	6/20/2007	133	82
06898100	7/25/2007	54	17
06898100	9/19/2007	132	26
06898100	11/16/2007	137	48
06898100	1/24/2008	200	20
06898100	3/12/2008	682	328
06898100	5/29/2008	481	196
06898100	7/10/2008	1280	1440
06898100	9/17/2008	569	300
06898100	10/22/2008	1380	2930
06898100	1/14/2009	235	74
06898100	3/5/2009	264	254
06898100	5/7/2009	614	336
06898100	7/16/2009	1220	718
06898100	9/3/2009	288	109
06898800 - Weldon River near Princeton, MO			
06898800	11/9/1999	5.3	
06898800	1/11/2000	10	
06898800	3/21/2000	13	
06898800	5/16/2000	2.4	< 10
06898800	7/11/2000	9.4	

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898800	9/6/2000	1.8	
06898800	11/30/2000	5.2	< 10
06898800	1/5/2001	8.1	
06898800	3/15/2001	2840	
06898800	5/2/2001	152	119
06898800	7/11/2001	63	
06898800	9/18/2001	18	
06898800	11/6/2001	36	18
06898800	1/15/2002	20	< 10
06898800	3/12/2002	101	114
06898800	5/7/2002	527	210
06898800	7/30/2002	17	14
06898800	8/15/2002	8.7	20
06898800	9/5/2002	3.3	13
06898800	10/24/2002	5	< 10
06898800	11/5/2002	6.5	< 10
06898800	12/10/2002	4.3	< 10
06898800	1/14/2003	1.9	< 10
06898800	3/7/2003	8.6	< 10
06898800	3/26/2003	7.3	< 10
06898800	5/20/2003	168	264
06898800	7/17/2003	6.1	19
06898800	9/5/2003	0.73	52
06898800	11/6/2003	99	120
06898800	1/21/2004	30	19
06898800	3/23/2004	90	39
06898800	5/18/2004	473	267
06898800	7/7/2004	44	14
06898800	9/8/2004	166	85
06898800	11/10/2004	20	< 10
06898800	1/19/2005	11	< 10
06898800	3/1/2005	80	51
06898800	5/23/2005	128	266
06898800	7/6/2005	23	< 10
06898800	9/14/2005	6	10
06898800	11/8/2005	6.5	21

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898800	1/18/2006	9.4	< 10
06898800	3/31/2006	117	750
06898800	5/23/2006	6.1	12
06898800	7/25/2006	1.5	60
06898800	9/6/2006	9.2	42
06898800	11/7/2006	5.5	< 10
06898800	1/4/2007	82	44
06898800	2/16/2007	7.2	< 10
06898800	3/23/2007	625	1250
06898800	4/6/2007	174	86
06898800	5/23/2007	97	28
06898800	6/20/2007	35	31
06898800	7/25/2007	19	15
06898800	9/19/2007	42	24
06898800	11/14/2007	24	13
06898800	1/24/2008	60	140
06898800	3/12/2008	615	472
06898800	5/29/2008	166	79
06898800	7/10/2008	307	426
06898800	9/17/2008	325	364
06898800	10/22/2008	6480	1850
06898800	1/14/2009	78	< 15
06898800	3/6/2009	121	112
06898800	5/7/2009	260	126
06898800	7/16/2009	98	54
06898800	9/3/2009	274	145
06899580 - No Creek near Dunlap, MO			
06899580	1/22/1998	3.7	1
06899580	6/2/1998	3.2	51
06899580	3/30/1999	4.4	
06899580	4/22/1999	14	
06899580	6/21/1999	0.25	70
06899580	10/25/1999	0.01	
06899580	11/29/1999	0.01	73
06899580	12/20/1999	0.1	
06899580	1/24/2000	0.1	28

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899580	2/23/2000	0.06	
06899580	4/20/2000	0.81	
06899580	5/9/2000	0.17	54
06899580	6/14/2000	6.4	
06899580	6/22/2000	0.4	
06899580	7/25/2000	0.11	45
06899580	10/24/2000	0.37	
06899580	11/15/2000	0.68	21
06899580	12/19/2000	0.08	
06899580	1/24/2001	1.6	18
06899580	2/15/2001	40	
06899580	3/27/2001	10	
06899580	4/24/2001	19	
06899580	5/22/2001	9.9	41
06899580	6/19/2001	2.7	
06899580	6/25/2001	5.2	
06899580	7/26/2001	59	290
06899580	8/9/2001	0.47	
06899580	9/13/2001	0.1	
06899580	10/23/2001	38	386
06899580	11/29/2001	0.28	78
06899580	12/13/2001	1	20
06899580	2/28/2002	1.7	22
06899580	3/21/2002	2.1	< 10
06899580	4/18/2002	4.3	36
06899580	5/23/2002	2.4	< 10
06899580	6/13/2002	0.53	20
06899580	6/28/2002	0.07	40
06899580	7/23/2002	0.01	< 10
06899580	8/22/2002	1	44
06899580	12/19/2002	0.01	37
06899580	3/13/2003	0.41	< 10
06899580	3/20/2003	0.34	12
06899580	4/25/2003	2.1	82
06899580	4/30/2003	0.62	12
06899580	5/6/2003	6.4	164

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899580	6/12/2003	3	68
06899580	7/9/2003	0.01	43
06899580	9/19/2003	0.26	144
06899580	10/23/2003	0.03	70
06899580	11/18/2003	0.1	23
06899580	12/11/2003	22	120
06899580	1/8/2004	1	17
06899580	2/27/2004	5.8	14
06899580	3/18/2004	52	117
06899580	4/20/2004	2.7	33
06899580	5/11/2004	1.3	< 10
06899580	6/22/2004	9.1	49
06899580	7/16/2004	0.41	23
06899580	8/23/2004	0.72	67
06899580	9/14/2004	0.76	520
06899580	10/26/2004	1	< 10
06899580	11/16/2004	3.7	< 10
06899580	12/14/2004	6.2	18
06899580	1/25/2005	0.08	18
06899580	2/10/2005	21	138
06899580	3/17/2005	2.9	< 10
06899580	4/5/2005	3.6	< 10
06899580	5/12/2005	2	52
06899580	6/30/2005	0.86	24
06899580	7/13/2005	0.03	< 10
06899580	8/19/2005	0.02	33
06899580	9/21/2005	0.05	53
06899580	10/5/2005	0.08	380
06899580	11/3/2005	0.01	1510
06899580	12/14/2005	0.1	44
06899580	1/25/2006	0.03	43
06899580	2/14/2006	0.01	22
06899580	3/9/2006	0.2	< 10
06899580	4/12/2006	2.1	72
06899580	5/9/2006	2.8	44
06899580	6/15/2006	0.23	24

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899580	7/19/2006	0	152
06899580	8/10/2006	3.1	147
06899580	9/21/2006	0.02	170
06899580	10/25/2006	0.02	93
06899580	12/13/2006	0.52	17
06899580	1/26/2007	0.84	< 10
06899580	2/20/2007	56	162
06899580	3/15/2007	8.1	37
06899580	4/27/2007	76	225
06899580	5/10/2007	18	110
06899580	6/28/2007	19	485
06899580	7/19/2007	E 0.03	165
06899580	8/23/2007	0.24	75
06899580	9/27/2007	0.19	105
06899580	10/16/2007	0.06	136
06899580	11/8/2007	0.01	16
06899580	12/20/2007	3.1	20
06899580	1/10/2008	22	58
06899580	2/26/2008	E 65	86
06899580	3/25/2008	8.3	34
06899580	4/16/2008	11	102
06899580	5/22/2008	2.1	138
06899580	6/17/2008	13	74
06899580	7/15/2008	0.8	46
06899580	8/12/2008	0.55	24
06899580	9/23/2008	3	< 10
06899580	10/28/2008	6.6	< 15
06899580	11/18/2008	11	< 15
06899580	12/2/2008	5.8	< 15
06899580	1/27/2009	1.9	< 15
06899580	2/24/2009	3	16
06899580	3/12/2009	16	250
06899580	4/24/2009	6.5	16
06899580	5/15/2009	29	730
06899580	6/23/2009	20	< 150
06899580	8/18/2009	56	266

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899585 - No Creek at Farmersville, MO			
06899585	11/16/2006	0.13	< 10
06899950 - Medicine Creek near Harris, MO			
06899950	10/26/1999	2.3	
06899950	11/30/1999	3	6
06899950	12/21/1999	0.1	
06899950	1/25/2000	0.5	3
06899950	2/22/2000	15	
06899950	3/27/2000	8.7	
06899950	4/18/2000	4	
06899950	5/10/2000	10	< 10
06899950	6/21/2000	6	
06899950	7/26/2000	6.6	37
06899950	9/20/2000	3.4	
06899950	10/26/2000	6.1	
06899950	11/14/2000	5.8	< 10
06899950	12/18/2000	3.1	
06899950	1/25/2001	12	< 10
06899950	2/13/2001	131	
06899950	3/29/2001	100	
06899950	4/26/2001	76	
06899950	5/24/2001	52	68
06899950	6/19/2001	79	
06899950	6/26/2001	60	
06899950	7/25/2001	353	1610
06899950	8/8/2001	13	
06899950	9/12/2001	7.4	
06899950	10/25/2001	33	118
06899950	11/28/2001	3.4	12
06899950	12/12/2001	6.2	
06899950	1/3/2002	4.6	< 10
06899950	1/8/2002	5	< 10
06899950	2/27/2002	9.9	12
06899950	3/19/2002	18	< 10
06899950	4/17/2002	68	130
06899950	5/21/2002	38	38

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899950	6/28/2002	5.6	13
06899950	7/24/2002	3.6	< 10
06899950	8/21/2002	17	41
06899950	9/10/2002	1.4	< 10
06899950	10/17/2002	1.4	< 10
06899950	11/19/2002	2	< 10
06899950	12/18/2002	2.8	< 10
06899950	1/30/2003	0.9	< 10
06899950	2/20/2003	3.4	< 10
06899950	3/12/2003	3.9	< 10
06899950	4/23/2003	14	12
06899950	5/8/2003	27	104
06899950	6/11/2003	51	282
06899950	7/10/2003	65	161
06899950	8/25/2003	0.61	< 10
06899950	9/17/2003	4.5	49
06899950	10/22/2003	1.3	< 10
06899950	11/20/2003	3	< 10
06899950	12/10/2003	368	E 692
06899950	1/7/2004	6.2	< 10
06899950	2/26/2004	55	66
06899950	3/16/2004	71	53
06899950	4/22/2004	21	12
06899950	5/13/2004	11	< 10
06899950	6/23/2004	42	49
06899950	7/14/2004	32	76
06899950	8/25/2004	378	1700
06899950	9/16/2004	25	15
06899950	10/27/2004	50	131
06899950	11/18/2004	16	< 10
06899950	12/16/2004	26	< 10
06899950	1/27/2005	169	280
06899950	2/9/2005	105	165
06899950	3/16/2005	28	< 10
06899950	4/8/2005	77	79
06899950	5/11/2005	24	15

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899950	6/29/2005	77	620
06899950	7/12/2005	5.7	< 10
06899950	8/17/2005	6.2	< 10
06899950	9/20/2005	3.6	14
06899950	10/5/2005	2.8	11
06899950	11/2/2005	2	< 10
06899950	12/15/2005	4.4	< 10
06899950	1/26/2006	2.6	< 10
06899950	2/17/2006	1.3	< 10
06899950	3/8/2006	9.8	< 10
06899950	4/13/2006	12	15
06899950	5/10/2006	18	20
06899950	6/14/2006	2.4	< 10
06899950	7/18/2006	4.8	16
06899950	8/9/2006	16	150
06899950	9/20/2006	1.4	< 10
06899950	10/24/2006	3	< 10
06899950	11/15/2006	2.6	< 10
06899950	12/14/2006	4.4	24
06899950	1/25/2007	8	< 10
06899950	2/21/2007	460	379
06899950	3/14/2007	60	72
06899950	4/27/2007	971	660
06899950	5/9/2007	349	424
06899950	6/27/2007	10	19
06899950	7/18/2007	4.6	10
06899950	8/21/2007	57	763
06899950	9/25/2007	9.8	< 20
06899950	10/16/2007	46	84
06899950	11/6/2007	14	< 10
06899950	12/19/2007	57	35
06899950	1/9/2008	483	406
06899950	2/27/2008	202	140
06899950	3/26/2008	64	49
06899950	4/16/2008	119	170
06899950	5/21/2008	36	19

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06899950	6/18/2008	112	148
06899950	7/16/2008	19	35
06899950	8/13/2008	25	46
06899950	9/24/2008	98	536
06899950	10/29/2008	60	39
06899950	11/19/2008	75	42
06899950	12/3/2008	49	16
06899950	1/28/2009	19	< 15
06899950	2/25/2009	34	22
06899950	3/11/2009	715	1180
06899950	4/22/2009	61	85
06899950	5/13/2009	377	1900
06899950	6/24/2009	75	220
06899950	7/22/2009	20	24
06899950	8/20/2009	180	455
06900100 - Little Medicine Creek near Harris, MO			
06900100	1/22/1998	8.7	1
06900100	6/2/1998	11	26
06900100	1/5/1999	4.8	5
06900100	3/31/1999	12	
06900100	4/21/1999	35	
06900100	6/22/1999	4.7	30
06900100	8/25/1999	0.62	
06900100	10/26/1999	0.67	
06900100	11/30/1999	0.73	1
06900100	12/21/1999	0.1	
06900100	1/25/2000	0.5	4
06900100	2/22/2000	1.8	
06900100	3/27/2000	1.1	
06900100	4/18/2000	2	
06900100	5/10/2000	1.4	< 10
06900100	6/21/2000	1.2	
06900100	7/26/2000	1.6	< 10
06900100	9/20/2000	1.6	
06900100	10/26/2000	1.8	
06900100	11/14/2000	1.8	< 10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06900100	12/19/2000	0.91	
06900100	1/25/2001	3.2	< 10
06900100	2/13/2001	46	
06900100	3/29/2001	35	
06900100	4/26/2001	18	
06900100	5/24/2001	16	31
06900100	6/19/2001	17	
06900100	6/26/2001	13	
06900100	7/25/2001	11	444
06900100	8/8/2001	1.4	
06900100	9/12/2001	1.2	
06900100	10/25/2001	7.5	54
06900100	11/28/2001	1.5	< 10
06900100	12/12/2001	1.7	< 10
06900100	1/8/2002	0.38	< 10
06900100	2/27/2002	1.8	< 10
06900100	3/19/2002	2	< 10
06900100	4/17/2002	13	66
06900100	5/21/2002	9.1	14
06900100	6/28/2002	2	< 10
06900100	7/24/2002	0.59	< 10
06900100	8/21/2002	3.1	< 10
06900100	9/10/2002	0.15	< 10
06900100	10/17/2002	0.31	< 10
06900100	11/19/2002	0.41	< 10
06900100	12/18/2002	0.64	< 10
06900100	1/29/2003	0.11	< 10
06900100	2/20/2003	0.64	< 10
06900100	3/12/2003	1.4	< 10
06900100	4/23/2003	0.47	< 10
06900100	5/8/2003	3.5	127
06900100	6/11/2003	30	344
06900100	7/10/2003	138	E 2060
06900100	8/25/2003	0.08	13
06900100	9/18/2003	0.48	20
06900100	10/22/2003	0.3	< 10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06900100	11/20/2003	0.52	< 10
06900100	12/10/2003	98	470
06900100	1/7/2004	0.73	16
06900100	2/26/2004	10	36
06900100	3/16/2004	25	56
06900100	4/22/2004	4.6	< 10
06900100	5/13/2004	8.9	102
06900100	6/23/2004	12	33
06900100	7/14/2004	6	37
06900100	8/25/2004	2150	1400
06900100	9/16/2004	5.8	64
06900100	10/27/2004	16	146
06900100	11/18/2004	5.2	< 10
06900100	12/17/2004	4.6	< 10
06900100	1/27/2005	24	51
06900100	2/10/2005	7	48
06900100	3/16/2005	7.6	< 10
06900100	4/8/2005	15	18
06900100	5/12/2005	8.6	38
06900100	6/30/2005	6	20
06900100	7/12/2005	1.4	< 10
06900100	8/17/2005	0.42	< 10
06900100	9/20/2005	0.64	< 10
06900100	10/5/2005	0.22	< 10
06900100	11/2/2005	0.15	< 10
06900100	12/15/2005	1.6	< 10
06900100	1/26/2006	0.73	< 10
06900100	2/17/2006	0.37	< 10
06900100	3/8/2006	2.2	< 10
06900100	4/13/2006	1.5	15
06900100	5/10/2006	2.3	19
06900100	6/14/2006	0.43	< 10
06900100	7/19/2006	0.22	< 10
06900100	8/9/2006	3	122
06900100	9/20/2006	0.16	< 10
06900100	10/24/2006	0.35	< 10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06900100	11/16/2006	0.45	< 10
06900100	12/14/2006	1.1	13
06900100	1/25/2007	2.2	< 10
06900100	2/21/2007	E 130	59
06900100	3/15/2007	14	64
06900100	4/25/2007	1830	1070
06900100	5/10/2007	52	184
06900100	6/27/2007	1.4	10
06900100	7/18/2007	0.53	13
06900100	8/21/2007	14	663
06900100	9/25/2007	1.5	< 20
06900100	10/17/2007	13	424
06900100	11/8/2007	1	< 10
06900100	12/19/2007	13	31
06900100	1/10/2008	68	88
06900100	2/27/2008	58	82
06900100	3/26/2008	21	43
06900100	4/16/2008	33	88
06900100	5/21/2008	7.3	< 10
06900100	6/18/2008	20	74
06900100	7/16/2008	3	10
06900100	8/13/2008	3.3	13
06900100	9/24/2008	300	2200
06900100	10/29/2008	18	23
06900100	11/19/2008	30	33
06900100	12/3/2008	17	< 15
06900100	1/28/2009	4.5	< 15
06900100	2/25/2009	12	18
06900100	3/11/2009	118	490
06900100	4/22/2009	15	15
06900100	5/13/2009	352	1760
06900100	6/24/2009	26	160
06900100	7/22/2009	2.5	< 15
06900100	8/20/2009	176	1290
06901500 - Locust Creek near Linneus, MO			
06901500	8/26/2003	0.8	<10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000 - Grand River near Sumner, MO			
06902000	11/8/1989	373	
06902000	1/18/1990	851	
06902000	5/9/1990	5480	
06902000	7/11/1990	1430	
06902000	11/7/1990	1310	
06902000	1/9/1991	452	
06902000	5/17/1991	14200	
06902000	7/16/1991	2510	
06902000	11/6/1991	470	
06902000	1/15/1992	2720	
06902000	7/8/1992	340	
06902000	11/12/1992	7780	
06902000	12/2/1992	4980	
06902000	1/6/1993	8980	
06902000	2/17/1993	2510	
06902000	3/17/1993	3220	
06902000	4/8/1993	29800	
06902000	5/12/1993	33700	
06902000	6/16/1993	18400	
06902000	7/27/1993	128000	
06902000	8/25/1993	2820	
06902000	9/16/1993	23600	
06902000	10/27/1993	1700	
06902000	11/16/1993	3300	
06902000	12/8/1993	1140	
06902000	1/5/1994	755	
06902000	2/3/1994	1200	
06902000	3/16/1994	1750	
06902000	3/30/1994	750	
06902000	4/27/1994	900	
06902000	5/10/1994	3700	
06902000	6/14/1994	4500	
06902000	8/23/1994	250	
06902000	9/14/1994	270	
06902000	10/26/1994	136	

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000	11/30/1994	1200	
06902000	12/14/1994	1140	
06902000	1/5/1995	350	
06902000	2/8/1995	2060	
06902000	3/30/1995	2720	
06902000	4/18/1995	5660	
06902000	5/24/1995	51600	
06902000	6/14/1995	4450	
06902000	7/12/1995	6100	
06902000	8/2/1995	2030	
06902000	9/5/1995	496	
06902000	10/24/1995	235	
06902000	11/6/1995	595	
06902000	12/13/1995	216	
06902000	1/22/1996	430	
06902000	2/14/1996	3050	
06902000	3/26/1996	1480	
06902000	4/16/1996	520	
06902000	5/20/1996	4660	
06902000	6/19/1996	14500	
06902000	7/17/1996	1050	
06902000	8/14/1996	906	
06902000	9/11/1996	1170	
06902000	10/9/1996	527	
06902000	11/20/1996	4930	
06902000	1/22/1997	466	
06902000	2/12/1997	1620	
06902000	3/17/1997	2510	
06902000	4/23/1997	29800	
06902000	5/27/1997	2130	
06902000	6/17/1997	15100	
06902000	7/29/1997	395	
06902000	8/19/1997	511	
06902000	9/9/1997	286	
06902000	11/17/1997	415	6
06902000	1/15/1998	1590	16

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000	6/9/1998	4290	452
06902000	8/18/1998	587	60
06902000	11/16/1998	4640	264
06902000	12/1/1998	6620	
06902000	1/25/1999	4150	231
06902000	2/23/1999	3040	
06902000	3/23/1999	2740	
06902000	4/13/1999	3460	
06902000	5/19/1999	31900	
06902000	6/15/1999	6840	1800
06902000	7/27/1999	429	
06902000	8/10/1999	639	80
06902000	9/13/1999	365	
06902000	10/26/1999	130	
06902000	11/30/1999	240	10
06902000	12/21/1999	157	
06902000	1/4/2000	198	16
06902000	2/1/2000	123	
06902000	3/7/2000	565	
06902000	4/3/2000	301	
06902000	5/2/2000	308	95
06902000	6/12/2000	217	
06902000	7/11/2000	924	180
06902000	8/2/2000	465	
06902000	9/12/2000	129	
06902000	10/2/2000	341	
06902000	11/21/2000	220	12
06902000	12/5/2000	207	
06902000	1/3/2001	E 203	< 10
06902000	2/14/2001	5880	
06902000	3/6/2001	8040	
06902000	4/17/2001	7800	
06902000	5/1/2001	1740	90
06902000	6/19/2001	6690	
06902000	7/10/2001	1830	174
06902000	8/13/2001	572	

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000	9/5/2001	404	
06902000	10/17/2001	3210	555
06902000	11/6/2001	416	18
06902000	12/4/2001	323	16
06902000	1/8/2002	179	< 10
06902000	2/5/2002	347	12
06902000	3/6/2002	573	12
06902000	4/10/2002	4220	1440
06902000	5/7/2002	43700	2420
06902000	6/10/2002	841	
06902000	7/16/2002	393	145
06902000	8/13/2002	175	< 10
06902000	9/4/2002	145	65
06902000	10/22/2002	97	39
06902000	11/27/2002	115	10
06902000	12/12/2002	102	< 10
06902000	2/12/2003	121	< 10
06902000	2/25/2003	E 130	< 10
06902000	3/21/2003	354	29
06902000	4/11/2003	163	46
06902000	5/2/2003	1940	524
06902000	6/20/2003	516	114
06902000	7/29/2003	130	19
06902000	8/21/2003	66	81
06902000	9/9/2003	85	58
06902000	10/21/2003	96	44
06902000	11/5/2003	75	26
06902000	12/15/2003	888	89
06902000	1/7/2004	E 275	< 10
06902000	2/3/2004	E 165	< 10
06902000	3/2/2004	997	112
06902000	4/6/2004	2040	136
06902000	5/19/2004	21000	1070
06902000	6/28/2004	1910	158
06902000	7/15/2004	7510	475
06902000	8/16/2004	715	49

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000	9/2/2004	E 125000	543
06902000	10/12/2004	900	132
06902000	11/9/2004	1410	56
06902000	12/1/2004	813	22
06902000	1/24/2005	1530	90
06902000	2/14/2005	55000	2160
06902000	3/8/2005	1460	43
06902000	4/4/2005	992	55
06902000	5/3/2005	1530	117
06902000	6/22/2005	1600	203
06902000	7/12/2005	513	135
06902000	8/22/2005	909	252
06902000	9/7/2005	301	55
06902000	10/12/2005	315	34
06902000	11/2/2005	220	< 10
06902000	12/19/2005	272	< 10
06902000	1/4/2006	459	14
06902000	2/7/2006	357	< 10
06902000	3/7/2006	267	12
06902000	4/10/2006	1010	415
06902000	5/3/2006	12500	1180
06902000	6/21/2006	386	154
06902000	7/6/2006	259	41
06902000	8/2/2006	131	138
06902000	9/6/2006	432	170
06902000	10/10/2006	121	51
06902000	11/6/2006	289	43
06902000	12/5/2006	546	76
06902000	1/4/2007	3400	767
06902000	2/14/2007	272	< 10
06902000	3/7/2007	3450	258
06902000	4/3/2007	7510	1120
06902000	5/2/2007	4620	360
06902000	6/6/2007	4600	200
06902000	7/10/2007	447	104
06902000	8/14/2007	1230	242

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06902000	9/11/2007	736	52
06902000	10/23/2007	3100	340
06902000	11/6/2007	569	27
06902000	12/4/2007	702	45
06902000	1/9/2008	16000	850
06902000	2/14/2008	1900	100
06902000	3/5/2008	50600	1180
06902000	4/16/2008	7050	144
06902000	6/2/2008	10700	1120
06902000	7/9/2008	4230	384
06902000	8/4/2008	8200	452
06902000	9/2/2008	803	80
06902000	10/21/2008	1940	106
06902000	11/24/2008	2600	75
06902000	12/9/2008	1500	48
06902000	2/2/2009	1080	< 15
06902000	3/10/2009	57300	1300
06902000	4/1/2009	10900	418
06902000	5/5/2009	8690	780
06902000	6/2/2009	3960	312
06902000	7/28/2009	986	62
06902000	8/17/2009	46900	1790
06902000	9/1/2009	6300	454
06905725 - Mussel Fork near Mystic, MO			
06905725	1/23/1998	1.6	12
06905725	6/3/1998	1.2	22
06905725	1/6/1999	1.9	4
06905725	3/31/1999	2.4	
06905725	4/21/1999	8.4	
06905725	6/23/1999	0.54	47
06905725	10/25/1999	0.01	
06905725	11/30/1999	0.01	11
06905725	12/20/1999	0.1	
06905725	1/24/2000	0.1	24
06905725	4/20/2000	0.16	
06905725	5/11/2000	0.07	< 10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06905725	6/14/2000	8.3	
06905725	6/15/2000	7.3	
06905725	6/20/2000	0.22	
06905725	7/27/2000	0	10
06905725	10/25/2000	0.03	
06905725	11/15/2000	0.1	< 10
06905725	12/20/2000	0.02	
06905725	1/24/2001	0.24	10
06905725	2/14/2001	59	
06905725	3/28/2001	4.3	
06905725	4/25/2001	4.1	
06905725	5/22/2001	1.1	
06905725	5/23/2001	0.82	11
06905725	6/18/2001	7.6	
06905725	6/28/2001	2.5	
06905725	7/26/2001	4.8	228
06905725	8/9/2001	0.13	
06905725	9/11/2001	0.03	
06905725	10/24/2001	3.5	50
06905725	11/29/2001	0.17	< 10
06905725	12/13/2001	0.83	20
06905725	1/9/2002	0.2	10
06905725	2/28/2002	1.4	18
06905725	3/20/2002	0.97	< 10
06905725	4/18/2002	1.6	17
06905725	5/22/2002	2.2	20
06905725	6/27/2002	0.06	10
06905725	8/22/2002	0.17	22
06905725	2/21/2003	0.05	< 10
06905725	3/13/2003	2.5	37
06905725	3/19/2003	0.3	14
06905725	4/24/2003	0.19	26
06905725	4/30/2003	1.9	32
06905725	5/7/2003	2.5	44
06905725	6/12/2003	0.72	16
06905725	7/9/2003	E 0.00	11

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06905725	9/17/2003	0.33	15
06905725	11/19/2003	E 0.01	38
06905725	12/11/2003	7.9	84
06905725	1/8/2004	0.24	19
06905725	2/20/2004	41	81
06905725	3/17/2004	25	60
06905725	4/21/2004	1.6	15
06905725	5/12/2004	0.55	< 10
06905725	6/24/2004	1.9	31
06905725	7/13/2004	11	52
06905725	8/24/2004	0.25	21
06905725	9/15/2004	0.52	< 10
06905725	10/28/2004	2	< 10
06905725	11/17/2004	1.8	< 10
06905725	12/17/2004	2.4	< 10
06905725	1/26/2005	18	46
06905725	2/8/2005	22	65
06905725	3/17/2005	2.9	< 10
06905725	4/7/2005	2.9	< 10
06905725	5/11/2005	11	10
06905725	6/29/2005	1.7	21
06905725	7/14/2005	0.02	< 10
06905725	8/18/2005	0.08	22
06905725	9/21/2005	0.05	74
06905725	10/4/2005	0.9	316
06905725	11/1/2005	0.04	22
06905725	12/13/2005	0.01	< 10
06905725	1/27/2006	0.12	< 10
06905725	2/15/2006	0.17	15
06905725	3/9/2006	0.3	< 10
06905725	4/14/2006	1.3	18
06905725	5/12/2006	1.1	10
06905725	6/15/2006	0.11	< 10
06905725	7/17/2006	0	34
06905725	8/8/2006	2.4	203
06905725	9/21/2006	0.06	11

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06905725	10/23/2006	0.03	20
06905725	11/15/2006	0.03	82
06905725	12/15/2006	0.2	< 10
06905725	1/24/2007	0.62	11
06905725	2/22/2007	8	< 10
06905725	3/13/2007	6.5	25
06905725	4/24/2007	1.7	< 50
06905725	5/8/2007	74	176
06905725	6/28/2007	12	444
06905725	7/17/2007	0.06	26
06905725	8/22/2007	2.5	245
06905725	9/26/2007	0.04	54
06905725	10/17/2007	0.07	312
06905725	11/7/2007	0.05	11
06905725	12/18/2007	2.8	20
06905725	1/9/2008	40	68
06905725	2/26/2008	39	180
06905725	3/25/2008	6.2	21
06905725	4/17/2008	5.8	28
06905725	5/22/2008	1.2	10
06905725	6/19/2008	2.5	25
06905725	7/18/2008	0.4	16
06905725	8/14/2008	3.9	182
06905725	9/23/2008	2.1	14
06905725	10/28/2008	1.5	< 15
06905725	11/20/2008	4.8	< 15
06905725	12/4/2008	3.5	< 15
06905725	1/29/2009	0.89	< 15
06905725	2/26/2009	4.8	< 15
06905725	3/12/2009	25	170
06905725	4/23/2009	5.4	< 15
06905725	5/14/2009	47	214
06905725	6/26/2009	5	< 150
06905725	7/21/2009	0.32	< 15
06905725	8/19/2009	2	106

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898000 - Thompson River at Davis City, IA			
06898000	10/14/1999	22	13
06898000	11/9/1999	12	14
06898000	12/15/1999	15	3
06898000	1/4/2000	19	4
06898000	2/1/2000	18	3
06898000	3/21/2000	30	6
06898000	4/10/2000	21	32
06898000	5/2/2000	27	76
06898000	6/19/2000	45	88
06898000	7/17/2000	40	49
06898000	8/15/2000	14	48
06898000	9/25/2000	30	14
06898000	10/12/2000	10	19
06898000	11/13/2000	30	14
06898000	12/13/2000	15	5
06898000	1/11/2001	0	3
06898000	2/15/2001	0	9
06898000	3/15/2001	4100	1690
06898000	4/11/2001	1200	1450
06898000	5/9/2001	180	440
06898000	6/12/2001	340	100
06898000	7/9/2001	82	30
06898000	8/14/2001	21	26
06898000	9/11/2001	120	100
06898000	10/8/2001	37	11
06898000	11/6/2001	24	13
06898000	12/4/2001	27	4
06898000	4/2/2002	59	9
06898000	5/8/2002	90	84
06898000	6/4/2002	74	62
06898000	7/2/2002	30	34
06898000	8/6/2002	29	91
06898000	9/5/2002	5.1	75
06898000	10/2/2002	5	34
06898000	11/4/2002	5.8	5
06898000	4/1/2003	26	18

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898000	5/6/2003	1900	2850
06898000	6/3/2003	69	60
06898000	7/1/2003	120	110
06898000	8/5/2003	15	39
06898000	9/2/2003	4	41
06898000	10/1/2003	1	25
06898000	11/4/2003	220	460
06898000	12/2/2003	9	12
06898000	3/2/2004	430	280
06898000	4/6/2004	250	98
06898000	5/5/2004	92	16
06898000	6/2/2004	540	480
06898000	7/1/2004	160	27
06898000	8/2/2004	100	24
06898000	9/2/2004	310	110
06898000	10/5/2004	100	10
06898000	11/2/2004	24	6
06898000	12/1/2004	15	11
06898000	4/5/2005	83	34
06898000	5/2/2005	200	48
06898000	6/2/2005	190	47
06898000	7/6/2005	80	45
06898000	8/1/2005	34	43
06898000	9/7/2005	14	34
06898000	10/4/2005	13	34
06898000	11/2/2005	3.9	7
06898000	12/6/2005	8	8
06898000	2/1/2006	12	7
06898000	4/5/2006	95	120
06898000	5/1/2006	2950	2240
06898000	6/1/2006	290	820
06898000	7/12/2006	12	21
06898000	8/2/2006	6	32
06898000	9/6/2006	34	36
06898000	10/3/2006	11	20
06898000	11/1/2006	19	9
06898000	12/5/2006	65	18

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06898000	1/3/2007	440	610
06898000	2/7/2007	19	4
06898000	3/7/2007	540	140
06898000	4/3/2007	400	770
06898000	5/2/2007	540	250
06898000	6/5/2007	470	97
06898000	7/5/2007	65	25
06898000	8/2/2007	29	29
06898000	9/6/2007	140	27
06898000	10/2/2007	98	20
06898000	11/6/2007	190	15
06898000	12/4/2007	460	180
06898000	1/8/2008	2100	530
06898000	2/5/2008	360	43
06898000	3/4/2008	4650	730
06898000	4/1/2008	620	1100
06898000	5/6/2008	710	88
06898000	6/3/2008	4100	4900
06898000	7/9/2008	2700	3200
06898000	8/5/2008	240	100
06898000	9/2/2008	59	34
06896187 – Middle Fork Grand River near Grant City, MO			
06896187	11/10/1999	2	9
06896187	5/17/2000	0.18	4.99
06896187	11/29/2000	1.2	4.99
06896187	5/1/2001	74	278
06896187	11/7/2001	3.2	4.99
06896187	1/16/2002	2.3	4.99
06896187	3/13/2002	4.4	7.5
06896187	5/8/2002	28	250
06896187	7/31/2002	0.4	4.99
06896187	9/4/2002	0.15	4.99
06896187	11/6/2002	0.96	4.99
06896187	1/15/2003	0.41	4.99
06896187	3/27/2003	0.46	8
06896187	5/21/2003	4.2	22
06896187	7/16/2003	0.39	12

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06896187	9/3/2003	0.01	28
06896187	11/5/2003	22	108
06896187	1/22/2004	1.1	4.99
06896187	3/24/2004	8.2	12
06896187	4/29/2004	20	4
06896187	5/19/2004	40	200
06896187	5/27/2004	32	120
06896187	6/24/2004	30	39
06896187	7/8/2004	5.7	4.99
06896187	7/30/2004	24	30
06896187	9/9/2004	3.5	10
06896187	9/23/2004	15	24
06896187	10/29/2004	10	14
06896187	11/9/2004	1.9	4.99
06896187	11/26/2004	4	23
06896187	1/20/2005	1.7	4.99
06896187	1/26/2005	150	305
06896187	2/25/2005	12	36
06896187	3/2/2005	80	32
06896187	3/21/2005	6.5	11
06896187	4/26/2005	24	69
06896187	5/24/2005	12	62
06896187	5/24/2005	23	87
06896187	6/21/2005	10	19
06896187	7/7/2005	2.6	17
06896187	7/26/2005	10	337
06896187	8/25/2005	3.8	41
06896187	9/15/2005	0.71	26
06896187	9/28/2005	1	18
06896187	10/25/2005	0.6	19
06896187	11/9/2005	0.71	4.99
06896187	11/21/2005	2	7
06896187	12/27/2005	4	18
06896187	1/19/2006	0.81	4.99
06896187	1/23/2006	2	6
06896187	3/28/2006	8	9
06896187	3/30/2006	3.3	4.99

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06896187	4/25/2006	8	21
06896187	5/23/2006	4.8	13
06896187	5/24/2006	4.6	34
06896187	6/27/2006	3.6	30
06896187	7/25/2006	1.2	31
06896187	7/26/2006	0.42	4.99
06896187	8/23/2006	21	40
06896187	9/7/2006	2.5	15
06896187	9/28/2006	13.5	9
06896187	10/24/2006	69	40
06896187	11/8/2006	6.5	18
06896187	11/21/2006	38	9
06896187	12/22/2006	295	205
06896187	1/5/2007	63	113
06896187	2/15/2007	4.7	4.99
06896187	2/20/2007	10	150
06896187	3/22/2007	32	118
06896187	3/28/2007	240	106
06896187	4/5/2007	40	174
06896187	4/25/2007	820	2408
06896187	5/24/2007	27	39
06896187	5/24/2007	10	68
06896187	6/21/2007	2.1	50
06896187	6/28/2007	325	2325
06896187	7/26/2007	0.98	15
06896187	7/31/2007	5	12
06896187	8/29/2007	5	37
06896187	9/20/2007	4.2	23
06896187	9/25/2007	6	12
06896187	10/26/2007	18	48
06896187	11/15/2007	2.6	4.99
06896187	11/21/2007	22	58
06896187	12/21/2007	48	71
06896187	1/23/2008	6.3	58
06896187	1/30/2008	48	61
06896187	2/22/2008	58	35
06896187	3/13/2008	96	178

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06896187	3/26/2008	96	62
06896187	4/30/2008	180	150
06896187	5/30/2008	320	1583
06896187	5/30/2008	5080	3430
06896187	6/27/2008	475	1204
06896187	7/11/2008	14	112
06896187	7/31/2008	74	103
06896187	8/28/2008	11	11
06896187	9/18/2008	12	48
06896187	9/26/2008	21	37
06896187	10/31/2008	120	84
06896187	11/26/2008	55	24
06900900 – Locust Creek near Unionville, MO			
06900900	11/30/1999	0.46	4
06900900	1/25/2000	0.1	8
06900900	5/11/2000	2	4.99
06900900	7/27/2000	0.94	20
06900900	11/13/2000	1.9	16
06900900	1/23/2001	4	4.99
06900900	5/23/2001	19	23
06900900	7/24/2001	2.9	26
06900900	10/24/2001	59	192
06900900	11/27/2001	4.4	4.99
06900900	1/2/2002	0.66	4.99
06900900	1/9/2002	0.94	4.99
06900900	2/26/2002	9.2	28
06900900	3/20/2002	8.8	4.99
06900900	4/16/2002	27	120
06900900	5/22/2002	16	15
06900900	6/27/2002	1.6	13
06900900	7/25/2002	0.52	4.99
06900900	8/20/2002	14	52
06900900	9/9/2002	0.05	18
06900900	10/16/2002	0.03	4.99
06900900	11/20/2002	0.15	4.99
06900900	12/17/2002	0.28	4.99
06900900	2/19/2003	0.36	4.99

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06900900	3/11/2003	0.23	4.99
06900900	4/24/2003	3.4	10
06900900	5/7/2003	20	68
06900900	6/10/2003	53	27
06900900	7/11/2003	25	216
06900900	9/16/2003	0.58	4.99
06900900	10/21/2003	0.09	9.99
06900900	11/19/2003	0.26	4.99
06900900	12/9/2003	5.8	13
06900900	1/6/2004	4.1	4.99
06900900	2/19/2004	44	36
06900900	3/17/2004	89	145
06900900	4/21/2004	17	35
06900900	5/12/2004	3.3	4.99
06900900	6/24/2004	9.2	13
06900900	7/15/2004	14	58
06900900	8/24/2004	80	1110
06900900	9/15/2004	4.2	4.99
06900900	10/28/2004	24	52
06900900	11/17/2004	14	4.99
06900900	12/16/2004	14	4.99
06900900	1/26/2005	25	412
06900900	2/9/2005	59	176
06900900	3/15/2005	13	4.99
06900900	4/6/2005	14	4.99
06900900	5/10/2005	11	11
06900900	6/28/2005	68	1200
06900900	7/13/2005	1.1	4.99
06900900	8/18/2005	0.79	4.99
06900900	9/19/2005	0.23	10
06900900	10/4/2005	0.56	18
06900900	11/1/2005	0.25	4.99
06900900	12/13/2005	0.46	4.99
06900900	1/25/2006	0.36	4.99
06900900	2/15/2006	0.51	4.99
06900900	3/7/2006	1.6	26
06900900	4/12/2006	7.7	13

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06900900	5/11/2006	5.7	4.99
06900900	6/13/2006	0.66	19
06900900	7/18/2006	0.7	10
06900900	8/8/2006	2.9	14
06900900	9/19/2006	0.65	4.99
06900900	10/24/2006	0.23	4.99
06900900	11/14/2006	0.5	4.99
06900900	12/13/2006	0.85	4.99
06900900	1/23/2007	0.73	4.99
06900900	2/22/2007	106	85
06900900	3/14/2007	25	40
06900900	4/26/2007	2960	670
06900900	5/9/2007	189	266
06900900	6/26/2007	2.7	11
06900900	7/17/2007	0.63	4.99
06900900	8/22/2007	4.3	58
06900900	9/26/2007	2.4	9.99
06900900	10/17/2007	17	58
06900900	11/7/2007	6	4.99
06900900	12/19/2007	24	21
06900900	1/8/2008	210	260
06900900	2/27/2008	82	28
06900900	3/26/2008	26	31
06900900	4/17/2008	42	107
06900900	5/20/2008	14	4.99
06900900	6/19/2008	73	312
06900900	7/17/2008	6.2	19
06900900	8/14/2008	16	326
06900900	9/25/2008	20	11
640/IOWAa – Chariton River at Centerville, IA			
640/IOWAa	10/16/1979	5	44
640/IOWAa	12/3/1979	5	14
640/IOWAa	1/2/1980	6	10
640/IOWAa	2/12/1980	2	25
640/IOWAa	3/4/1980	4	14
640/IOWAa	5/5/1980	9	56
640/IOWAa	6/18/1980	408	144

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	7/1/1980	713	60
640/IOWAa	8/4/1980	778	40
640/IOWAa	8/28/1980	25	38
640/IOWAa	9/11/1980	685	12
640/IOWAa	10/20/1980	8	18
640/IOWAa	11/5/1980	8	16
640/IOWAa	12/10/1980	1235	58
640/IOWAa	1/13/1981	9	16
640/IOWAa	2/25/1981	67	512
640/IOWAa	3/3/1981	495	50
640/IOWAa	4/6/1981	67	14
640/IOWAa	5/4/1981	7	76
640/IOWAa	6/29/1981	5	116
640/IOWAa	8/10/1981	1100	64
640/IOWAa	9/1/1981	1050	28
640/IOWAa	10/5/1981	1018	16
640/IOWAa	11/16/1981	10	26
640/IOWAa	12/14/1981	1000	34
640/IOWAa	1/21/1982	24	18
640/IOWAa	2/17/1982	30	56
640/IOWAa	3/10/1982	587	16
640/IOWAa	5/2/1982	346	50
640/IOWAa	6/21/1982	387	58
640/IOWAa	7/15/1982	500	1500
640/IOWAa	8/3/1982	1440	48
640/IOWAa	10/5/1982	26	10
640/IOWAa	11/8/1982	1105	26
640/IOWAa	12/7/1982	19	200
640/IOWAa	1/3/1983	1425	32
640/IOWAa	2/14/1983	497	76
640/IOWAa	3/8/1983	1410	30
640/IOWAa	4/18/1983	720	26
640/IOWAa	5/11/1983	779	12
640/IOWAa	6/6/1983	698	30
640/IOWAa	7/5/1983	720	42
640/IOWAa	8/1/1983	20	41
640/IOWAa	9/12/1983	7	54

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	10/27/1983	13	26
640/IOWAa	11/8/1983	12	84
640/IOWAa	12/12/1983	95	89
640/IOWAa	1/3/1984	205	8
640/IOWAa	2/21/1984	1098	28
640/IOWAa	3/14/1984	35	15
640/IOWAa	4/19/1984	720	22
640/IOWAa	5/7/1984	710	50
640/IOWAa	6/12/1984	11	350
640/IOWAa	7/12/1984	1120	68
640/IOWAa	8/15/1984	9	56
640/IOWAa	9/26/1984	26	42
640/IOWAa	10/23/1984	415	40
640/IOWAa	11/6/1984	416	34
640/IOWAa	12/5/1984	10	35
640/IOWAa	1/14/1985	109	31
640/IOWAa	2/18/1985	23	8
640/IOWAa	3/11/1985	1130	200
640/IOWAa	4/3/1985	189	26
640/IOWAa	5/2/1985	50	54
640/IOWAa	6/3/1985	8	56
640/IOWAa	9/10/1985	20	32
640/IOWAa	10/15/1985	56	42
640/IOWAa	11/14/1985	313	150
640/IOWAa	12/12/1985	1100	22
640/IOWAa	1/9/1986	164	14
640/IOWAa	2/20/1986	12	40
640/IOWAa	3/4/1986	52	16
640/IOWAa	4/9/1986	630	38
640/IOWAa	5/12/1986	439	44
640/IOWAa	6/10/1986	713	62
640/IOWAa	7/7/1986	849	49
640/IOWAa	8/18/1986	1050	17
640/IOWAa	9/9/1986	54	34
640/IOWAa	10/13/1986	737	40
640/IOWAa	11/6/1986	716	22
640/IOWAa	12/4/1986	1017	18

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	1/15/1987	15	280
640/IOWAa	2/9/1987	15	15
640/IOWAa	3/3/1987	14	160
640/IOWAa	4/8/1987	722	34
640/IOWAa	5/26/1987	168	37
640/IOWAa	6/8/1987	410	53
640/IOWAa	7/1/1987	11	108
640/IOWAa	8/3/1987	242	36
640/IOWAa	9/3/1987	660	62
640/IOWAa	10/21/1987	98	20
640/IOWAa	11/4/1987	217	28
640/IOWAa	12/7/1987	840	23
640/IOWAa	1/14/1988	56	13
640/IOWAa	2/8/1988	23	8
640/IOWAa	3/17/1988	390	74
640/IOWAa	4/13/1988	32	29
640/IOWAa	5/23/1988	28	69
640/IOWAa	6/20/1988	27	39
640/IOWAa	7/12/1988	12	52
640/IOWAa	8/1/1988	30	61
640/IOWAa	9/1/1988	30	44
640/IOWAa	10/20/1988	28	29
640/IOWAa	11/3/1988	30	10
640/IOWAa	12/1/1988	20	6
640/IOWAa	1/16/1989	10	6
640/IOWAa	2/2/1989	10	5
640/IOWAa	3/1/1989	15	0.5
640/IOWAa	4/20/1989	20	40
640/IOWAa	5/3/1989	20	38
640/IOWAa	6/7/1989	22	81
640/IOWAa	7/5/1989	20	42
640/IOWAa	8/3/1989	20	50
640/IOWAa	9/5/1989	20	43
640/IOWAa	10/11/1989	22	33
640/IOWAa	11/1/1989	20	13
640/IOWAa	12/6/1989	14	9
640/IOWAa	1/10/1990	13	12

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	2/1/1990	11	6
640/IOWAa	3/1/1990	12	21
640/IOWAa	4/4/1990	12	37
640/IOWAa	5/3/1990	13	52
640/IOWAa	6/6/1990	500	52
640/IOWAa	7/23/1990	250	190
640/IOWAa	8/13/1990	700	54
640/IOWAa	9/6/1990	800	59
640/IOWAa	10/18/1990	801	34
640/IOWAa	11/20/1990	12	15
640/IOWAa	12/26/1990	601	16
640/IOWAa	1/21/1991	50	10
640/IOWAa	2/12/1991	600	160
640/IOWAa	3/4/1991	11	100
640/IOWAa	4/3/1991	600	22
640/IOWAa	5/20/1991	700	37
640/IOWAa	6/11/1991	800	37
640/IOWAa	7/9/1991	600	40
640/IOWAa	8/12/1991	1200	70
640/IOWAa	9/5/1991	11	76
640/IOWAa	10/3/1991	11	26
640/IOWAa	11/13/1991	8	9
640/IOWAa	12/10/1991	15	12
640/IOWAa	1/22/1992	500	8
640/IOWAa	2/12/1992	12	4
640/IOWAa	3/9/1992	12	52
640/IOWAa	4/1/1992	400	27
640/IOWAa	5/4/1992	700	77
640/IOWAa	6/4/1992	750	36
640/IOWAa	7/2/1992	300	39
640/IOWAa	8/17/1992	1000	35
640/IOWAa	9/22/1992	1400	62
640/IOWAa	10/12/1992	800	24
640/IOWAa	11/4/1992	800	32
640/IOWAa	12/3/1992	1190	24
640/IOWAa	1/14/1993	1500	28
640/IOWAa	2/1/1993	1500	22

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	3/15/1993	1500	14
640/IOWAa	4/12/1993	1500	40
640/IOWAa	5/17/1993	800	23
640/IOWAa	6/11/1993	410	89
640/IOWAa	7/20/1993	1500	54
640/IOWAa	8/2/1993	1800	76
640/IOWAa	9/2/1993	1000	32
640/IOWAa	10/7/1993	1800	30
640/IOWAa	11/4/1993	1800	27
640/IOWAa	12/2/1993	590	24
640/IOWAa	1/10/1994	18	15
640/IOWAa	2/2/1994	20	22
640/IOWAa	3/9/1994	1200	160
640/IOWAa	4/14/1994	18	20
640/IOWAa	5/5/1994	110	27
640/IOWAa	6/1/1994	17	45
640/IOWAa	7/5/1994	17	57
640/IOWAa	8/1/1994	14	69
640/IOWAa	9/8/1994	17	35
640/IOWAa	10/3/1994	18	41
640/IOWAa	11/1/1994	15	16
640/IOWAa	12/1/1994	13	7
640/IOWAa	1/9/1995	10	6
640/IOWAa	2/8/1995	12	37
640/IOWAa	3/9/1995	10	5
640/IOWAa	4/19/1995	9	170
640/IOWAa	5/3/1995	600	51
640/IOWAa	6/2/1995	800	74
640/IOWAa	7/7/1995	1000	140
640/IOWAa	8/4/1995	1200	56
640/IOWAa	9/5/1995	1200	56
640/IOWAa	10/4/1995	18	22
640/IOWAa	11/3/1995	4	9
640/IOWAa	12/7/1995	400	9
640/IOWAa	1/11/1996	15	6
640/IOWAa	2/5/1996	3	6
640/IOWAa	3/1/1996	100	19

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
640/IOWAa	4/4/1996	9	16
640/IOWAa	5/2/1996	400	76
640/IOWAa	6/13/1996	800	78
640/IOWAa	7/1/1996	1200	71
640/IOWAa	8/1/1996	1200	60
640/IOWAa	9/5/1996	400	73
640/IOWAa	10/3/1996	16	30
640/IOWAa	11/13/1996	16	16
640/IOWAa	12/6/1996	800	64
640/IOWAa	1/2/1997	15	10
640/IOWAa	2/3/1997	14	24
640/IOWAa	3/6/1997	1500	130
640/IOWAa	4/17/1997	30	870
640/IOWAa	5/15/1997	800	44
640/IOWAa	6/2/1997	800	29
640/IOWAa	7/9/1997	14	28
640/IOWAa	8/1/1997	16	46
640/IOWAa	9/4/1997	16	26
640/IOWAa	10/17/1997	15	32
640/IOWAa	11/11/1997	16	8
640/IOWAa	12/12/1997	1200	34
640/IOWAa	1/2/1998	600	220
640/IOWAa	2/6/1998	50	8
640/IOWAa	3/24/1998	820	52
640/IOWAa	4/23/1998	800	44
640/IOWAa	5/26/1998	200	98
640/IOWAa	6/25/1998	800	66
640/IOWAa	7/28/1998	1200	53
640/IOWAa	8/25/1998	1200	58
640/IOWAa	9/24/1998	200	48
640/IOWAa	10/22/1998	600	75
640/IOWAa	11/5/1998	400	54
640/IOWAa	12/1/1998	13	19
06904000 – Chariton River near Centerville, IA			
06904000	10/25/1999	13	7
06904000	11/29/1999	13	14
06904000	12/13/1999	12	10

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06904000	1/5/2000	13	20
06904000	2/14/2000	12	7
06904000	3/6/2000	12	26
06904000	4/3/2000	12	41
06904000	5/2/2000	12	33
06904000	6/20/2000	11	78
06904000	7/24/2000	17	54
06904000	8/28/2000	16	73
06904000	9/12/2000	17	35
06904000	10/5/2000	7	43
06904000	11/9/2000	9	10
06904000	12/7/2000	11	8
06904000	1/3/2001	8	5
06904000	2/8/2001	10	16
06904000	3/8/2001	1200	57
06904000	4/3/2001	1500	29
06904000	5/1/2001	800	32
06904000	6/6/2001	800	370
06904000	7/3/2001	1500	27
06904000	8/1/2001	800	21
06904000	9/4/2001	12	27
06904000	10/2/2001	21	29
06904000	11/5/2001	13	25
06904000	12/3/2001	11	14
06904000	2/4/2002	13	10
06904000	4/1/2002	8	29
06904000	5/1/2002	13	60
06904000	6/3/2002	1500	41
06904000	7/1/2002	160	43
06904000	8/5/2002	9	24
06904000	9/4/2002	11	30
06904000	10/1/2002	11	25
06904000	11/5/2002	10	10
06904000	12/2/2002	8	6
06904000	1/6/2003	9	5
06904000	3/3/2003	9	5
06904000	4/1/2003	10	9

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06904000	5/5/2003	9	990
06904000	6/4/2003	11	30
06904000	7/2/2003	19	46
06904000	8/4/2003	14	55
06904000	9/1/2003	14	30
06904000	10/1/2003	22	19
06904000	11/3/2003	16	27
06904000	12/1/2003	24	11
06904000	3/1/2004	7	26
06904000	4/5/2004	200	31
06904000	5/3/2004	8	20
06904000	6/1/2004	7	260
06904000	7/1/2004	810	57
06904000	8/2/2004	10	46
06904000	9/1/2004	800	70
06904000	10/4/2004	98	37
06904000	11/1/2004	4	14
06904000	12/1/2004	3	7
06904000	2/1/2005	20	27
06904000	4/4/2005	7	11
06904000	5/2/2005	800	39
06904000	6/1/2005	5	16
06904000	7/6/2005	400	37
06904000	8/1/2005	14	22
06904000	9/6/2005	12	30
06904000	10/3/2005	15	22
06904000	11/1/2005	10	9
06904000	1/4/2006	8	4
06904000	2/1/2006	13	6
06904000	3/1/2006	9	6
06904000	4/4/2006	9	20
06904000	5/2/2006	9	110
06904000	6/1/2006	7	35
06904000	7/3/2006	8	29
06904000	8/1/2006	10	17
06904000	9/6/2006	4	21
06904000	10/2/2006	12	8

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06904000	11/1/2006	11	3
06904000	12/4/2006	10	9
06904000	1/4/2007	11	18
06904000	3/5/2007	10	23
06904000	4/2/2007	43	30
06904000	5/1/2007	790	47
06904000	6/4/2007	800	44
06904000	7/5/2007	1200	49
06904000	8/1/2007	400	19
06904000	9/5/2007	400	73
06904000	10/1/2007	800	40
06904000	11/5/2007	800	37
06904000	12/3/2007	800	25
06904000	1/7/2008	200	340
06904000	2/5/2008	790	20
06904000	4/1/2008	1200	200
06904000	5/5/2008	790	27
06904000	6/2/2008	790	27
06904000	7/9/2008	12	430
06904000	8/6/2008	1500	31
06904000	9/4/2008	1500	29
06906300 – East Fork Little Chariton River at Huntsville, MO			
06906300	10/20/1982	52	15
06906300	11/3/1982	54	36
06906300	12/14/1982	416	50
06906300	1/5/1983	232	37
06906300	2/8/1983	113	35
06906300	3/8/1983	270	156
06906300	4/12/1983	798	122
06906300	5/11/1983	287	101
06906300	6/7/1983	188	66
06906300	7/19/1983	17	60
06906300	8/16/1983	4.8	30
06906300	9/28/1983	1	18
06906300	10/13/1983	10	31
06906300	11/21/1983	59	27
06906300	12/13/1983	442	78

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06906300	1/10/1984	100	37
06906300	2/14/1984	74	24
06906300	3/13/1984	144	33
06906300	4/10/1984	623	117
06906300	5/17/1984	320	110
06906300	6/12/1984	433	152
06906300	7/26/1984	16	40
06906300	8/23/1984	6	45
06906300	9/20/1984	6.3	19
06906300	10/12/1984	20	30
06906300	11/15/1984	322	75
06906300	12/13/1984	122	53
06906300	1/17/1985	194	53
06906300	2/15/1985	90	47
06906300	3/14/1985	626	81
06906300	4/4/1985	243	87
06906300	5/9/1985	72	261
06906300	6/6/1985	26	5
06906300	7/18/1985	13	68
06906300	9/19/1985	58	98
06906300	10/10/1985	1290	674
06906300	11/14/1985	1760	238
06906300	12/12/1985	300	71
06906300	1/15/1986	66	50
06906300	2/5/1986	320	376
06906300	3/7/1986	220	46
06906300	4/3/1986	130	67
06906300	5/6/1986	21	30
06906300	6/4/1986	274	117
06906300	7/16/1986	196	335
06906300	8/12/1986	60	66
06906300	9/4/1986	51	79
06906300	10/22/1986	324	79
06906300	11/20/1986	123	62
06906300	12/9/1986	790	189
06906300	1/14/1987	80	53
06906300	2/11/1987	83	47

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06906300	3/11/1987	73	35
06906300	4/7/1987	88	47
06906300	5/13/1987	29	36
06906300	6/2/1987	18	113
06906300	10/11/1989	7.8	30
06906300	11/8/1989	8.2	28
06906300	12/6/1989	8.6	20
06906300	1/19/1990	18	60
06906300	2/14/1990	16	22
06906300	3/22/1990	36	38
06906300	4/11/1990	26	24
06906300	5/8/1990	283	169
06906300	6/5/1990	180	0.5
06906300	7/10/1990	140	49
06906300	8/7/1990	30	34
06906300	9/5/1990	10	14
06906300	10/10/1990	16	19
06906300	11/14/1990	11	29
06906300	12/10/1990	27	10
06906300	1/9/1991	68	8
06906300	2/5/1991	87	90
06906300	3/11/1991	64	15
06906300	4/3/1991	73	67
06906300	5/15/1991	196	216
06906300	6/12/1991	128	39
06906300	11/9/1999	12	22
06906300	5/1/2000	9.5	20
06906300	11/20/2000	14	11
06906300	5/1/2001	74	59
06906300	11/5/2001	18	14
06906300	1/7/2002	10	4.99
06906300	3/5/2002	20	4.99
06906300	5/6/2002	3170	1280
06906300	7/15/2002	61	98
06906300	9/4/2002	51	39
06906300	11/26/2002	8.9	4.99
06906300	1/9/2003	12	4.99

USGS Gage Number	Sample Date	Flow (cfs)	Total Suspended Solids (mg/L)[1]
06906300	3/19/2003	23	14
06906300	5/1/2003	205	804
06906300	7/31/2003	8.5	13
06906300	9/10/2003	14	20
06906300	11/4/2003	28	4.99
06906300	1/6/2004	38	4.99
06906300	3/1/2004	57	33
06906300	5/19/2004	51	51
06906300	7/14/2004	64	56
06906300	9/1/2004	304	188
06906300	11/8/2004	151	51
06906300	1/25/2005	90	28
06906300	3/7/2005	37	32
06906300	5/3/2005	36	18
06906300	7/11/2005	7	25
06906300	9/6/2005	9.1	12
06906300	11/2/2005	12	4.99
06906300	1/5/2006	11	7.5
06906300	3/6/2006	17	4.99
06906300	5/3/2006	422	348
06906300	7/5/2006	49	14
06906300	9/5/2006	13	13
06906300	11/7/2006	17	4.99
06906300	1/4/2007	26	4.99
06906300	2/13/2007	36	13
06906300	3/6/2007	230	51
06906300	4/3/2007	274	120
06906300	5/2/2007	297	76
06906300	6/5/2007	144	56
06906300	7/10/2007	56	54
06906300	9/11/2007	13	25

Note: Blank cells indicate that there was no data for that particular parameter on that date.
[1]non-filterable residue data (NFR) is interchangeable with total suspended solids data (TSS)

Appendix D

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 Sandy Creek TMDL.

Point Sources

The point source portion of a TMDL is typically 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 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 cause or contribute to the impairment of Sandy Creek. Additionally, permitted facilities identified to contribute to the pollutant loading of the impaired segment shall adopt appropriate best management practices (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.

In addition to permitted point sources, this TMDL also cites AMLs as contributors to the impairment of Sandy Creek. As stated in Section 3.1.2, the MDNR Land Reclamation Program is in the process of reclaiming the AMLs in the vicinity of Sandy Creek through the use of forfeited bond funds. The goal of the Land Reclamation Program is to return AMLs to productive uses, such as wildlife habitat, farming, grazing or other recreational uses.

Nonpoint Sources

Nonpoint sources of sediment are not regulated in Missouri. However, with cropland and grassland comprising a significant portion of the land area in the watershed, agricultural runoff is a likely contributor of sediment to the impaired water body. Contributions of sediment from agricultural areas should be reduced to meet the TMDL targets.

To reduce the loading and effect of sediment on Sandy Creek, 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 Sandy

Creek 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.

In an effort to most effectively implement voluntary BMPs, MDNR may work with the Natural Resources Conservation Service, 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.