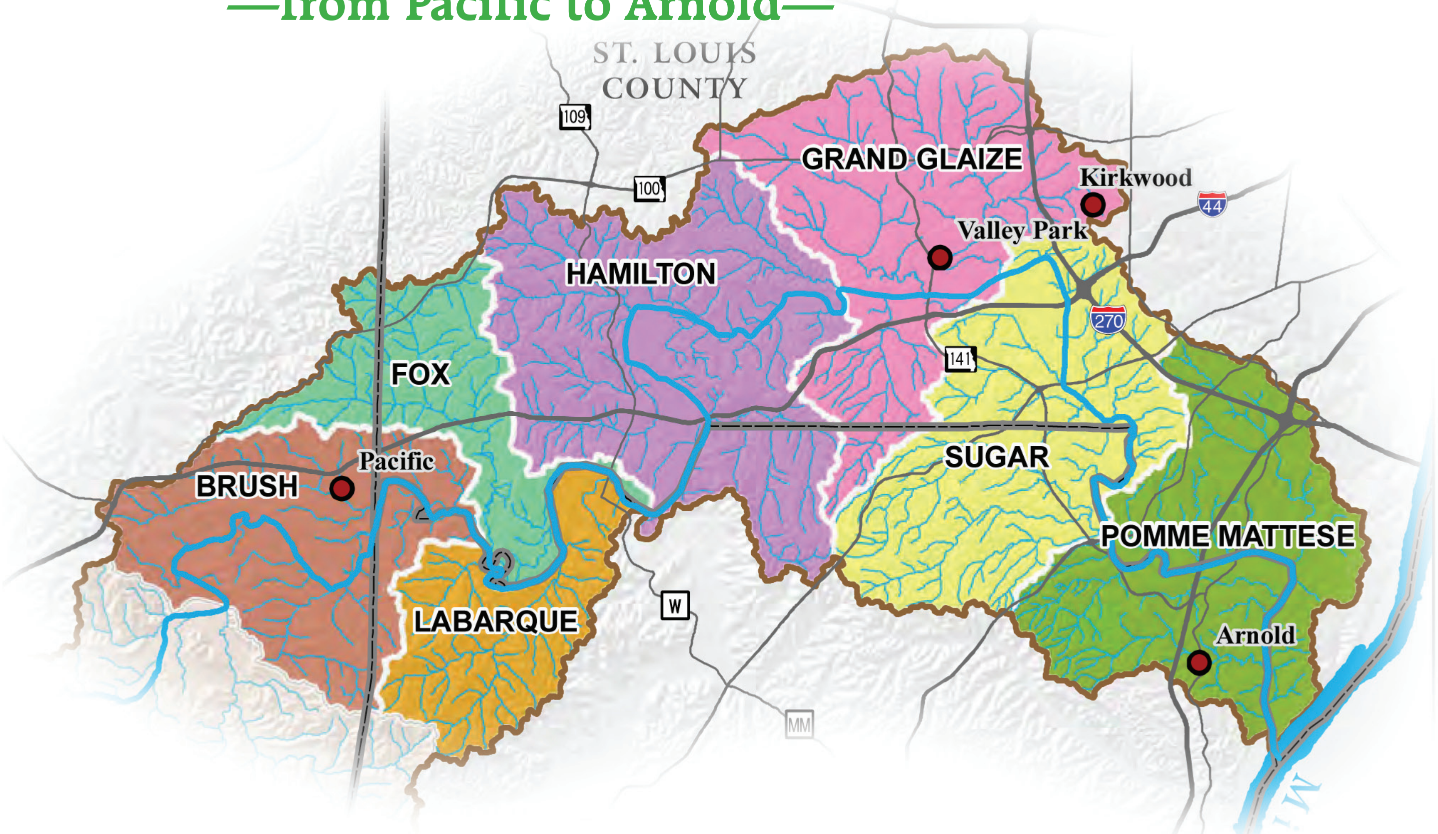
FINAL

Appendix | **September 2017**

Lower Meramec Watershed Plan

—from Pacific to Arnold—



This project has been funded in part by the U.S. Environmental Protection Agency, Region7, through the Missouri Department of Natural Resources under assistance agreement G16-NPS-05 to East-West Gateway Council of Governments. Other funders include Great Rivers Greenway, Missouri Department of Conservation and The Nature Conservancy.

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Creating Solutions Across Jurisdictional Boundaries

Appendices

Lower Meramec Watershed Management Plan 2017 Update: Including Mattese/Pomme, Sugar/Fenton, Grand Glaize/Fishpot/ Williams, Hamilton/Kiefer, Fox/LaBarque, and Brush Creeks

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Prepared by East-West Gateway Council of Governments
September 2017

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APPENDIX A

BACKGROUND INFORMATION – CHARACTERIZE THE WATERSHED

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Appendix A. Background Information Lower Meramec River Watershed

A. Planning Area Overview and Description – Updated

Some of the elements from Section II Characterize the Watershed of the 2012 Plan[1], have been updated and revised to include the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds. Those elements not updated are noted as such. Section L contains a discussion about the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds.

B. Planning Area Overview and Description – Updated

The 2012 Plan addressed four watersheds draining approximately 116,000 acres (182 square miles) of Franklin, Jefferson, and St. Louis counties, extending from Pacific in Franklin County to Valley Park in St. Louis County. The watersheds addressed in this plan were Brush Creek (HUC 071401020902), Fox/LaBarque Creeks (HUC 071401020903), Hamilton Creek (HUC 071401021001), and Grand Glaize Creek (HUC 071401021002) (Maps 1-5 and other maps referenced in this report can be found at the end of this report in Section N).

The planning area has been extended from Valley Park to the confluence of the Meramec River and the Mississippi River adding Sugar Creek, including Fenton Creek, (HUC 071401021003) and Pomme/Mattese Creeks (HUC 071401021004) watersheds have been included. (Maps 6 and 7). Information about these watersheds (incorporated units, creeks, size) is presented in Table 1 below. Table 2 lists information on the municipalities incorporated within the lower Meramec watershed and the percent of each municipality that lies within the lower Meramec watershed. Parkdale and Arnold, in Jefferson County, and Fenton, Kirkwood, Green Park and Sunset Hills, in St. Louis County, are located, either partially or entirely, within the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds (see Table 2).

[1] http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

Table 1. Lower Meramec River Watersheds

12-Digit Hydrologic Unit	County	Acres	Square Miles	Creeks	Municipalities
Brush Creek 071401020902	Franklin St. Louis Jefferson	23,584	36.9	Brush, Winch Brush, Segment draining to Meramec* Segment draining to Meramec	Pacific
Fox Creek 071401020903 Fox Creek sub-watershed LaBarque Creek sub-watershed	Franklin St. Louis Jefferson	28,201 14,691 13,510	44.1 23.0 21.1	Little Fox Little Fox, Fox, Segment draining to Meramec McFall, LaBarque, Segment draining to Meramec	Pacific Wildwood, Eureka Lake Tekakwitha
Hamilton Creek 071402021001	St. Louis Jefferson	34,956	54.6	Hamilton, Carr, Forby, Flat, Kiefer Segment draining to Meramec Antire, Little Antire	Wildwood, Eureka, Ellisville, Ballwin Byrnes Mill, Peaceful Village
Grand Glaize Creek 0714010021002	St. Louis Jefferson	29,895	46.7	Fishpot, Grand Glaize, Segment draining to Meramec Williams, Segment draining to Meramec	Ellisville, Ballwin, Chesterfield, Town & Country, Twin Oaks, Winchester, Manchester, Country Life Acres, Des Peres, Kirkwood, Fenton, Valley Park Parkdale
Sugar/Fenton Creeks 071401021003	Jefferson St. Louis	28,851.0	45	Sugar, Saline, Romaine, Segment draining to Meramec Fenton, Segment draining to Meramec	Parkdale Fenton, Kirkwood, Sunset Hills
Pomme/Mattese Creeks 071401021004	Jefferson St. Louis	27,974.1	43.7	Pomme, Segment draining to Meramec Mattese, Segment draining to Meramec	Arnold Sunset Hills, Green Park
Total		173,461.1	270.9		

* Refers to that portion of HUC12 watershed which does not drain directly into the identified creeks and on to the Meramec River.
Source: Center for Applied Research and Environmental Systems (CARES) for acreage, University of Missouri-Columbia and East-West Gateway Council of Governments

Table 2. Incorporated Land within the Lower Meramec River Watershed

Municipality	Total Municipal Acres	Incorporated Acres within Meramec River Watershed	Percent Share
Franklin County			
Pacific	3,362.8	3,362.8	100
Jefferson County			
Arnold	7,364.1	6,844.7	92.9
Byrnes Mill	3,352.9	168.3	5.0
Lake Tekakwitha	136.9	136.9	100
Parkdale	80.1	80.1	100
Peaceful Village	125.1	125.1	100
St. Louis County			
Ballwin	5,718.1	5,094.9	89.1
Chesterfield	21,511.3	51.0	0.2
Country Life Acres	78.2	11.9	15.3
Des Peres	2,773.5	1,820.2	65.6
Ellisville	2,797.2	1,909.3	68.3
Eureka	6,787.1	6,787.1	100
Fenton	4,088.8	4,088.8	100
Green Park	836.9	39.2	4.7
Kirkwood	5,871.1	3,286.7	56.0
Manchester	3,231.2	3,231.2	100
Pacific	388.0	388.0	100
Sunset Hills	5,785.6	5,059.7	87.5
Town & Country	7,385.2	2,509.8	34
Twin Oaks	173.4	173.4	100
Valley Park	2,714.3	2,714.3	100
Wildwood	42,986.4	17,810.4	41.4
Winchester	160.1	160.1	100

East-West Gateway Council of Governments, 2017

C. Socio-Economic Background - Updated

Using population estimates from the 2015 5 Year American Community survey, in 2015 the population in the planning area was estimated to be 296,953. Approximately 73.5 percent of the planning area population resides in the St. Louis County portion of the Hamilton, Grand Glaize Creek, Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds (see Table 3). The Fox Creek and LaBarque Creek watersheds together contain about two percent of the total watershed population.

Since 1990, the population in the planning area has increased 19.8 percent (see Table 4). The population in the Hamilton Creek watershed has increased 95.7 percent over this 20-year period, while the population in the Grand Glaize watershed increased ten percent from 97,324 to 107,687. In 1990, the majority of the population was in those portions of the Grand Glaize Creek and the Pomme/Mattese watersheds north of the Meramec River. There aree freestanding communities, such as Arnold, Eureka and Pacific, and population concentrations along I-44 in Franklin County. Over the last two decades, population increases have occurred in the west beyond Kiefer Creek into Wildwood, and south into northern Jefferson County.

The median household income by watershed ranges from $46,900 in the Brush Creek watershed to $98,100 in the Hamilton Creek watershed. The median for the entire planning area is $72,200 (see Table 5).

Table 3. Lower Meramec Watershed: 2015 Population by Sub-Watershed

Watershed	2015 Estimated Population	Percent Share
Brush Creek	11,581	3.9
Fox Creek	2,269	0.8
LaBarque Creek	3,358	1.1
Hamilton Creek	29,071	9.8
Grand Glaize Creek	107,687	36.3
Sugar/Fenton Creeks	57,197	19.3
Pomme/Mattese Creeks	85,789	28.8
Total	296,953	100

2015 5 Year American Community Survey

Table 4. 1990-2015 Population by Watershed

Watershed	1990 Population	2000 Population	2010 Population	2015 Estimated Population	Percent Increase 1990-2015
Brush Creek	9,756	10,644	12,133	11,581	18.7
Fox Creek	1,676	3,233	2,542	2,269	35.4
LaBarque Creek	2,033	2,920	2,812	3,358	65.2
Hamilton Creek	14,852	24,952	29,449	29,071	95.7
Grand Glaize Creek	97,324	104,827	104,543	107,687	10.6
Sugar/Fenton Creeks	47,908	52,493	57,274	57,197	19.4
Pomme/Mattese Creeks	74,211	82,424	84,521	85,789	15.6
Total	247,760	281,493	293,275	296,953	19.8

U.S. Bureau of the Census, 2015 5 Year American Community Survey
East-West Gateway Council of Governments

Table 5. Median Household Income by Watershed

Watershed	Estimated 2015 Households	Estimated Median Household Income
Brush Creek	4,428	$46,900
Fox Creek	905	$74,400
LaBarque Creek	1,085	$91,600
Hamilton Creek	10,077	$98,100
Grand Glaize Creek	41,665	$82,100
Sugar/Fenton Creeks	21,481	$65,800
Pomme/Mattese Creeks	34,648	$64,200
Lower Meramec PlanningArea	114,289	$72,200

Source: 2015 Year American Community Survey, US. Bureau of the Census

D. Land Use

The contents of this section have not been updated. Please see Section II.C. of the 2012 Plan. Land use information for Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds can be found in Section L.

E. Wastewater Systems in the Lower Meramec Watershed –Updated

In the lower Meramec River planning area, MoDNR issued National Pollutant Discharge Elimination System (NPDES) permits to 74 entities have with 98 point source discharge locations into creeks and the Meramec River.)(See Map 8 with tables describing Map key in Section M). The majority of these NPDES permits were issued for domestic wastewater treatment owned or operated by: six sewer districts; a private sewer company; city of Pacific; city of Eureka; subdivisions; apartment units; and mobile home parks. The MSD covers St. Louis County, east of State Highway 109 in Wildwood. MSD operates the Grand Glaize, Fenton, and Lower Meramec Wastewater Treatment Plants. The Grand Glaize and Fenton plants discharge into the Meramec River. Some St. Louis County residences not served by MSD have individual on-site wastewater treatment systems. The Franklin County Public Water and Sewer District #3 operates the wastewater treatment facilities at four subdivisions in Franklin County. The

Northeast Public Sewer District (NPSD) has five wastewater treatment facilities in Jefferson County. The Saline Region Wastewater Treatment Facility serves the majority of the Jefferson County residents, while the remaining facilities serve one or two individual subdivisions. Some residences in this district are not served by NPSD. The Brush Creek Sewer District and the City of Pacific have an agreement whereby the City of Pacific can accept the wastewater of the Brush Creek Sewer District for treatment. The wastewater collection system for the city of Arnold in Jefferson County is owned and operated by the Missouri American Water Company (MAWC). Arnold has an agreement with MSD for the treatment of their wastewater. The planning area lies outside of the MSD Combined Sewer Overflow (CSO) service area, therefore, local CSO issues have not been identified. To comply with the EPA. Missouri, MCE and MSD Consent Decree, MSD has prepared a Sanitary Sewer Overflow Master Plan detailing the activities to be undertaken to provide additional sanitary system capacity in order to address constructed sanitary sewer overflows (CSSOs) in their service area.[2] During 2014-2018 MSD is to eliminate the one CSSO in the Fishpot Creek watershed and the two CSSOs in the Grand Glaize Creek watershed. To comply with the The Brush Creek Sewer District has completed an infiltration/inflow study and is implementing corrective actions.

There are 11 industrial facilities with 25 discharge sites within the planning area. Three of these are for stormwater which discharge from two landfills and an electric power plant. The majority of outfall discharge stormwater and processed water. There are permits for a groundwater remediation action in St. Louis County and a remediated landfill in Jefferson County. The remaining permits have been issued for commercial-institutional uses which range from an amusement park to golf courses to convenience stores. Information on the type of treatment, design flow and discharge from domestic, industrial, and commercial-institutional permits can be found at the end of this report.

Six municipal recreation centers or subdivisions, a camp, and a shopping center with a waterfall have general permits for discharge. This general permit includes filter backwash and drainage from pools and lined ponds, which use chlorine as a sanitizer, and water drained from swimming pools, lined decorative ponds and fountains. The privately owned MAWC has two drinking water treatment plants in the planning area, Meramec Plant and South County Plant, each with a general permit. The permits allow for the discharge of filter backwash water and solids, and allow the operation of no-discharge sludge holding systems and land application of water treatment plant sludge. There are a total of nine general permits in the lower Meramec watershed.

F. Individual On-site Wastewater Treatment Systems in the Lower Meramec Watershed as of 1990 – Updated

The 1990 Census contains the most recent information on the types of wastewater systems available in the planning area by housing units. At that time, 15 percent of the housing units in the planning area had individual on-site wastewater treatment systems (such as a septic tank) (see Table 6). However, there was a wide range of on-site wastewater treatment system usage

[2] http://www.stlmsd.com/sites/default/files/FY2017%20-%20FY2020%20Rate%20Proposal%20Exhibits/Exhibit%20MSD%2047B%20-%20MSD%20Sanitary%20Sewer%20Overflow%20Control%20Master%20Plan%20Executive%20Summary.pdf

between the watersheds. In 1990, 96 percent of the housing units in the LaBarque Creek watershed had on-site wastewater treatment systems, while only 4.6 percent of the housing units in the Grand Glaize Creek watershed were using on- site wastewater treatment. Nevertheless, Kiefer Creek in the Hamilton watershed, Grand Glaize, Fishpot and Williams Creeks in the Grand Glaize watershed, and Fenton Creek and Mattese Creeks have been identified by MoDNR as being impaired by bacteria. Brush Creek, on the other hand, has seen a major reduction in the number of on-site wastewater-treatment systems in use after the establishment of the Brush Creek Sewer District.

Table 6. 1990 Sewer Service in Lower Meramec River Planning Area

Watershed	Housing Units Connected to						Total	
	Public Sewer		On-Site Wastewater Treatment Systems		Uses Other Means (Privy or Outhouse)			
	Total	%	Total	%	Total	%	Total	%
Brush Creek	1,934	58.1	1,314	39.5	82	2.5	3,330	100
Fox Creek	732	51.2	658	46.0	41	2.9	1,431	100
LaBarque Creek	18	2.4	713	96.1	11	1.5	742	100
Hamilton Creek	5,192	70.9	2,024	27.6	110	1.5	7,326	100
Grand Glaize Creek	25,531	95.2	1,241	4.6	34	0.1	26,806	100
Sugar/Fenton Creeks	17,235	74.2	5,877	25.3	127	0.5	23,239	100
Pomme/Mattese Creeks	31,165	86.2	4,843	13.4	140	0.4	36,148	100
Planning Area	81,807	84.2	16,670	15.3	545	0.6	99,022	100

In the Kiefer Creek Watershed plan, the MCE identified 259 potential on-site wastewater treatment systems in the watershed that may be the source of most of the bacteria loading in Kiefer Creek. The target for this plan is to address approximately 50 percent of those individual systems which are likely failing to perform as designed.

G. Hydrologic Soil Group Classification – Updated

Specific soil characteristics affect the rate of infiltration of water into the soil, and conversely, the volume and velocity of stormwater runoff. Soils are classified by the Natural Resource Conservation Group (NRCS) into four hydrologic soil groups, A, B, C, D, based on the physical drainage properties of each soil series, including texture and permeability, as well as certain physiographic properties, such as depth to bedrock and water table. Soils are categorized in terms of their runoff potential, with Group A being well-drained and Group D being poorly drained.

Group A soils have low runoff potential and high infiltration rates even when thoroughly saturated. They consist primarily of deep sand, loamy sand or sandy loam type soils and have a high rate of water infiltration. Typically, these soils are located near streams and in floodplains.

Group B soils have a moderate infiltration rate when thoroughly saturated and consist chiefly of moderately deep to deep soils, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils include silt loams or loams.

Group C soils have low infiltration rates when thoroughly saturated. This group contains sandy clay loam soils. They consist chiefly of soils with a layer near the surface that impedes downward movement of water or soils with moderately fine to fine texture.

Group D soils have the highest runoff potential. They have very low infiltration rates when thoroughly saturated, and in combination with suburban development, will intensify runoff volumes and velocities which will increase streambank erosion and flash flooding. This group contains clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious materials. These poorly drained soils should be avoided for placement of onsite wastewater treatment drainfields. Dual soil groups include certain soils placed in Group D because of a high water table, creating a drainage problem. If these soils can be adequately drained, they can be placed in a different soil hydrologic group. The first letter of the dual group applies to the drained condition.

Soils for which the hydrologic characteristics could not be determined were noted as “No Data”. Development activities have resulted in soil compaction and mixing of soil types.

The 2012 Plan contained Hydrological Soil Group maps for both the entire five watershed planning area and for each individual watersheds. In the 2017 plan, maps have been prepared for the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds. Information about the distribution of these soils groups in the entire planning area is found in Table 7.

Table 7. Hydrologic Soil Groups by Watershed (Acres) Lower Meramec River Planning Area

Hydrologic Soil Group	Brush Creek	Fox Creek	LaBarque Creek	Hamilton Creek	Grand Glaize Creek	Sugar/ Fenton Creeks	Pomme/ Mattese Creeks	Total	Percent Share
A	2.8	68	7.1	385.8	61.4	148.5	117.0	790.6	0.5
B	4,977.8	7,030.4	2,081.4	12,730.2	8,209.2	4,212.1	693.9	39,944.0	23.0
B/D	0.5	0	87.3	18.4	0	363.0	1,834.7	2,303.9	1.3
C	11,136.3	5,290.5	6,003.2	9,702.6	3,550.4	5,998.2	3,818.3	45,499.5	26.2
C/D	696.4	0	130.4	41.8	0	2,115.7	2,988.8	5,973.1	3.4
D	5,776.7	2,144.9	4,995.6	10,802.2	16,902.1	7,502.7	4,931.8	53,056.0	30.6
No Data	993.5	157.2	205.0	1,275.0	1,171.9	8,510.8	13,589.6	25,903.0	14.9
Total	23,604.0	14,691.0	13,510.0	34,956.0	29,895.0	28,851.0	27,974.1	173,481.1	100

Source: USDA, Natural Resource Conservation Service

Hydrologic Soil Groups
A – Low runoff potential, well drained
B – Moderately low runoff potential
C – Moderately high runoff potential
D – High runoff potential, poorly drained
B/D – High water table, if soil was drained could be placed in Group B
C/D – High water table, if soil was drained could be placed in Group C
No Data – Hydrologic characteristics of soil could not be determined

H. Geology

The contents of this section were not updated. For more information please see Section II.G. of the 2012 Plan. Section L below describes the Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds and contains information about the geology in these two watersheds.

I. Conservation Opportunity Areas

The contents of this section were not updated. Please see Section II.I. of the 2012 Plan.

J. Cultural Resources

The contents of this section were not updated. Please see Section II.H. of the 2012 Plan.

K. Water Quality Sampling and Biological Assessment (Element I – Monitoring Component)

1. Water Quality Sampling

a. Volunteer Monitoring Efforts

There is much public interest in the river and streams located in the lower Meramec River planning area. Trained volunteers participating in the Missouri Stream Team program have adopted sites on the Meramec River and the major creeks in the watershed to perform water quality monitoring and other activities. Stream Teams can work with more than one stream and over time a site can be adopted by one or more Stream Teams. In addition to water quality monitoring, Stream Teams can also visually survey a site, organize and perform litter pick-up, adopt access projects, plant trees, improve habitats, prepare inventory guides, and/or work on a greenway projects. Information on the location, type and schedule of Missouri Stream Team activities and analysis results can be found at the Missouri Stream Team website at www.mostreamteam.org/interactivemap.

In the 2012 Plan, it was noted that there were 72 teams active in the watershed or had been in the past. Table 8 presents by watershed those Stream Teams identified in the 2012 Plan. Information on the Stream Teams operating in the Sugar/Fenton Creeks and Pomme/Mattese Creeks watershed can be found in Table 9. Table 10 lists those tributary sub-watersheds which have had Stream Team water quality monitoring performed. Table 11 contains information on Meramec River Stream Team water quality monitoring sites along the main stem of the lower Meramec River.

Table 8. Stream Teams in Lower Meramec River Planning Area (2012 Plan)

Watershed	Teams *	Water Quality Monitoring Sites	Non Monitoring Sites
Brush Creek	12	16	1
Fox Creek	11	8	0
LaBarque Creek	18	18	1
Hamilton Creek	27	14	7

Watershed	Teams *	Water Quality Monitoring Sites	Non Monitoring Sites
Grand Glaize Creek	28	30	15
Total	72	86	24

*A Stream Team can be active in more than one watershed.
Source: Missouri Stream Team interactive map, www.mostreamteam.org

Table 9. Current Stream Teams in the Sugar/Fenton Creeks and Pomme/Mattese Creeks

Watershed	Teams*	Water Quality Monitoring Sites	Non Monitoring Sites
Sugar/Fenton Creeks	20	21	9
Pomme/Mattese Creeks	18	18	21
Total	38	39	30

*A Stream Team can be active in more than one watershed.
Source: Missouri Stream Team interactive map, www.mostreamteam.org

Table 10. Tributary Sub-Watersheds with Stream Team Activities- listed from West to East

Sub-Watersheds	Sub-Watersheds, continued
Brush Creek	Grand Glaize Creek
Fox Creek	Fenton Creek
Forby Creek	East of Meramec River in St. Louis County (part of Sugar/Fenton Creeks watershed)
LaBarque Creek	Saline Creek
Hamilton Creek	Pomme Creek
Kiefer Creek	Unnamed tributary to Meramec River in Jefferson County (part of Pomme/Mattese Creeks watershed)
Fishpot Creek	Mattese Creek
Williams Creek	Unnamed tributary to Meramec River in St. Louis County (part of Pomme/Mattese Creeks watershed)

Source: Missouri Stream Team interactive map, www.mostreamteam.org

Table 11. Stream Team Meramec River Water Quality Sampling Sites

Site	County
Brush Creek Watershed to Grand Glaize Creek Watershed – West to East	
Between Riverview Drive and Fish Trap Rapids Loop	Franklin
Downstream of Fish Trap Rapids Loop	Franklin
Near Goddard Trail at Shaw Nature Reserve	Franklin
Shaw Nature Reserve near Barn Road	Franklin
Downstream of Shaw Nature Reserve	Franklin
Upstream Meramec Farm Valley and downstream Gravel Pit	Franklin
400 Feet upstream Bend Road in Pacific	Franklin
Catawissa Conservation Area upstream of Winch Creek	Franklin
0.56 miles upstream of Highway F near Pacific	Franklin
0.6 miles above Pacific Palisades Conservation Area boat ramp between Clear Creek and Brush Creek	St. Louis
0.5 miles upstream Pacific Palisades Conservation Area Access Boat Ramp	St. Louis

Site	County
Pacific Palisades Conservation Area Boat Ramp northeast side of river	St. Louis
300 yards downstream Pacific Palisades Conservation Area Boat Ramp	Jefferson
Near end of Shamrock Hill Road	St. Louis
0.7 miles upstream of Fox Creek	Jefferson
Upstream of McFall Creek	Jefferson
0.7 miles downstream of LaBarque Creek confluence	St. Louis
Allenton Access Boat Ramp	St. Louis
Downstream of Hunters Ford Road	St. Louis
Upstream Highway 109 near St. Stephens Church	St. Louis
Near Bald Hill downstream of Highway 109	St. Louis
Downstream of confluence with Big River	Jefferson
1 mile upstream Route 66 State Park	Jefferson
Upstream Boland Farm Road	Jefferson
Upstream I-44 bridge	St. Louis
Near Eureka downstream of I-44	St. Louis
Near Times Beach	St. Louis
Downstream railroad tracks near Crescent	St. Louis
Downstream of Flat Creek	St. Louis
Near Yeatman	St. Louis
Downstream of railroad bridge near Jedburgh	St. Louis
Jedburgh near Minke Hollow	St. Louis
Near Cedar Bluff	St. Louis
Castlewood State Park boat ramp upstream Kiefer Creek near Lincoln Beach	St. Louis
0.5 upstream Williams Creek confluence	St. Louis
Meramec River at Valley Park Access	St. Louis
Meramec River upstream Grand Glaize Creek at Kena Street	St. Louis
Near Marshall Road and Tree Court Industrial Boulevard downstream of Grand Glaize confluence with Meramec River	St. Louis
Greentree Park Access Ramp	St. Louis
Sugar/Fenton Creeks Watershed to Pomme/Mattese Creeks Watershed – West to East	
Near Unger Park	St. Louis
At intersection of Yarnell Road and Fabricator Drive	St. Louis
0.75 miles upstream of U.S. Highway 30 near Larkin Williams Road	St. Louis
0.3 miles downstream U.S. Highway 30 bridge	St. Louis
Near George Winter Park next to gravel quarry	St. Louis
George Winter Park boat ramp	St. Louis
George Winter Park near county line	St. Louis
Near Crystal Tree Corners Road and Crystal Park Circle	St. Louis
Near Winter Park adjacent Corisande Hills Road	Jefferson
Upstream of Sugar Creek confluence and adjacent Springdale Park	Jefferson
At Paulina Hills at State Highway 21	St. Louis
Downstream State Highway 21 near Twin Oaks Drive	Jefferson
0.3 miles upstream Interstate 55 near Lonedell Road	Jefferson
Downstream of Mattese Creek	St. Louis
Near Starling Airport Road between Carol Lane and Wyfield Terrace Drive	Jefferson
Near Ten Brook adjacent Rivershore Avenue and downstream of Cliff Drive	Jefferson
State Highway 231 upstream Pomme Creek	Jefferson
Flamm City Access boat ramp, 275 feet downstream Highway 231	Jefferson
0.25 miles downstream of Flamm City Access	Jefferson
Near Mouth upstream of Taylor Road	Jefferson

Source: Missouri Stream Team interactive map, www.mostreamteam.org

The kayakswarm is an unofficial group of local kayakers composed of both recreational as well as more advanced boaters. In 2008, the kayakswarm partnered with the Missouri Stream Team program to gather water quality data and photographs of each mile of the Meramec River. In the 2012 Plan Appendix C contains the 2008 water chemistry data collected at the GPS measured mile points in the lower Meramec planning area. More information about kayakswarm activities can be found at their website, www.lmvp.org/kayakswarm.

i. Mattese Creek Cooperative Stream Investigation Project

ii. Fenton Creek Cooperative Stream Investigation Project

The MoDNR Environmental Services Program organized a Cooperative Stream Investigation (CSI) projects in Mattese Creek from November 2013 – December 2014 and in Fenton Creek from November 2014 – December 2015. Assisting in this project was Missouri Stream Team 4220 and the MAWC laboratory in Chesterfield. The objective was to provide data to be used in TMDL development, to prepare TMDL implementation strategies and to determine major source tracking of *E. coli* and chloride. Sample sites for Mattese Creek included three sites along the main stem and on four unnamed tributaries, while Fenton Creek included four sites along the main stem and three on unnamed tributaries. In both CSI projects, surface water grab samples were collected for *E. coli* and chloride. . The *E. coli* samples were submitted to the Missouri American Water laboratory for analysis. Grab samples collected during the recreational season, April 1 through October 31, were provided to MoDNR. Chloride was determined on-site using chloride test strips. Surface water grab samples for chloride were collected quarterly and submitted to the MoDNR Environmental Services Laboratory for analysis to verify results collected using the sample strips. For more information see https://www.dnr.mo.gov/env/esp/csi.htm.

iii. Meramec River Basin Nutrient Monitoring Project

From September 2015 through August 2016, the Missouri Stream Team Volunteer Water Quality Monitoring Program (VWQM) conducted a Meramec River Basin Nutrient Monitoring project. The purpose of this project was to gather spatial nutrient data which would help to define current conditions across the entire Meramec basin. As part of the project, trained Stream Team volunteers collected surface water grab samples and analyzed the samples for nitrate, orthophosphate as phosphorous (P), and turbidity levels. The volunteers then entered the monitoring data into the online VWQM database and interactive map website (www.mostreamteam.org).

Once a month samples were collected at 25 locations along the main stem of the Meramec River and its major tributaries, Bourbeuse and Big Rivers. Seven monitoring locations were in small sub-watershed tributaries to the Lower Meramec River which has had a history of volunteer monitoring. They include Williams Creek, Grand Glaize Creek, Kiefer Creek, Hamilton Creek, LaBarque Creek, Fox Creek, and Brush Creek. Minimums, maximums, and geometric means were calculated for turbidity, nitrate, and orthophosphate as total phosphate (P). The geometric means were used to look at the relationship between nutrient levels and watershed size, to classify and rank nutrient concentrations by monitor sites and watersheds, and to examine nutrient transport out of the Meramec River Basin. Information collected was compared to EPA guidance and MoDNR draft nutrient criteria. Higher levels of turbidity were found at the mouths of the Meramec River (Flam City access point) and the Bourbeuse River. Higher nitrate concentrations were found at the Kiefer Creek monitoring location. The Williams Creek and Hamilton Creek sites had higher orthophosphate as P concentrations. For more information see https://www.dnr.mo.gov/env/esp/csi.htm.

iv. Hamilton Creek Cooperative Stream Investigation Project Plan

As part of the 2015-2016 Meramec River Basin nutrient monitoring project conducted by the Missouri Stream Team volunteers, nitrate and orthophosphate sampling took place at 25 sites. Project results showed that the Hamilton Creek watershed ranked second highest in the geometric mean for the monthly samples. Historical Stream Team water quality monitoring data indicated that high nutrient, and on occasion, high ammonia concentrations were observed..

The Environmental Services Program of MoDNR is currently working with Missouri Stream Team 4913 on a year-long Cooperative Stream Investigation project (November 2016 – October 2017) for Hamilton Creek. The focus is on the collection of monthly samples for total phosphorous, total nitrogen and ammonia, and measurement of stream discharge at four locations along the 1.8 mile Class P (maintain permanent flow) section of Hamilton Creek. Trained Stream Team volunteers will perform sample collection and transmission. The MoDNR Environmental Services Program will conduct analyses of the samples. Data will be used in the evaluation of potential sources of nutrients and ammonia in the Hamilton Creek watershed by MoDNR. For more information see https://www.dnr.mo.gov/env/esp/csi.htm.

v. Williams Creek Cooperative Stream Investigation Project Plan

The one-mile Class P segment (maintain permanent flow) of Williams Creek has been identified as impaired for the designated use of whole body contact recreation Category B. The pollutant of concern for this segment is *E. coli* bacteria. A TMDL for Williams Creek is to be developed by MoDNR.

The Environmental Services Program of MoDNR is working with Missouri Stream Team 2297 on a year-long Cooperative Stream Investigation project (April 2017 – October 2017) for Williams Creek. This project is to assist the Water Protection Program of MoDNR by providing additional *E. coli* data for this creek. The Stream Team volunteers will collect surface water grab samples *E. coli* samples from five sites along the main stem of Williams Creek and two unnamed tributaries along with stream discharge measurements at two sites. A water quality and compliance specialist with MAWC laboratory in Chesterfield will analyze the *E. coli* samples and provide this information to MoDNR. For more information see https://www.dnr.mo.gov/env/esp/csi.htm.

b. Government/Sewer District Water Quality Monitoring

Within the lower Meramec watershed, sediment, fish tissue, effluent and surface water grab sampling has taken place on both the Meramec River and its tributaries. Since the 1980s, the Missouri Department of Conservation (MDC), MoDNR, USGS, EPA Region 7, MSD, Washington University in St. Louis (WU), University of Missouri at Columbia(UMC) and two engineering firms have been involved in various sampling efforts. The surface water grab samples have been analyzed for either chemical composition or bacteria counts. Tables 18 (tributary streams) and 19 (Meramec River) contain information about the types of sampling, the collector and sample collection data ranges. Monitoring can occur on an ongoing schedule or it may be conducted for a limited period of time. The on-line Missouri Water Quality Assessment System contains sampling information including collector, date conducted and analysis results by stream sample site. It can be found at www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do.

Water quality sampling results and information used by MoDNR in their impaired streams assessment can be found at https://www.dnr.mo.gov/emv/wpp/waterquality/303d/2016-listing-worksheets.zip .

Table 12. Tributary Streams Monitoring Efforts

Stream	Period sampling occurred*	Kind of Sampling	Collectors
Brush Creek Watershed			
Brush Creek – 10 sampling sites			
Brush Creek	2005 - 2008	Water – Surface – Grab	MDNR
Fox Creek Watershed			
Fox Creek and Little Fox Creek – 6 sampling sites			
Fox Creek	2001, 2005, 2010	Community Data Survey – Fish	MDC
Fox Creek	2007 - 2014	Water - Surface - Grab	MDNR, WU
Fox Creek	2013 - 2014	Sediment – Solid Phase	MDNR
Fox Creek	2006, 2007, 2014	Community Data Survey - Invertebrates	MDNR, SCI Engineering
LaBarque Creek Watershed			
LaBarque Creek and Tributary – 5 sampling sites			
LaBarque Creek	2001, 2005, 2010	Community Data - Fish	MDC
Hamilton Creek Watershed			
Hamilton Creek – 1 sampling site			
Hamilton Creek	1984	Fish Tissue - Whole	MDC
Carr Creek		No sampling	
Flat Creek – 3 sampling sites			
Flat Creek	2004 - 2007	Water - Surface - Grab	MDNR, UMC
Kiefer Creek – 2 sample sites			
Kiefer Creek	1996 - 2016	Water - Surface - Grab	Brookside Environmental Services, MDNR, MSD, USGS
Kiefer Creek	1984	Fish Tissue - Whole	MDC
Antire Creek and Little Antire Creek – 3 sampling sites			
Antire Creek	2005 - 2016	Water - Surface - Grab	MSD
Grand Glaize Creek Watershed			
Fishpot Creek – 3 sample sites			
Fishpot Creek	1996 - 2016	Community Data Survey– Fish Water - Surface - Grab	MDC MSD, USGS
Grand Glaize Creek – 16 sampling sites			
Grand Glaize Creek – Simpson Park Lake	1994	Community Data Survey - Fish	MDC

Stream	Period sampling occurred*	Kind of Sampling	Collectors
Grand Glaize Creek – Simpson Park Lake	1984 - 2016	Fish Tissue	MDC, EPA
Grand Glaize Creek – Simpson Park Lake	2004 - 2015	Water - Surface - Grab	UMC
Grand Glaize Creek	1994	Community Data Survey - Fish	MDC
Grand Glaize Creek	1997 - 2016	Water - Surface – Grab Water – Surface - Composite	MDNR, Midwest Environmental Consultants, MSD, USGS, WU
Williams Creek – 4 sampling sites			
Williams Creek	1997 - 2016	Water Surface Grab	MDNR, MSD, USGS
Sugar/Fenton Creeks Watershed			
Fenton Creek – 7 sample sites			
Fenton Creek	1997 - 2016	Water - Surface - Grab	MDNR, MSD, USGS
Fenton Creek	2010	Effluent	MDNR
Fenton Creek	2010	Water - Surface - Composite	MDNR
Sugar Creek – 3 sampling sites			
Sugar Creek	1992 2005 - 2007	Water - Surface - Grab	MDNR, USGS
Lower Saline Creek and Romaine Creek – 2 sampling sites			
Saline Creek	1992, 2005, 2009	Water -Surface - Grab	MDNR
Saline Creek	1984	Fish Tissue - Unknown	MDC
Upper Saline Creek – 6 sampling sites			
Saline Creek	1992	Effluent	MDNR
Saline Creek (upper)	1992, 1995, 2005, 2007	Water - Surface - Grab	MDNR, USGS
Pomme/Mattese Creeks Watershed			
Mattese Creek – 4 sampling sites			
Mattese Creek	1997 - 2016	Water - Surface - Grab	MDNR, MSD, USGS

Water Quality Data Search -MoDNR
www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

Table 13. Lower Meramec River Watershed Sampling Efforts

Stream Name	Period sampling occurred*	Kind of Sampling	Collectors
West Meramec River Watershed – North of Robertsville State Park to Eureka -ID 1841			
Meramec River – 6 sampling sites			
Meramec River	1984 – 1987 2001 – 2002 2010, 2012	Fish Tissue	MDC, EPA
Meramec River	2008 - 2009	Water - Surface – Grab	USGS

Stream Name	Period sampling occurred*	Kind of Sampling	Collectors
Meramec River	2008 - 2009	Sediment	USGS
Middle Meramec River Watershed - Eureka to Valley Park – ID 2185			
Meramec River – 8 sampling sites			
Meramec River	1980 – 1996 1998, 2001, 2012	Fish Tissue	MDC, EPA
Meramec River	1998, 2006 - 2007, 2009	Sediment	MDNR, USGS
Meramec River	1979 - 2016	Water Surface Grab	EPA, USGS
Meramec River	2009	Effluent	USGS
East Meramec River Watershed – Valley Park to Mississippi River confluence – ID 2183			
Meramec River – 17 sampling sites			
Meramec River	Too many to list – see MDNR web site	Fish Tissue	MDC, USGS, EPA
Meramec River	Too many to list – see MDNR web site	Water - Surface – Grab	USGS, MAWC, MSD
Meramec River	Too many to list – see MDNR web site	Sediment	MDNR, USGS

Water Quality Data Search -Missouri Department of Natural Resources
www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

2. Impaired Streams – Updated

Eight tributary streams, one lake, and two sections of the Meramec River have been identified by MoDNR as not meeting water quality standards protecting specific uses (see Table 20). In fact, all but two of the tributary streams in the lower Meramec watershed planning area are considered degraded in terms of their ability to host a full complement of fish species. However, LaBarque Creek, south of Eureka in Jefferson County, and Fox Creek, north and east of Pacific in Franklin and St. Louis counties, have adequate fish populations and are considered healthy streams. Erosion, sedimentation, the decline of year-round flow and habitat degradation may also contribute to the aquatic life impairment in those streams (see Map 9).

MoDNR has established a schedule to develop TMDL studies for these impaired streams which will delineate the maximum amount of the identified pollutant (load) a stream can receive in order to meet state water quality standards.[3] In addition to a TMDL, implementation strategy will also be developed. The implementation strategy document will describe what best management practices could be utilized, the potential participants, and pollutant reduction calculations which can show how the waterway will be restored to unimpaired status. The bacteria TMDL for Fishpot Creek was approved by EPA in 2016. An implementation plan for Fishpot Creek was also prepared[4].

In the lower Meramec watershed, stream impairment have been identified for bacteria, chloride, mercury (atmospheric deposition) and lead (in sediment). NPS urban runoff into these streams

[3] https://dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm
[4] https://dnr.mo.gov/env/wpp/tmdl/docs/2186-fishpot-ecoli-tmdl-final.pdf

has contributed to high levels of bacteria and chloride. The presence of *E. coli* is an indicator that a potential health risk exists for individuals exposed to this water. *E. coli* may occur as a result of inadequate on-site wastewater treatment systems, the overflow of domestic sewage, or non-point sources of human and animal waste. Chloride in surface waters can be toxic to aquatic life. Chloride in ground and surface water comes from the use and storage of salt for de-icing roads, on-site waste water systems, water softening, animal waste, fertilizers, discharges from landfills, natural sources of salt and brine in geologic deposits and from natural and human sources in precipitation.

Mercury occurs in the environment through natural processes and industrialactivity,(through atmospheric deposition), and because it can vaporize, mercury can enter the atmosphere and is deposited in waterways through precipitation and runoff. Mercury can accumulate in fish muscle tissue (filets) of commercial and recreational bottom-feeding fish. In the Missouri portion of the St. Louis region, Ameren Missouri has electric generating facilities in northeastern Franklin County, southern Jefferson County, eastern St. Charles County and far south St. Louis County. The Meramec Energy Center, natural gas-fired, is located in lower Meramec watershed planning area and it is scheduled to be retired in 2022.

Starting where the Big River enters the Meramec River and eastward to the mouth of the Meramec, sediment has become contaminated with lead. It is the result of erosion of lead mine tailing piles in the southern portion of the Big River watershed in St. Francois County. The contamination of stream sediment has resulted in the contamination of fish and other aquatic life.

a. Applicable Water Quality Criteria

The Missouri Water Quality Standards can be found at 10 CSR 20-7.031[5]. The numeric criteria to protect a designated use for a waterbody by specific pollutant are found in Table 20 below. According to these standards, the whole body contact recreation designated use is divided into three categories which refer to recreation in and on the water. Category A includes those waters established by a property owner as public swimming areas and waters with documented existing whole body contract recreational use(s) by the public. Examples include public swimming beaches and property which is open to and accessible to the public through law or written permission. Category B encompasses those waters designated for whole body contact recreation not covered by Category A. Secondary Contact Recreation includes waters where physical contact with the water is not likely to result in exposure of the eyes, ears, nose or mouth. For protection of waters designated for Category A use, bacteria (*E. coli*) are not to exceed 126 counts per 100 milliliters (mL) of water, measured as a geometric mean, for the recreational season. For waters designated for Category B use, *E. coli* counts are not to exceed 206 counts/100 mL of water. The standards define the recreational season as running from April 1 through October 31. For the protection of aquatic life from chloride, the chloride criteria are dependent upon water hardness and sulfate concentrations. Since this criteria was not approved by the EPA, MoDNR used Missouri's previous chronic chloride criterion of 230 milligrams per liter in the assessment and impairment identification concerning Kiefer, Fishpot, Grand Glaize, Fenton and Mattese Creeks.

[5] http://www.sos.mo.gov/cmsimages/adrules/csr/current/10csr/10c20-7a.pdf

Table 14. 2016 Section 303(d) Impaired Waters List for the Lower Meramec River Watershed

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Antire (2188)	St. Louis	1.9	*E. Coli* (2012)	WBC-B	Urban runoff/storm sewers
			pH (2012)	AQL	Sources unknown
Fox (1842)	St. Louis	7.2	Aquatic macroinvertebrate bioassessments/ Unknown (2012)	AQL	Source unknown
Fenton (3595)	St. Louis	0.5	*E. Coli* (2012)	WBC-B	Urban runoff/storm sewers
			Chloride (2016)	AQL	Source Unknown
Fishpot (2186)	St. Louis	3.5	*E. Coli* (2008)	WBC-B	Urban runoff/storm sewers
			Chloride (2012)	AQL	Urban runoff/storm sewers
Grand Glaize (2184)	St. Louis	4	*E. Coli* (2008)	WBC-B	Urban runoff/storm sewers
			Chloride (2006)	AQL	Urban runoff/storm sewers
			Mercury in Fish Tissue (2002)	HHP	Atmospheric deposition - toxics
Kiefer (3592)	St. Louis	1.2	*E. Coli* (2012)	WBC-A	Rural non-point source
			Chloride (2012)	AQL	Road/bridge runoff, non-construction
Mattese (3596)	St. Louis	1.1	*E. Coli* (2014)	WBC-B	Urban runoff/storm sewers
			Chloride (2014)	AQL	Urban runoff/storm sewers
Williams (3594)	St. Louis	1	*E. Coli* (2012)	WBC-B	Residential area

Stream (WBID)	County	Length of impaired portion from Mouth (miles)	Pollutant (Year Listed)	Impaired Use	Source of Impairment
Bee Tree Lake (7309)	St. Louis	10 acres	Mercury in Fish Tissue (2014)	HHP	Atmospheric deposition-toxics
Meramec River section Valley Park to Confluence (2183)	St. Louis	22.8	*E. coli* (2016)	WBC-B	Source unknown
			Lead in sediment (2008)	AQL	Old Lead belt tailings
Meramec River section Eureka-Valley Park (2185)	Jefferson/St. Louis	15.7	Lead in sediment (2008)	AQL	Old Lead belt tailings

Source: MoDNR, 2016 EPA Approved Section 303(d) Listed Waters, final approval October 2016
Impairment based on stream use designation(s)

Designated Use AQL – Protection of aquatic life
Designated Use HHP – Human health protection

*TMDL Schedule sources of information - 1 – MoDNR Online TMDL under development schedule https://dnr.mo.gov/env/wpp/tmdl/wpc-tmdl-progress.htm and 2 – Missouri Integrated Water Quality Report and Section 303(d) List, 2016 (April 2016)

3. Biological Assessments – Updated

The purpose of a biologic assessment is to determine if the aquatic life protection designation use for a particular stream is supported. As part of this, a macroinvertebrate assessment is performed and habitat and water quality are characterized. Biological assessments are conducted by MoDNR for wadeable, perennial streams.

In the spring and fall of 2014, macroinvertebrate samples were collected from two sites on Fox Creek. A previous analysis of samples from a riffle/pool site on this creek had been conducted in 2006 and 2007. Fox Creek is the only creek in the planning area for which macroinvertebrate sampling and stressor study has been conducted by MoDNR. The metrics calculated included the Taxa Richness Index, Ephemeroptera/Plecoptera/Trichoptera Taxa Index, Biotic Index, and Shannon Diversity Index. Results from these indices were then translated into a multi-metric score indicating the ability of a stream to support the aquatic life protection designation. The Fox Creek macroinvertebrate stream condition index scores are presented in Table 15. The creek can be considered to be partially supporting for the aquatic life beneficial use.

Taxa Richness reflects the health of the macroinvertebrate community through a measurement of the number of taxa present in a sample. A taxon (group of one or more organisms) is defined as the lowest identifiable level in the Linnaean taxonomic classification system. The Ephemeroptera/Plecoptera/Trichoptera Taxa Index is the total number of distinct taxa within the insect orders of Ephemeroptera, Plecoptera, and Trichoptera. They are considered to be pollution sensitive. The Biotic Index quantifies the invertebrate community as to its overall tolerance to organic pollution by summing tolerances of individual taxon. The Shannon Diversity Index is a measure of the macroinvertebrate community composition which takes into account both richness and evenness.

Table 15. Fox Creek Macroinvertebrate Stream Condition Index Score

Spring Sample – March 24, 2014		
Metric Type	**Metric Value**	**Final Score**
Site 1 – Downstream of Wallach Road Crossing, in mitigation bank zone		
Total Taxa Richness	75	3
Ephemeropta, Plecoptera, Trichoptera Taxa	9	1
Biotic Index	7.0	3
Shannon Diversity Index	2.83	3
Macroinvertebrate Stream Condition Index Score		10
Site 2 – Eureka KOA Campground, upstream of camping and picnic area		
Total Taxa Richness	48	3
Ephemeropta, Plecoptera, Trichoptera Taxa	11	1
Biotic Index	7.2	3
Shannon Diversity Index	1.55	1
Macroinvertebrate Stream Condition Index Score		8

Fall Sample – September 23, 2014		
Metric Type	**Metric Value**	**Final Score**
Site 1 – Downstream of Wallach Road Crossing, in mitigation bank zone		
Total Taxa Richness	71	3

Ephemeropta, Plecoptera, Trichoptera Taxa	10	1
Biotic Index	6.7	3
Shannon Diversity Index	3.04	3
Macroinvertebrate Stream Condition Index Score		10
Site 2 – Eureka KOA Campground, upstream of camping and picnic area		
Total Taxa Richness	76	3
Ephemeropta, Plecoptera, Trichoptera Taxa	12	3
Biotic Index	7.0	3
Shannon Diversity Index	3.07	3
Macroinvertebrate Stream Condition Index Score		12

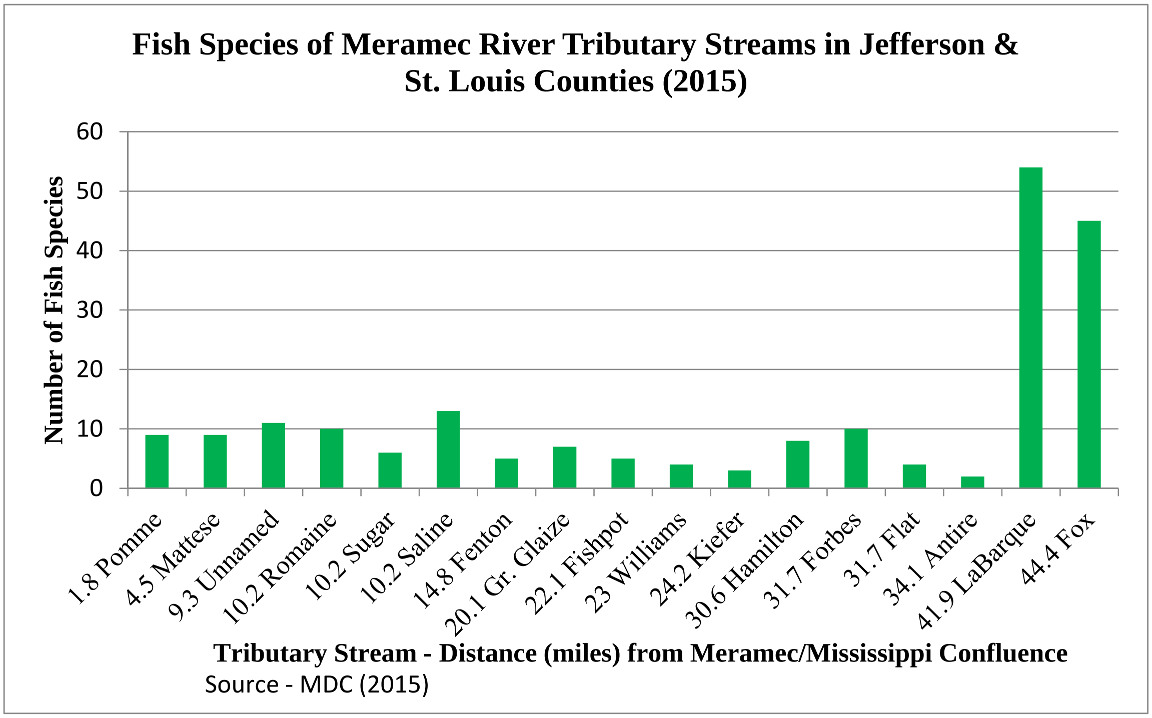
Source: Environmental Services Program, MoDNR
Macroinvertebrate Stream Condition Index Total Score
Total Score 16 to 20 – Stream is fully supporting of the aquatic life beneficial use.
Total Score 10 to 14 – Stream is partially supporting of the aquatic life beneficial use.
Total Score 4 to 8 – Stream is not supporting of the aquatic life beneficial use.
Total Score less than 0 – the Index Score information was unavailable at this time.
Due to the scoring procedure, scores with odd integers or integers <4 are not possible.

a. Aquatic Biodiversity

The Meramec River is an outstanding example of unique aquatic biodiversity, emblematic of certain river systems in the interior highlands of the Ozark Mountains. The Meramec River's rich mussel and crayfish fauna include several species not found in any other watershed on earth and equals or exceeds that of any other Ozark river. Indeed, the Meramec River's mussel fauna is one of the most diverse and unique in North America. The river supports one of the highest levels of biodiversity of any river in the United States, being home to more than 125 species of fish, 45 species of mussels, and 32 species of crayfish. The pink mucket mussel (*Lampsilis abrupta*), which is on the federal endangered species list, is found in the area. Mussel population monitoring indicates that reproduction in some mussel species is not occurring to maintain that diversity over time.

Fish population studies conducted on the lower Meramec River (109 miles from Sullivan to mouth) by MDC have revealed an unexpected finding; while the Meramec River itself has recovered in the last thirty years and currently supports 125 species of fish, its tributaries are in decline. None of the smaller tributaries between the mouth at the Mississippi River and mile 41.9 near Eureka supports a broad diversity of fish species (se Figure 2). LaBarque Creek in Jefferson County, with 54 fish species, and Fox Creek in St. Louis County, with 45 fish species, at miles 41.9 and 44.4 respectively, are considered healthy streams. None of the 15 comparably sized tributaries to the east have more than 13 species (Saline Creek in Jefferson County) and most have fewer than 10. More research is needed to understand changing habitats and population declines, but it appears likely that the declining fish species is a direct result of the suburban development patterns in the lower Meramec River watershed.

Figure 3. Fish Species in Meramec River Tributary Streams



b. Threatened or Endangered Species

For the 2012 Plan, information on threatened or endangered flora and/or fauna species within the five watershed lower Meramec River planning area was assembled (see Map 14, 2012 Plan). On this map, squares represent the one square mile sections within the Public Land Survey System (PLSS) (township and range), which have at least one known location of a species listed as threatened or endangered at the state or federal level. These sections are along the Meramec River and the headwater areas of Hamilton and Carr Creeks. Table 22 contains the most recent information on federally identified threatened and endangered species in Franklin, Jefferson, and St. Louis counties. Endangered species are in danger of extinction throughout the area in which they are native. Threatened species could become endangered in the near future.

Table 16. Federally Identified Threatened or Endangered Species Franklin, Jefferson, and St. Louis counties, Missouri

Species	Status	Habitat	Planning Area Distribution
Birds			
Least Tern (Interior Population) (*Sterna antillarum*)	Endangered	Riverine sandbars	Franklin, Jefferson, St. Louis Counties
Piping Plover (*Charadrius melodus*) Northern Great Plains Breeding Population	Threatened	Riverine sandbars	Franklin, Jefferson, St. Louis Counties
Rufa Red Knot (*Calidris canutus rufa*)	Threatened	Shorebird that migrates through Missouri – irregularly observed feeding on mudflats, sandbars, shallowly flooded areas and pond margins along the Missouri and Mississippi Rivers from May 1 through September 30.	Franklin, Jefferson, St. Louis Counties

Mammals			
Gray Bat (*Myotis grisescens*)	Endangered	Caves	Franklin, Jefferson, St. Louis Counties
Indiana Bat (*Myotis sodalis*)	Endangered	Hibernacula = caves and mines; Maternity and foraging habitat = small stream corridors with well-developed riparian woods; upland forests	All counties in Missouri
Indiana Bat (*Myotis sodalis*)	Critical Habitat Designated	Caves 009 and 017	Franklin
Northern Long-eared Bat (*Myotis septentrionalis*)	Threatened	Hibernates in caves and mines – swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.	Statewide
Fish			
Pallid Sturgeon (*Scaphirhynchus albus*)	Endangered	Mississippi and Missouri Rivers	Franklin, Jefferson, St. Louis Counties
Clams (Freshwater Mussels)			
Pink Mucket (*Lampsilis abrupta*)	Endangered	Rivers	Franklin, Jefferson, St. Louis Counties
Scaleshell (*Leptodea leptodon*)	Endangered	Big, Big Piney, Bourbeuse, Gasconade and Meramec Rivers	Franklin, Jefferson, St. Louis Counties
Sheepnose (*Plethobasus cyphyus*)	Endangered	Bourbeuse, Gasconade (Ozark Fork), Meramec and Mississippi Rivers	Franklin, Jefferson, St. Louis Counties
Snuffbox (*Epioblasma triquetra*)	Endangered	Small to medium-sized creeks with a swift Current	Franklin, Jefferson, St. Louis Counties
Spectaclecase (*Cumberlandia Monodonta*)	Endangered	Big, Big Piney, Bourbeuse, Gasconade, Meramec and Mississippi Rivers	Franklin, Jefferson, St. Louis Counties
Winged Mapleleaf (*Quadrula fragosa*)	Endangered	Medium to large rivers in mud, sand or gravel	Franklin County
Plants			
Decurrent False Aster (*Boltonia decurrens*)	Threatened	Disturbed alluvial soils	Franklin, St. Louis Counties
Mead's milkweed (*Asclepias meadii*)	Threatened	Virgin prairies	St. Louis County
Running buffalo clover (*Trifolium stolonifereum*)	Endangered	Disturbed bottomland meadows	St. Louis County

Source: U.S. Fish and Wildlife Service, April 2015

L. Watershed Descriptions – Updated

Information about Sugar/Fenton Creeks and Pomme/Mattese Creeks watersheds now extends the lower Meramec planning area from Pacific to the confluence of the Meramec River and the Mississippi River. This section discusses these additional watersheds. For information on the watershed and sub-watershed that have been addressed previously, please see the 2012 Plan.

1. Sugar/Fenton Creeks and Pomme/Mattese Creeks Watersheds

The Sugar/Fenton Creeks Watershed is 28,851 acres (45 square miles) in size, is located in the eastern part of the planning area, between Valley Park and Sunset Hills. The watershed is divided between south St. Louis County located in southern St. Louis County and northern Jefferson County (see Map 6). The major streams in this watershed are Sugar Creek, 7.7 miles in Jefferson County and Fenton Creek, 4.6 miles, in St. Louis County. Both of these creeks are located west of the Meramec River. Also in this watershed are Saline and Romaine Creeks which are tributaries of Sugar Creek, as well as smaller streams and land areas which drain directly into the Meramec River. Approximately 9.9 miles of the Meramec River flows through this watershed. Sugar Creek enters the Meramec River at river mile 10.2, north of the Highway 21 bridge over the Meramec River. Fenton Creek enters the Meramec River in the city of Fenton, 14.8 miles upstream of the confluence with the Mississippi River.

The Pomme/Mattese Creeks Watershed is 27,974 acres (43.7 square miles) in size, is located in the eastern part of the planning area. The watershed is divided between northeast Jefferson County and south St. Louis County (see Map 7). The major streams in the watershed are Pomme Creek, 6.3 miles, found south of the Meramec River, and Mattese Creek, 7.5 miles north of the Meramec River. Also in this watershed are tributaries to these creeks and smaller streams and land areas, which drain directly into the Meramec River. Approximately 10 miles of the Meramec River flows through this watershed. Pomme Creek enters the Meramec River in Arnold, 1.8 miles upstream of the confluence with the Mississippi River. Mattese Creek enters the Meramec River in St. Louis County4.5 miles upstream of the confluence.

The Sugar/Fenton Creeks watershed and the Pomme/Mattese Creeks watershed are not part of any terrestrial or aquatic Conservation Opportunity Areas of the MDC. No creeks in these two watersheds have been identified by MoDNR as Outstanding National Resource Waters or Outstanding State Resource Waters.

2. Physical Characteristics

The Sugar/Fenton Creeks watershed is part of the dissected till plains, it consists of rolling and moderately dissected basins with low hills and broad ridges adjacent to the lower Meramec and Mississippi Rivers. The southern part of the watershed, adjacent to Sugar and Romaine Creeks in Jefferson County, contains hilly to steep ridges with narrow valleys. The steepest slopes (greater than 31 percent) are found in this area, as well as along the southern part of Saline Creek and along the Meramec River bluff line in St. Louis County. Gentler slopes (less than 20 percent) can be found in the valleys of the Meramec River, the major creeks, and in Fenton (see Map 10). Land cover is presented in Map 11.

The Pomme/Mattese Creeks watershed is also part of the dissected till plains. It consists of rolling and moderately dissected basins with low hills and broad ridges adjacent to the lower Meramec and Mississippi Rivers. In the western part of this watershed, adjacent to Highway 21 in Jefferson County, are hilly to steep ridges with narrow valleys. The steepest slopes, greater than 31 percent, are found in this area, as well as along the bluff line of the Meramec River and the edges of Mattese Creek. Slopes in the majority of the Pomme/Mattese Creeks watershed are less than 20 percent and can be found in the valleys of the Meramec River and tributary creeks, in Arnold, and north of Butler Hill Road in St. Louis County (see Map 12). Land cover is presented in Map 13.

The majority of the Sugar/Fenton Creeks watershed and the Pomme/Mattese Creeks watershed are underlain by Mississippian System limestone which is primarily thickly bedded, chert, gypsum, and dolomite are also present (see Maps 14 and 15). The limestone weathers easily and produces deep, cherty soils. Bedrock along the creek, with valleys in the Jefferson County portion of Sugar/Fenton Creeks watershed, consists of limestone and shale with some sandstone. The southernmost portion of the Meramec River floodplain in the Pomme/Mattese Creeks watershed is part of the Quaternary Alluvium with thick layers of silt, sand and gravel.

3. Sugar/Fenton Creeks and Pomme Mattese Creeks Watershed Hydrologic Soil Group Classification

Specific soil characteristics affect the rate of infiltration of water into the soil, and conversely, the volume and velocity of stormwater runoff. Soils are classified by the NRCS into four hydrologic soil groups (A, B, C, D) based on the physical drainage properties of each soil series, including texture and permeability, as well as certain physiographic properties, such as depth to bedrock and water table. Soils are categorized in terms of their runoff potential, with the best soils being well drained (Group A) and the worst being poorly drained (Group D). For additional information about these groups see Section G.

The majority of the soils found in the Sugar/Fenton Creeks and the Pomme/Mattese Creeks watersheds have moderate to high potential for runoff due to slow infiltration rates. Some soils have layers near the surface which limit the downward movement of water or are clayey or are thin soils over bedrock (see Maps 16 and 17 and Table 17). In the Sugar/Fenton Creeks watershed the hydrologic characteristics of 29 percent of the soils found there could not be determined because of soil compaction and mixing of types as a result of development. In the Pomme/Mattese Creeks watershed, it was not possible to identify the hydrologic characteristics of almost half of the soils in the watershed for similar reasons. In the Sugar/Fenton Creeks watershed, approximately 15 percent of the soils have high to moderate infiltration rates with low to moderate runoff potential. Only three percent of the soils in the Pomme/Mattese Creeks watershed have high to moderate infiltration rates with low to moderate runoff potential. In both watersheds, alluvium or alluvial soils are found in the Meramec River valley and the major creeks. These soils have low run-off potential due to their moderate infiltration rates. These soils primarily consist of moderately deep and moderately well to well drained soils with moderately fine to moderately coarse textures.

Table 17. Sugar/Fenton Creeks and Pomme/Mattese Creeks Watersheds Hydrologic Soil Groups

Hydrologic Soil Group	Sugar/Fenton Acres	Percent Share	Pomme/Mattese Acres	Percent Share
A	148.5	0.5	117.0	0.4
B	4,212.1	14.6	693.9	2.5
B/D	363.0	1.3	1,834.7	6.6
C	5,998.2	20.8	3,818.3	13.6
C/D	2,115.7	7.3	2,988.8	10.7
D	7502.7	26.0	4,931.8	17.6
No Data	8,510.8	29.5	13,589.6	48.6
Total	28,851.0	100	27,974.1	100

Source: USDA, Natural Resource Conservation Service
Hydrologic Soil Groups

A – Low runoff potential, well drained
B – Moderately low runoff potential
C – Moderately high runoff potential
D – High runoff potential, poorly drained
B/D – High water table, if soil was drained could be placed in Group B
C/D – High water table, if soil was drained could be placed in Group C
No Data – Hydrologic characteristics of soil could not be determined

4. Population and Land Use

Part or all of three cities in St. Louis County are located in the Sugar/Fenton Creeks watershed, which includes all of the city of Fenton, the majority of Sunset Hills, and a small portion of Kirkwood. In Jefferson County, the eastern section of the village of Parkdale is in this watershed. The unincorporated areas of Murphy and High Ridge along State Highway 30 are in the center of Sugar/Fenton Creeks watershed in Jefferson County. In 2015, 57,197 people lived in this watershed, divided between St. Louis and Jefferson Counties (see Table 18).

All of the city of Arnold is in the Jefferson County portion of the Pomme/Mattese Creeks watershed. In the northern section of this watershed, between I-270 and State Highway 30, is a small portion of Sunset Hills in St. Louis County. Unincorporated St. Louis and Jefferson Counties makes up the majority of this watershed. In 2015, it is estimated that 85,790 people lived in the Pomme/Mattese Creeks watershed (see Table 18).

Table 18. 2015 Population Estimated by Watershed

Watershed	St. Louis County		Jefferson County		**Total**	
	Population	Percent Share	Population	Percent Share	Population	Percent Share
Sugar/Fenton	26,090	45.6	31.107	54.4	57,197	100
Pomme/Mattese	59,344	69.2	26,446	30.8	85,790	100
Total	85,434	59.7	57,553	40.3	142,987	100

Source: 2015 5 Year American Community Survey

5. Land Use

Approximately 57 percent of the land area in the Sugar/Fenton Creeks watershed can be considered developed (see Map 18). Multi and single-family residential areas make up 43 percent of developed land and can be found throughout the watershed. Commercial uses are primarily along Interstate 44, State Highway 30, State Highway 141 and Gravois Road in Sunset Hills. Industrial activity (manufacturing and extraction) makes up seven percent of the land area (see Table 19). Recreation areas open to the public include county and municipal parks along the Meramec River. The MDC Powder Valley Conservation Nature Center is located in the northern portion of the Sugar/Fenton Creeks watershed in St. Louis County (see Map 19).

A majority of the land identified as agricultural is found in the Jefferson County portion of this watershed. Approximately 24 percent of the land is in the vacant/undeveloped or unassigned category and can be found throughout the watershed. Vacant/undeveloped land did not have any structures on it and could be forest, grass, pasture or land being prepared for development. No specific use could be determined for land in the unassigned category.

In the Pomme/Mattese Creeks watershed, approximately 60 percent of the land can be considered developed (see Map 20). Multi and single-family residential land use make up 45 percent of the watershed. Residential areas can be found throughout the watershed. Commercial uses primarily can be found along Highways 61-67 in Arnold in Jefferson County, Baumgartner Road in St. Louis County, State Highway 21/Tesson Ferry in Jefferson and St. Louis counties, and adjacent to the I-55/I-270 and I-255 interchange at the northern edge of the watershed in St. Louis County. Industrial activity (manufacturing and quarry operations) makes up six percent of the land area (see Table 19). Industrial activities in the Pomme/Mattese Creeks watershed include the Ameren Meramec power plant, the MSD Meramec wastewater treatment facility, and the MAWC Meramec drinking water treatment plant. Recreation areas open to the public in Jefferson County include the Strawberry Creek Nature Area, Arnold and Flam City parks, and the MDC Teszars Wood Conservation Area. There are five parks in the St. Louis County portion of the watershed, see Map 21. The Lower Meramec County Park and the Earl Widman County Park are on the Meramec River. Only 2.7 percent of the land is classified as agricultural, while approximately 27 percent of the land has been assigned to the vacant/undeveloped or unassigned category. Vacant/undeveloped land is land void of structures and could be forest, grass, pasture, or land being prepared for development. No use could be determined for land in the unassigned category. A large portion of the unassigned category is in the city of Arnold adjacent to the Meramec River where buyouts of flood-impacted structures have occurred. In these areas, where Federal Emergency Management Agency (FEMA) funds were used to purchase property, development or redevelopment of the land will be restricted and parks or green space will be the permitted land use.

Table 19. 2017 Sugar/Fenton Creeks and Pomme/Mattese Creeks Watersheds Land Use Acres

Land Use Categories	Sugar/Fenton Creeks		Pomme/Matesse Creeks	
	Acres	Percent Share	Acres	Percent Share
Multi-Family Residential	1,129	3.9	1,074	3.8
Single-Family Residential	11,335	39.3	11,840	42.3
Commercial	1,321	4.6	1,352	4.8
Industrial	2,097	7.3	1,851	6.6
Institutional	618	2.1	894	3.2
Recreation	2,352	8.2	1,327	4.7
Common Ground	997	3.5	1,333	4.8
Right-of-Way	51	0.2	59	0.2
Agriculture	1,931	6.7	746	2.7
Vacant/Undeveloped*	3,765	13.0	3,796	13.6
Unassigned*	3,255.0	11.3	3,702.1	13.2
Total	28,851.0	100	27,974.1	100

Source: St. Louis County and Jefferson County GIS Departments
*The acreage for each land use category was based on how each county assessor assigned property to a specific use category for assessment purposes. Vacant/undeveloped land did not have any structures on it. These could be forested areas, grass or pasture, or land being prepared for development. If the assessor could not identify a specific use for a property, it was placed in the unassigned category

6. Stream Classification

Below is a summary of the stream classifications for the waterbodies located in the Sugar/Fenton Creeks and Pomme/Mattese Creeks watershed. Stream classification and designated uses are summarized in the following paragraphs. This information can be found at the MoDNR website at https://dnr.mo.gov/mocwis_public/waterQualityStandardsSearch.do. Sugar Creek (WBID 2191) in Jefferson County has been classified by MDNR as a Class C stream from its mouth upstream for 5.5 miles. A Class C stream may cease to flow in dry periods but maintains permanent pools which support aquatic life. Designated uses for this creek are livestock and wildlife watering, protection of warm water aquatic life (general warm-water fishery) and human-health fish consumption, Category B whole body contact (no public access swimming areas) and secondary contact recreation (activities resulting in incidential or accidental contact with water) and irrigation.

MoDNR has classified Fenton Creek (WBID 3595) in St. Louis County as a Class P stream upstream from its mouth for 0.5 miles. A Class P stream maintains permanent flow in drought periods. Designated uses for this creek are livestock and wildlife watering, protection of warm water aquatic life and human-health fish consumption, Category B whole body contact and secondary contact recreation and irrigation. This stream is on the Missouri 2016 303(d) Impaired Waters List for bacteria due to urban runoff/storm sewers and chloride due to unknown sources (http://dnr.mo.gov/env/wpp/waterquality/303d/docs/2016-ir305b-report.pdf). TMDLs are scheduled to be developed.

Upstream from the mouth of Saline Creek (WBID 2189) in Jefferson County, MoDNR has classified it for 1.8 miles as being a Class P stream. Designated uses for this creek are livestock and wildlife watering, protection of warm water aquatic life and human-health fish consumption, Category B whole body contact and secondary contact recreation and irrigation. After that point, Saline Creek (WBID 2190) has been classified as a Class C stream for 2.3 miles. Designated uses for this section of Saline Creek include livestock and wildlife watering, protection of warm water aquatic life and human-health fish consumption, Category B whole body contact and secondary contact recreation and irrigation, and secondary contact recreation.

The upper portion of Romaine Creek in Jefferson County is an unclassified stream which has been identified as a losing stream for two miles. A losing stream distributes 30 percent or more of its flow through permeable geologic materials into the bedrock aquifer. Losing streams are associated with areas of karst topography.

MoDNR has classified Pomme Creek (WBID 2192), located in Jefferson County, as a Class P stream for 1.8 miles upstream from its mouth. Designated uses for this creek are livestock and wildlife watering, protection of warm water aquatic life and human-health fish consumption, and Category B whole body contact and secondary contact recreation (activities resulting in incidental or accidental contact with water) and irrigation.

Mattese Creek (WBID 3596), located in St. Louis County, also has been classified as a Class P stream for 1.1 miles upstream of its mouth, a Class P stream maintains permanent flow in drought periods. Designated uses for this creek are livestock and wildlife watering, protection of warm water aquatic life and human-health fish consumption, Category B whole body contact and secondary contact recreation and livestock watering. A section of Mattese Creek is also on the Missouri 2016 303(d) Impaired Waters List. The impaired section of this creek extends 1.1 miles upstream from where it enters the Meramec. This section of Matesse Creek was identified as impaired for bacteria and chloride from urban runoff and storm sewers. A TMDL is scheduled to be developed.

7. Wastewater Treatment and Drinking Water

In the Sugar/Fenton Creeks watershed, MoDNR has issued 12 NPDES permits for the discharge of treated wastewater to creeks and the Meramec River. (See Map 8 and Map key in Section M) Information on domestic, industrial, and commercial-institutional permits can be found at the end of this report. The Northeast Public Sewer District (NPSD) operates two wastewater treatment facilities in the Jefferson County portion of the watershed. One NPSD facility serves a single small residential area (10 households) and the other serves multiple residential areas and commercial locations along State Highway 141 and State Highway 30. The St. Louis County portion of this watershed is within the service area of the MSD. The MSD Fenton Wastewater Treatment Facility is located in this watershed. There is a permit for the MDC Powder Valley Conservation Nature Center in St. Louis County and the remaining permits are for free-standing apartment complexes and subdivisions. An industrial facility along Highway 141 in Jefferson County has a NPDES permit.

In the Jefferson County portion of the Pomme/Mattese Creeks watershed, MoDNR has issued two NPDES permits for the discharge of treated wastewater to tributaries of the Meramec River. (See table in Section M) One permit is for a free-standing apartment complex and the other for a shopping center. The St. Louis County portion of this watershed is within the service area of MSD. The MSD Lower Meramec Wastewater Treatment Facility is located in St. Louis County near the confluence of the Meramec and Mississippi rivers. Treated effluent from this facility is discharged into the Mississippi River. The wastewater collection system for the city of Arnold is owned and operated by the Missouri American Water Company. Arnold has an agreement with MSD for the treatment of their wastewater.

The MAWC has two General NPDES Permits allowing the discharge of filter backwash water and solids, and allowing operation of no-discharge sludge holding systems and land application of water treatment plant sludge. These permits are for the South County Drinking Water Treatment Plant located in St. Louis County in the Sugar/Fenton Creeks watershed and the Meramec Drinking Water Treatment Plant located in St. Louis County in the Pomme/Matesse Creeks watershed. In the Sugar/Fenton Creeks watershed two municipal recreation centers and a shopping center with a waterfall have General Permits for the discharge of filter backwash and pool drainage from swimming pools and lined decorative ponds which use chlorine as a sanitizer. There are two stormwater permits in the Pomme/Matesse Creeks watershed, both in St. Louis County. One permit covers two stormwater outfalls for the Ameren Meramec Energy Center near the confluence. The other permit is for two stormwater discharges at the MSD Meramec Wastewater Treatment Facility.

The 1990 Census contains the most recent estimate of on-site wastewater treatment systems. At that time the Pomme/Matesse Creeks, 4,843 housing units were estimated to have individual on-site wastewater treatment systems. Jefferson County has begun a more rigorous inspection program when homes change ownership, and the success of this program should be monitored. It is estimated that in 1990, the Sugar/Fenton Creeks watershed contained 5,877 housing units which utilized individual on-site wastewater treatment systems.

In the Sugar/Fenton Creeks watersheds there are 106 private domestic water wells, with 92 in Jefferson County and 14 in St. Louis County. In the St. Louis County portion of this watershed, drinking water is available through the privately-owned Missouri American Water Company. In the Jefferson County portion, drinking water is available through the Jefferson County Public Water and Supply District (PWSD) #2 (west) and the Jefferson County PWSD #3 (east). The Jefferson County PWSD #3 purchases drinking water from MAWC. The Big River is the source of water for Jefferson County PWSD #2. There are also three community water systems which serve a subdivision and two mobile home parks in the Jefferson County portion.

There are 22 private domestic water wells in the Pomme/Mattese Creeks watershed with 16 in the Jefferson County portion of this watershed and six in the St. Louis County portion. Drinking water in the St. Louis County portion is available through the privately-owned MAWC. In the Jefferson County portion of this watershed, drinking water is available through the following districts- Jefferson County PWSD #1 (Arnold), Jefferson County PWSD #3 (unincorporated area in west), Jefferson County PWSD #10 (unincorporated, southeast of Arnold), and Jefferson County Consolidated PWSD #1 (small unincorporated area south of Arnold). All of these PWSDs purchase their drinking water from the MAWC.

8. Baseline Pollutant Loads

In the 2012 Plan, the Simple Method to Calculate Urban Stormwater Loads was used to estimate stormwater pollutant loadings for developed land uses within four watersheds, and it has again been used here within the Sugar/Fenton Creeks and Pomme/Matesse Creeks watersheds. It is a spreadsheet model which requires basic information characterizing a watershed, including the watershed drainage area and impervious cover by land use type, stormwater runoff pollutant concentrations and annual precipitation. With the Simple Method, the various pollutant loads, i.e. total nitrogen (N), total phosphorus (P), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), and bacteria loads (fecal coliform and *E. coli*) are calculated by land use type and then totaled. The stormwater pollutant concentrations can be estimated from local or regional data or from national data sources. For the purposes of this analysis, default concentration factors from both the Simple Method and the spreadsheet tool for Estimating Pollutant Load (STEPL) were utilized. Bacteria concentrations came from the Minnesota Pollution Control Agency Estimator tool to calculate TMDL benefits. A description of the Simple Method technique can be found in Appendix D of the 2012 Plan. Tables 20 and 21 below contain the estimates developed for the four pollutants and bacteria for Sugar/Fenton Creeks and Pomme/Mattese Creeks watershed. The estimates calculated using the Simple Method can be used as a starting point for making decisions on management strategies until additional funds become available to conduct more sophisticated watershed modeling or coupled with additional water quality monitoring efforts. Baseline pollutant loadings for the impaired watersheds can be found at the end of this section.

Table 20. Baseline Annual Pollutant Loads (Pounds per Year) Update - Lower Meramec River Study Area

Watershed	Phosphorus	Nitrogen	Total Suspended Solids	Biological Oxygen Demand
Sugar/Fenton Creeks	11,552.0	74,640.3	3,481,691.3	228,739.0
Pomme/Matesse Creeks	12,273.3	78,709.3	3,676,929.5	243,962.2
Total	23,825.3	153,349.6	7,158,620.8	472,701.2

Table 21. Baseline Year Annual Bacteria Loads (Billion Colonies) Update - Lower Meramec River Study Area

Watershed	Fecal Coliform	*E. Coli*
Sugar/Fenton Creeks	537,365.6	474,905.1
Pomme/Matesse Creeks	554,679.0	489,892.7
Total	1,092,044.6	964,797.8

Pollutant Loadings

Baseline Pollutant Loadings – Sugar/Fenton Creeks Watershed

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	951.1	1,126.3
Nitrogen	0.226	26.2	2	951.1	11,263.3
Total Suspended Solids	0.226	26.2	75	951.1	422,374.0
BOD	0.226	26.2	9.3	951.1	52,374.4
Industrial					
Phosphorus	0.226	19.8	0.3	652.1	875.4
Nitrogen	0.226	19.8	2.5	652.1	7,295.0
Total Suspended Solids	0.226	19.8	120	652.1	350,162.0
BOD	0.226	19.8	5.1	652.1	14,881.9
Institutional					
Phosphorus	0.226	13.5	0.2	210.1	128.2
Nitrogen	0.226	13.5	1.8	210.1	1,153.8
Total Suspended Solids	0.226	13.5	67	210.1	42,948.0
BOD	0.226	13.5	7.8	210.1	4,999.9
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	485.5	724.2
Nitrogen	0.226	16.5	2.2	485.5	3,982.9
Total Suspended Solids	0.226	16.5	100	485.5	181,043.0
BOD	0.226	16.5	5.1	485.5	9,233.2
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	2720.4	2,483.8
Nitrogen	0.226	10.1	2.2	2720.4	13,661.1
Total Suspended Solids	0.226	10.1	100	2720.4	620,958.5
BOD	0.226	10.1	5.1	2720.4	31,668.9
Roads					
Phosphorus	0.226	35.6	0.5	1544.7	6,214.0
Nitrogen	0.226	35.6	3	1544.7	37,284.1
Total Suspended Solids	0.226	35.6	150	1544.7	1,864,205.7
BOD	0.226	35.6	9.3	1544.7	115,580.8
Watershed Total					
Phosphorus					11,552.0
Nitrogen					74,640.3
Total Suspended Solids					3,481,691.3
BOD					228,739.0

Baseline Bacteria Loadings – Sugar/Fenton Creeks Watershed

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Bacteria Event Mean Concentration (CFU/100 mL)	* A Total Acreage	= L Annual Loading (Billion Colonies)
Commercial					
Fecal Coliform	0.00103	26.2	4500	951.1	115,498.7
E. coli	0.00103	26.2	3958	951.1	101,587.6
Industrial					
Fecal Coliform	0.00103	19.8	2500	652.1	33,247.3
E. coli	0.00103	19.8	2123	652.1	28,233.6
Institutional					
Fecal Coliform	0.00103	13.5	3100	210.1	9,056.5
E. coli	0.00103	13.5	2666	210.1	7,788.6
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	485.5	63,945.8
E. coli	0.00103	16.5	7043	485.5	58,112.3
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	2720.4	219,327.5
E. coli	0.00103	10.1	7043	2720.4	199,319.2
Roads					
Fecal Coliform	0.00103	35.6	1700	1544.7	96,289.8
E. coli	0.00103	35.6	1410	1544.7	79,863.9
Total Fecal Coliform					537,365.6
Total *E. coli*					474,905.1

CFU - Colony forming unit

Baseline Pollutant Loadings – Pomme/Matesse Creeks Watershed

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	973.4	1,152.7
Nitrogen	0.226	26.2	2	973.4	11,527.4
Total Suspended Solids	0.226	26.2	75	973.4	432,277.2
BOD	0.226	26.2	9.3	973.4	53,602.4
Industrial					
Phosphorus	0.226	19.8	0.3	492.9	661.7
Nitrogen	0.226	19.8	2.5	492.9	5,514.1
Total Suspended Solids	0.226	19.8	120	492.9	264,675.5
BOD	0.226	19.8	5.1	492.9	11,248.7
Institutional					
Phosphorus	0.226	13.5	0.2	304	185.5
Nitrogen	0.226	13.5	1.8	304	1,669.5
Total Suspended Solids	0.226	13.5	67	304	62,142.8
BOD	0.226	13.5	7.8	304	7,234.5
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	461.8	688.8
Nitrogen	0.226	16.5	2.2	461.8	3,788.5
Total Suspended Solids	0.226	16.5	100	461.8	172,205.2
BOD	0.226	16.5	5.1	461.8	8,782.5
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	2841.6	2,594.5
Nitrogen	0.226	10.1	2.2	2841.6	14,269.7
Total Suspended Solids	0.226	10.1	100	2841.6	648,623.6
BOD	0.226	10.1	5.1	2841.6	33,079.8
Roads					
Phosphorus	0.226	35.6	0.5	1737.6	6,990.0
Nitrogen	0.226	35.6	3	1737.6	41,940.1
Total Suspended Solids	0.226	35.6	150	1737.6	2,097,005.2
BOD	0.226	35.6	9.3	1737.6	130,014.3
Watershed Total					
Phosphorus					12,273.3
Nitrogen					78,709.3
Total Suspended Solids					3,676,929.5
BOD					243,962.2

Baseline Bacteria Loadings – Pomme/Matesse Creeks Watershed

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Bacteria Event Mean Concentration (CFU/100 mL)	* A Total Acreage	= L Annual Loading (Billion Colonies)
Commercial					
Fecal Coliform	0.00103	26.2	4500	973.4	118,206.8
E. coli	0.00103	26.2	3958	973.4	103,969.4
Industrial					
Fecal Coliform	0.00103	19.8	2500	492.9	25,130.5
E. coli	0.00103	19.8	2123	492.9	21,340.8
Institutional					
Fecal Coliform	0.00103	13.5	3100	304	13,104.1
E. coli	0.00103	13.5	2666	304	11,269.5
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	461.8	60,824.3
E. coli	0.00103	16.5	7043	461.8	55,275.5
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	2841.6	229,099.0
E. coli	0.00103	10.1	7043	2841.6	208,199.3
Roads					
Fecal Coliform	0.00103	35.6	1700	1737.6	108,314.3
E. coli	0.00103	35.6	1410	1737.6	89,837.2
Total Fecal Coliform					554,679.0
Total *E. coli*					489,891.7

CFU - Colony forming unit

Baseline Pollutant Loadings – Kiefer Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	117.2	138.8
Nitrogen	0.226	26.2	2	117.2	1,387.9
Total Suspended Solids	0.226	26.2	75	117.2	52,047.3
BOD	0.226	26.2	9.3	117.2	6,453.9
Industrial					
Phosphorus	0.226	19.8	0.3	13.5	18.1
Nitrogen	0.226	19.8	2.5	13.5	151.0
Total Suspended Solids	0.226	19.8	120	13.5	7,249.2
BOD	0.226	19.8	5.1	13.5	308.1
Institutional					
Phosphorus	0.226	13.5	0.2	19.8	12.1
Nitrogen	0.226	13.5	1.8	19.8	108.7
Total Suspended Solids	0.226	13.5	67	19.8	4,047.5
BOD	0.226	13.5	7.8	19.8	471.2
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	118.9	177.4
Nitrogen	0.226	16.5	2.2	118.9	975.4
Total Suspended Solids	0.226	16.5	100	118.9	44,337.8
BOD	0.226	16.5	5.1	118.9	2,261.2
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	488.3	445.8
Nitrogen	0.226	10.1	2.2	488.3	2,452.1
Total Suspended Solids	0.226	10.1	100	388.3	88,633.4
BOD	0.226	10.1	5.1	488.3	5,684.4
Roads					
Phosphorus	0.226	35.6	0.5	183.3	737.4
Nitrogen	0.226	35.6	3	183.3	4,424.3
Total Suspended Solids	0.226	35.6	150	183.3	221,213.8
BOD	0.226	35.6	9.3	183.3	13,715.3
Watershed Total					
Phosphorus					1,529.6
Nitrogen					9,499.5
Total Suspended Solids					417,528.9
BOD					28,894.1

Baseline Bacteria Loadings – Kiefer Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C** Bacteria **Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	117.2	14,232.4
E. coli	0.00103	26.2	3958	117.2	12,518.2
Industrial					
Fecal Coliform	0.00103	19.8	2500	13.5	688.3
E. coli	0.00103	19.8	2123	13.5	584.5
Institutional					
Fecal Coliform	0.00103	13.5	3100	19.6	844.9
E. coli	0.00103	13.5	2666	19.6	726.6
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	118.9	15,660.5
E. coli	0.00103	16.5	7043	118.9	14,231.8
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	488.3	39,368.3
E. coli	0.00103	10.1	7043	488.3	35,776.9
Roads					
Fecal Coliform	0.00103	35.6	1700	183.3	11,426.1
E. coli	0.00103	35.6	1410	183.3	9,477.0
Total Fecal Coliform					82,220.5
Total *E. coli*					73,315.0

CFU - Colony forming unit

Baseline Pollutant Loadings – Fishpot Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	257.9	305.4
Nitrogen	0.226	26.2	2	257.9	3,054.2
Total Suspended Solids	0.226	26.2	75	257.9	114,530.8
BOD	0.226	26.2	9.3	257.9	14,201.8
Industrial					
Phosphorus	0.226	19.8	0.3	42.3	56.8
Nitrogen	0.226	19.8	2.5	42.3	473.2
Total Suspended Solids	0.226	19.8	120	42.3	22,714.1
BOD	0.226	19.8	5.1	42.3	965.3
Institutional					
Phosphorus	0.226	13.5	0.2	130.8	79.8
Nitrogen	0.226	13.5	1.8	130.8	718.3
Total Suspended Solids	0.226	13.5	67	130.8	26,737.7
BOD	0.226	13.5	7.8	130.8	3,112.8
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	133.3	198.8
Nitrogen	0.226	16.5	2.2	133.3	1,093.6
Total Suspended Solids	0.226	16.5	100	133.3	49,707.6
BOD	0.226	16.5	5.1	133.3	2,535.1
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	870.7	795.0
Nitrogen	0.226	10.1	2.2	870.7	4,372.4
Total Suspended Solids	0.226	10.1	100	870.7	198,746.0
BOD	0.226	10.1	5.1	870.7	10,136.0
Roads					
Phosphorus	0.226	35.6	0.5	707.2	2,844.9
Nitrogen	0.226	35.6	3	707.2	17,069.5
Total Suspended Solids	0.226	35.6	150	707.2	853,477.2
BOD	0.226	35.6	9.3	702.2	52,541.5
Watershed Total					
Phosphorus					4,280.8
Nitrogen					26,781.2
Total Suspended Solids					1,265,913.4
BOD					83,492.5

Baseline Bacteria Loadings – Fishpot Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C Bacteria Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	257.9	31,318.6
E. coli	0.00103	26.2	3958	257.9	27,546.5
Industrial					
Fecal Coliform	0.00103	19.8	2500	42.3	2,156.7
E. coli	0.00103	19.8	2123	42.3	1,831.4
Institutional					
Fecal Coliform	0.00103	13.5	3100	130.8	5,638.2
E. coli	0.00103	13.5	2666	130.8	4,848.9
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	133.3	17,557.1
E. coli	0.00103	16.5	7043	133.3	15,955.4
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	870.7	70,198.7
E. coli	0.00103	10.1	7043	870.7	63,794.7
Roads					
Fecal Coliform	0.00103	35.6	1700	707.2	44,083.7
E. coli	0.00103	35.6	1410	707.2	36,563.6
Total Fecal Coliform					170,953.0
Total *E. coli*					150,540.5

CFU - Colony forming unit

Baseline Pollutant Loadings – Grand Glaize Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	689.2	816.2
Nitrogen	0.226	26.2	2	689.2	8,161.8
Total Suspended Solids	0.226	26.2	75	689.2	306,066.8
BOD	0.226	26.2	9.3	689.2	37,952.3
Industrial					
Phosphorus	0.226	19.8	0.3	176.5	236.9
Nitrogen	0.226	19.8	2.5	176.5	1,974.5
Total Suspended Solids	0.226	19.8	120	176.5	94,776.3
BOD	0.226	19.8	5.1	176.5	4,028.0
Institutional					
Phosphorus	0.226	13.5	0.2	176.3	107.6
Nitrogen	0.226	13.5	1.8	176.3	968.2
Total Suspended Solids	0.226	13.5	67	176.3	36,038.7
BOD	0.226	13.5	7.8	176.3	4,195.6
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	280.2	417.9
Nitrogen	0.226	16.5	2.2	280.2	2,298.7
Total Suspended Solids	0.226	16.5	100	280.2	104,486.6
BOD	0.226	16.5	5.1	280.2	5,328.8
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	1787.7	1,632.2
Nitrogen	0.226	10.1	2.2	1787.7	8,977.3
Total Suspended Solids	0.226	10.1	100	1787.7	408,060.4
BOD	0.226	10.1	5.1	1787.7	20,811.1
Roads					
Phosphorus	0.226	35.6	0.5	739.5	2,974.9
Nitrogen	0.226	35.6	3	739.5	17,849.2
Total Suspended Solids	0.226	35.6	150	739.5	892,458.2
BOD	0.226	35.6	9.3	739.5	55,332.4
Watershed Total					
Phosphorus					6,185.7
Nitrogen					40,229.7
Total Suspended Solids					1,841,887.0
BOD					127,648.1

Baseline Bacteria Loadings – Grand Glaize Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C Bacteria Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion of Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	689.2	83,694.4
E. coli	0.00103	26.2	3958	689.2	73,613.9
Industrial					
Fecal Coliform	0.00103	19.8	2500	176.5	8,998.9
E. coli	0.00103	19.8	2123	176.5	7,641.8
Institutional					
Fecal Coliform	0.00103	13.5	3100	176.3	7,599.5
E. coli	0.00103	13.5	2666	176.3	6,535.6
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	280.2	36,905.5
E. coli	0.00103	16.5	7043	280.2	33,538.8
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	1787.7	144,130.2
E. coli	0.00103	10.1	7043	1787.7	130,981.8
Roads					
Fecal Coliform	0.00103	35.6	1700	739.5	46,097.2
E. coli	0.00103	35.6	1410	739.5	38,233.5
Total Fecal Coliform					327,425.6
Total *E. coli*					290,545.3

CFU - Colony forming unit

Baseline Pollutant Loadings – Williams Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	124.5	147.4
Nitrogen	0.226	26.2	2	124.5	1,474.4
Total Suspended Solids	0.226	26.2	75	124.5	55,289.2
BOD	0.226	26.2	9.3	124.5	6,855.9
Industrial					
Phosphorus	0.226	19.8	0.3	71	95.3
Nitrogen	0.226	19.8	2.5	71	794.3
Total Suspended Solids	0.226	19.8	120	71	38,125.3
BOD	0.226	19.8	5.1	71	1,620.3
Institutional					
Phosphorus	0.226	13.5	0.2	35.9	21.9
Nitrogen	0.226	13.5	1.8	35.9	197.2
Total Suspended Solids	0.226	13.5	67	35.9	7,338.6
BOD	0.226	13.5	7.8	35.9	854.3
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	11.3	16.9
Nitrogen	0.226	16.5	2.2	11.3	92.7
Total Suspended Solids	0.226	16.5	100	11.3	4,213.8
BOD	0.226	16.5	5.1	11.3	214.9
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	452.3	413.0
Nitrogen	0.226	10.1	2.2	452.3	2,271.3
Total Suspended Solids	0.226	10.1	100	452.3	103,242.0
BOD	0.226	10.1	5.1	452.3	5,265.3
Roads					
Phosphorus	0.226	35.6	0.5	249.6	1,004.1
Nitrogen	0.226	35.6	3	249.6	6,024.5
Total Suspended Solids	0.226	35.6	150	249.6	301,227.3
BOD	0.226	35.6	9.3	249.6	18,676.1
Watershed Total					
Phosphorus					1,698.6
Nitrogen					10,854.4
Total Suspended Solids					509,436.1
BOD					33,486.9

Baseline Bacteria Loadings – Williams Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C Bacteria Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	124.5	15,118.9
E. coli	0.00103	26.2	3958	124.5	13,297.9
Industrial					
Fecal Coliform	0.00103	19.8	2500	71	3,619.9
E. coli	0.00103	19.8	2123	71	3,074.0
Institutional					
Fecal Coliform	0.00103	13.5	3100	35.9	1,547.5
E. coli	0.00103	13.5	2666	35.9	1,330.8
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	11.3	1,488.3
E. coli	0.00103	16.5	7043	11.3	1,352.6
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	452.3	36,465.9
E. coli	0.00103	10.1	7043	452.3	33,139.3
Roads					
Fecal Coliform	0.00103	35.6	1700	249.6	15,559.0
E. coli	0.00103	35.6	1410	249.6	12,904.8
Total Fecal Coliform					73,799.5
Total *E. coli*					65,099.4

CFU - Colony forming unit

Baseline Pollutant Loadings – Fenton Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	252.2	298.7
Nitrogen	0.226	26.2	2	252.2	2,986.7
Total Suspended Solids	0.226	26.2	75	252.2	111,999.5
BOD	0.226	26.2	9.3	252.2	13,887.9
Industrial					
Phosphorus	0.226	19.8	0.3	28.4	38.1
Nitrogen	0.226	19.8	2.5	28.4	317.7
Total Suspended Solids	0.226	19.8	120	28.4	15,250.1
BOD	0.226	19.8	5.1	28.4	648.1
Institutional					
Phosphorus	0.226	13.5	0.2	38.5	23.5
Nitrogen	0.226	13.5	1.8	38.5	211.4
Total Suspended Solids	0.226	13.5	67	38.5	7,870.1
BOD	0.226	13.5	7.8	38.5	916.2
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	64.6	96.4
Nitrogen	0.226	16.5	2.2	64.6	530.0
Total Suspended Solids	0.226	16.5	100	64.6	24,089.3
BOD	0.226	16.5	5.1	64.6	1,228.6
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	416.5	380.3
Nitrogen	0.226	10.1	2.2	416.5	2,091.5
Total Suspended Solids	0.226	10.1	100	416.5	95,070.3
BOD	0.226	10.1	5.1	416.5	4,848.6
Roads					
Phosphorus	0.226	35.6	0.5	410.6	1,651.8
Nitrogen	0.226	35.6	3	410.6	9,910.6
Total Suspended Solids	0.226	35.6	150	410.6	495,528.5
BOD	0.226	35.6	9.3	410.6	30,722.8
Watershed Total					
Phosphorus					2,488.7
Nitrogen					16,047.9
Total Suspended Solids					749,807.8
BOD					52,252.2

Baseline Bacteria Loadings – Fenton Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C Bacteria Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	252.2	30,626.4
E. coli	0.00103	26.2	3958	252.2	26,937.6
Industrial					
Fecal Coliform	0.00103	19.8	2500	28.4	1,448.0
E. coli	0.00103	19.8	2123	28.4	1,229.6
Institutional					
Fecal Coliform	0.00103	13.5	3100	38.5	1,659.6
E. coli	0.00103	13.5	2666	38.5	1,427.2
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	64.6	8,508.5
E. coli	0.00103	16.5	7043	64.6	7,732.3
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	416.5	33,579.6
E. coli	0.00103	10.1	7043	416.5	30,516.3
Roads					
Fecal Coliform	0.00103	35.6	1700	410.6	25,595.0
E. coli	0.00103	35.6	1410	410.6	21,228.8
Total Fecal Coliform					101,417.1
Total *E. coli*					89,071.9

CFU - Colony forming unit

Baseline Pollutant Loadings – Matesse Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	CF Conversion Factor	* R Annual Runoff (Inches/Year)	* C Pollutant Concentration (Milligrams/Liter)	* A Total Acreage	= L Annual Loading (Pounds/Year)
Commercial					
Phosphorus	0.226	26.2	0.2	363.3	430.2
Nitrogen	0.226	26.2	2	363.3	4,302.3
Total Suspended Solids	0.226	26.2	75	363.3	161,337.9
BOD	0.226	26.2	9.3	363.3	20,005.9
Industrial					
Phosphorus	0.226	19.8	0.3	130.3	174.9
Nitrogen	0.226	19.8	2.5	130.3	1,457.7
Total Suspended Solids	0.226	19.8	120	130.3	69,968.0
BOD	0.226	19.8	5.1	130.3	2,973.6
Institutional					
Phosphorus	0.226	13.5	0.2	124.1	75.7
Nitrogen	0.226	13.5	1.8	124.1	681.5
Total Suspended Solids	0.226	13.5	67	124.1	25,368.1
BOD	0.226	13.5	7.8	124.1	2,953.3
Multi-Family Residential					
Phosphorus	0.226	16.5	0.4	160.5	239.4
Nitrogen	0.226	16.5	2.2	160.5	1,316.7
Total Suspended Solids	0.226	16.5	100	160.5	59,850.5
BOD	0.226	16.5	5.1	160.5	3,052.4
Single-Family Residential					
Phosphorus	0.226	10.1	0.4	1027.1	937.8
Nitrogen	0.226	10.1	2.2	1027.1	5,157.8
Total Suspended Solids	0.226	10.1	100	1027.1	234,445.8
BOD	0.226	10.1	5.1	1027.1	11,956.7
Roads					
Phosphorus	0.226	35.6	0.5	684.1	2,752.0
Nitrogen	0.226	35.6	3	684.1	16,512.0
Total Suspended Solids	0.226	35.6	150	684.1	825,599.2
BOD	0.226	35.6	9.3	684.1	51,187.2
Watershed Total					
Phosphorus					4,610.1
Nitrogen					29,428.0
Total Suspended Solids					1,376,569.6
BOD					92,129.1

Baseline Bacteria Loadings – Matesse Creek Sub-Watershed – Impaired Stream

Land Use/ Pollutant	**CF Conversion Factor**	*** R Annual Runoff (Inches/Year)**	*** C Bacteria Event Mean Concentration (CFU/100 mL)**	*** A Total Acreage**	**= L Annual Loading (Billion Colonies)**
Commercial					
Fecal Coliform	0.00103	26.2	4500	363.3	44,118.1
E. coli	0.00103	26.2	3958	363.3	38,804.3
Industrial					
Fecal Coliform	0.00103	19.8	2500	130.3	6,643.3
E. coli	0.00103	19.8	2123	130.3	5,641.5
Institutional					
Fecal Coliform	0.00103	13.5	3100	124.1	5,349.4
E. coli	0.00103	13.5	2666	124.1	4,600.5
Multi-Family Residential					
Fecal Coliform	0.00103	16.5	7750	160.5	21,139.7
E. coli	0.00103	16.5	7043	160.5	19,211.2
Single-Family Residential					
Fecal Coliform	0.00103	10.1	7750	1027.1	82,808.1
E. coli	0.00103	10.1	7043	1027.1	75,253.9
Roads					
Fecal Coliform	0.00103	35.6	1700	684.1	42,643.8
E. coli	0.00103	35.6	1410	684.1	35,369.3
Total Fecal Coliform					202,702.4
Total *E. coli*					178,880.6

CFU - Colony forming unit

M. Lower Meramec River National Pollutant Discharge Elimination System Permits

Lower Meramec Watershed Domestic (Sanitary) NPDES Permits/Discharge Sites Since 2002
Lower Meramec Watershed Industrial NPDES Permits/Discharge Sites Since 2002
Lower Meramec Watershed General NPDES Permits/Discharge Sites Since 2002

Lower Meramec Watershed Domestic (Sanitary) NPDES Permits/Discharge Sites Since 2002
Map # matches up with Map 8

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
Sewer Districts							
Franklin County Public Water and Sewer District (FCPSWD)#3							
1	F	MO0119113	11-2014	FCPWSD#3 Twin View WWTP POTW	Flow equalization, extended aeration, chlorination	Design- 18,500 Actual - 8,000	Tributary to Brush Ck
3	F	MO0106534	5-2014	FCPWSD#3 Ad Deum Subdivision POTW	Extended aeration, chlorination	Design - 16,400 Actual - 15,000	Tributary to Brush Ck
17	F	MO0111937	3-2015	FCPWSD#3 Little Fox Creek POTW	Extended aeration	Design - 40,000 Actual - 60,000	Little Fox Ck
18	F	MO0132802	6-2018	FCPWSD#3 Horseshoe Valley WWTF	Flow equalization, extended aeration	Design - 10,500 Actual – 1,440	Little Fox Ck
Calvey Creek Sewer District							
4	F	MO0115410	9-2017	Calvey Creek Sewer District - Catawissa Lagoon POTW	3 cell aerated lagoon	Design - 185,000 Actual - 68,000	Winch Ck
Sylvan Manor – Sunset Acres Sewer District							

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
8	F	MO0098043	9-2017	Sylvan Manor - Sunset Acres Sewer District	Extended aeration, UV disinfection	Adjusted Design - 17,999 Actual - 15,000	Wet weather tributary to Meramec R
Jefferson County Sewer District							
16	J	MO0134147	6-2018	Jefferson County Sewer District Mirasol WWTF POTW	Lift station, extended aeration, UV disinfection	Design - 150,000 Actual – 44,000	Meramec R
Northeast Public Sewer District (NPSD)							
37	J	MO0099252	9-2017	NPSD Antire Springs Plant POTW	Extended aeration, seasonal chlorination, dechlorination	Design - 20,000 Actual – 16,000	Antire Ck
38	J	MO0095281	9-2017	NPSD Walnut Ridge WWTF POTW	Extended aeration, chlorination, dechlorination	Design - 14,400 Actual – 5,200	Tributary to Antire Ck (losing)
46	J	MO0090026	9-2017	NPSD Pere Cliff MHP POTW	Septic tanks, sand filter, chlorination, dechlorination	Design - 2,475 Actual - 0	Tributary to Little Antire Ck (losing)
74	J	MO0092649	12-2017	NPSD – Terry Jean Acres WWTF	Septic tank, recirculating sand filter, chlorination, dechlorination	Design – 4,500 Actual – 1,000	Sugar Ck

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
92	J	MO0128490	6-2018	NPSD – Interim Saline Creek Regional WWTF	Lift station, bar screen, peak flow holding basin, multiple channel oxidation ditch, 2 secondary clarifiers, UV disinfection, effluent cascade aerator 2 sites instream monitoring	Design – 4 MGD Actual – 2.75 MGD	Meramec R
Metropolitan St. Louis Sewer District (MSD)							
65 66 67 68 69	STL	MO0101362	12-2017	MSD Grand Glaize WWTF POTW	Outfall 1 - Lift station, primary clarification, activated sludge, chlorination, dechlorination, cascade re-aeration Outfall 2 – discharge no longer authorized Outfall 3, 4, 5 and 6 - Stormwater runoff, no treatment	Outfall 1 Design - 21 MGD Actual – 17.8 MGD	Outfall 1 - Meramec R Outfalls 3, 4, 5 and 6 - Tributary to Grand Glaize Ck
85	STL	MO0086126	12-2017	MSD – Fenton WWTP POTW	Lift station, primary clarifier, 2 final clarifiers, 3 ultraviolet disinfection units	Design – 6.75 MGD Actual – 4.8 MGD	Meramec R
97 98	STL	MO0127949	3-2017	MSD – New Lower Meramec WWTF	2 stormwater outfalls, no treatment (plant discharges to Mississippi R)	N/A	Tributary to Meramec R
Municipal							
6	F	MO0041131	9-2017	Pacific WWTF	4 cell lagoon, 2 aerated cells with fixed film media, partial floating cover on 2nd aerated cell, UV disinfection	Design - 2 MGD Actual – 1.01 MGD	Meramec R

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
33	STL	MO0039659	3-2016	Eureka WWTF POTW	Aerated lagoon, UV disinfection	Design - 2.8 MGD Actual - 1.3 MGD	Meramec R
Subdivision, Apartment Complex or Mobile Home Park (MHP)							
2	F	MO0095583	11-2014	Kober's MHP	3 cell facultative lagoon	Design - 4,800 Actual - 1,500	Tributary to Meramec R
5	F	MO0108901	9-2017	Summit Hills Farm Subdivision	Extended aeration	Design - 16,650 Actual - 9,400	Tributary to Brush Ck
7	F	MO0081035	10-2016	Windfall Estates MHP	Extended aeration, chlorination	Design - 10,000 Actual - 4,800	Tributary to Winch Ck
9	J	MO0120332	9-2017	Palisades Village Subdivision	Extended aeration, chlorination	Design - 28,000 Actual – 2,000	Tributary to Meramec R
12	J	MO0106747	6-2017	Lake Cattails Subdivision (aka Fairways Subdivision)	Extended aeration, chlorination	Design - 22,220 Actual - 5,500	Tributary to Meramec R

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
15	J	MO0124036	10-2013	Winterwood Subdivision	Septic tank, recirculating sand filter	Design - 20,000 Actual - Unknown, No observable flow	Tributary to LaBarque Ck
19	STL	MO0123871	7-2018	Estates at Autumn Farms	Septic tank, effluent filters, recirculating sand filter, chlorination	Design - 3,300 Actual – 1,200	Tributary to Fox Ck
21	STL	MO0132331	6-2017	Hencken Valley Estates WWTF	STEP system, recirculating sand filter, chlorination, dechlorination	Design - 4,800	Tributary to Fox Ck
23	STL	MO0120031	6-2016	Estates at August Tavern Creek	Septic tank, recirculating sand filter, chlorination and dechlorination	Design - 10,000 Actual - 7,250	Tributary to Fox Ck
28	STL	MO0122629	9-2016	Bartizan Point Estates	Septic tank, recirculating sand filter, UV disinfection	Design - 4,800 Actual - 3,000	Tributary to Hamilton Ck
30	STL	MO0111261	9-2017	Radcliffe Place Subdivision	Extended aeration, UV disinfection	Design - 58,200 Actual – 9,800	Hamilton Ck
35	STL	MO0122751	9-2017	Pevely Farm (Subdivision) Interim WWTF	Extended aeration, UV disinfection	Design - 100,000 Actual 10,000	Meramec R

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
36	J	MO0086347	10-2009	Jeffco Holding – Laurel Acres MHP	2 cell lagoon, chlorination	Design – 12,120 Actual – 7,400	Little Antire Ck
45 47	J	MO0091359	9-2017	Pembroke Park Apartments	Extended aeration, single cell storage lagoon, wastewater irrigation Domestic wastewater mechanical plant with no-discharge storage and land application/irrigation system	Design with 1-in-10 year net rainfall less evaporation - 5,500 Average Dry Weather Design - 5,000 Actual - Unknown	Tributary to Antire Ck (losing)
50	J	MO0084646	9-2017	Villas of Williams Creek MHP (formerly Rosecliff MHP)	Extended aeration, sock filter, chlorination, dechlorination	Design - 6,000 Actual – 2,700	Tributary to Little Antire Ck
52	J	MO0040347	12-2016	Woodridge Apartments	Septic tank, recirculating sand filter, chlorination, dechlorination	Design - 16,500 Actual – 12,700	Tributary to Williams Ck

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
72	J	MO0090956	11-2017	Murphy Ann Apartments WWTP	Extended aeration, sock filter, UV disinfection	Design – 2,000 Actual – 1,475	Tributary to Saline Ck
73	J	MO0107981	11-2016	Brennens Point Apartments	Extended aeration, sand filter, year round chlorination	Design – 4,800 Actual – 1,200	Tribuary to Saline Ck
75	J	MO0090484	12-2017	Big Valley MHP	Recirculating sand filter, chlorination	Design – 5,000 Actual – 1,500	Romaine Ck
77	J	MO0088897	8-2017	Sir Thomas Manor Apartments	Two cell lagoon	Design – 9,200 Actual – 8,500	Tributary to Sugar Ck
79	J	MO0114413	12-2017	Tesson Hills Apartments	Extended aeration sock filters, chlorination	Design – 4,000	Tributary to Romaine Ck
80	J	MO0094374	3-2015	McArthy Homesites #2 WWT	Extended aeration, sock filter, chlorination	Design – 4,500 Actual – 3,400	Tributary to Romaine Ck
81	J	MO0084930	11-2017	Woodglen Apartments	Extended aeration, sock filters, chlorination, dechlorination	Design – 9,500 Actual – 3,000	Tributary to Romaine Ck
93	J	MO0088846	2-2013	Brookshire Court Apartments	Extended aeration, chlorination	Design – 3,600 Actual – 1,260	Tributary to Meramec R

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
Privately Owned Company							
86	J	MO0091162	12-2017	Missouri American Water Company – Meramec Sewer WWTP	Extended aeration, seasonal chlorination	Design – 209,000 Actual – 156,000	Tributary to Meramec R
Commercial – Institutional							
14	J	MO0081426	6-2018	St. Joseph's Hill Infirmary	Single cell aerated lagoon	Design - 20,000 Actual – 5,720	Tributary to LaBarque Ck
20	STL	MO0120375	6-2018	Lafayette Bible Baptist Church	Septic tank, recirculating sand filter, chlorination, dechlorination	Design - 1,500 Actual - 140	Tributary to Fox Ck
22	STL	MO0122424	9-2017	Metro West FPD Station #5	Septic tank, recirculating sand filter, chlorination, dechlorination	Design - 1,000 Actual - 700	Tributary to Fox Ck
24 25	STL	MO0105473	6-2018	Six Flags St. Louis	Outfall 1 - 3 cell settling basin, dechlorination (seasonal discharge from water-based rides, stormwater runoff) Outfall 2 - single cell settling basin, dechlorination (seasonal discharge from water park, stormwater runoff)	Outfall 1 Design - 1.5 MGD Actual – 83,600 Outfall 2 Design - 225,000 Actual – 113,000	Outfall 1 - Tributary to Fox Ck Outfall 2 – Flat Ck

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
26	STL	MO0096083	9-2017	Kiwanis Camp Wyman	Extended aeration, voluntary chlorination	Design - 12,000 Actual - 10,000	Tributary to Flat Ck
27	STL	MO0113131	11-2014	Hidden Valley Golf Course	Extended aeration, flow equalization tank, tertiary sock filter, chlorination & dechlorination	Design - 5,000 Actual - 1,500	Tributary to Carr Ck (losing)
29	STL	MO0113743	3-2017	LaSalle Springs Middle School – Rockwood School District	Lift station, extended aeration, chlorination, dechlorination	Adjusted Design - 11,999 Actual - 9,000	Hamilton Ck
32	STL	MO0131733	9-2017	Marianist Retreat Center	Septic tank, recirculating sand filter, chlorination, dechlorination	Design - 5,200 Actual – 2,400	Tributary to Hamilton Ck
34	STL	MO0098124	9-2012	Crescent Farms Golf Club	Extended aeration, sand filter, year round chlorination	Design - 2,500 Actual - 150	Tributary to Meramec R
42	STL	MO0107549	9-2017	BSA Beaumont Scout Reservation	Extended aeration, chlorination, dechlorination	Design - 9,000	Little Antire Ck
43	STL	MO0107549	9-2017	BSA Beaumont Scout Reservation	Septic tank, sand filter, chlorination, dechlorination	Design - 4,650	Tributary to Little Antire Ck
56	STL	MO0134651	6-2018	Peerless Park I-44 Center	Lift station, flow equalization, extended aeration, chlorination, dechlorination	Design - 6,000 Actual - 550	Williams Ck

Map #	Co.	Permit	Permit Expires	Name	Domestic (Sanitary) Treatment Description	Flow (Gallons per Day)	Discharge Stream
61	STL	MO0120910	4-2017	Motomart	Oil-water separator, lift station, extended aeration, chlorination, dechlorination	Design - 3,000 Actual – 3,700	Tributary Meramec R
84	STL	MO0109975	12-2107	Missouri Department of Conservation (MDC) – Powder Valley Conservation Nature Center	Bar screen, extended aeration, chlorination, dechlorination	Design – 3,500 Actual – 3,900	Tributary to Meramec R
89	J	MO0127949	6-2018	Meramec Heights Shopping Center	Extended aeration, clarifier, sock filters, chlorination	Design – 12,000 Actual – 1,300	Tributary to Meramec R

Source – Missouri Department of Natural Resources
Abbreviations
F – Franklin County
J – Jefferson County
STL – St. Louis County
WWTP – Wastewater Treatment Plant (same as Treatment Facility)
WWTF – Wastewater Treatment Facility
POTW – Publicly Owned Treatment Works
UV - Ultraviolet
STEP – Septic Tank Effluent Pumping System
MGD – Million Gallons per Day

Lower Meramec Watershed Industrial NPDES Permits/Discharge Sites Since 2002
Map # matches up with Map 8

Map #	**Co.**	**Permit**	**Permit Expires**	**Name**	**Industrial Treatment Description**	**Discharge Stream**
10 11 13	STL	MO0000493	9-2017	U.S. Silica Sand Mining	Outfall 1 - Stormwater runoff, sand washing, sand quarry Treatment - Settling basin/stormwater runoff Actual Flow - 0.90MGD Outfall 2 - Stormwater runoff Treatment - Settling basin/stormwater runoff Actual Flow - 0.30 MGD Outfall 3 - Stormwater runoff Treatment - Settling basin/stormwater runoff Design Flow – 3.7 MGD	Outfall 1 - Clear Ck Outfall 2 - Tributary to Meramec R Outfall 3 – Tributary to Meramec R
39 40	J	MO0094956	9-2017	H.R. Electronics Manufacturing and warehouse Only warehouse in use	Outfall 1 - Warehouse wastewater system Septic tank, recirculating sand filter, chlorination, effluent pump Design Flow – 13,000 GPD Actual Flow – 100 GPD Outfall 2 - Industry, stormwater Single cell lagoon, stormwater runoff	Antire Ck (losing)
44 48 49	J	MO0097926	7-2016	Engineered Coil, doing business as Marlo Coil Air conditioning and warm air heating equipment and commercial and industrial refrigeration equipment	Outfall 1 - Facility wastewater system Extended aeration, sock filters, year round chlorination Design Flow - 3,000 GPD Actual Flow - 2,400 GPD Outfall 3 - Industry process water, non-contact cooling water Design flow – 11,000 GPD Outfall 4 – Vehicle and equipment washing, flushing coils Design flow – 3,000 GPD	Antire Ck

Map #	Co.	Permit	Permit Expires	Name	Industrial Treatment Description	Discharge Stream
53 54 55	STL	MO0113000	6-2018	Advanced Disposal Oak Ridge Landfill	Outfall 2 - Stormwater runoff Sedimentation basin, stormwater runoff Flow dependent upon precipitation Actual Flow - 0.00248 MGD Outfall 3- Stormwater runoff Best Management Practices Flow dependent upon precipitation Outfall 5 - Stormwater runoff Best Management Practices Flow dependent upon precipitation Outfalls 1 and 4 have been eliminated	Outfall 2 and 5 - Tributary to Fishpot Ck Outfall 3 - Meramec R
57 58 59 60	STL	MO0110779	2-2015	Peerless Demolition Landfill Construction and demolition landfill	Outfall 2 - Stormwater runoff Design flow - 1.53 MGD based on 10-year, 24-hour rainfall event Average flow - 40,000 GPD Outfall 3 - Stormwater runoff Design flow - 0.98 MGD based on 10-year, 24-hour rainfall event Average flow - 30,000 GPD Outfall 4 - Stormwater runoff Design flow - 1.24 MGD based on 10-year, 24-hour rainfall event Average flow - 40,000 GPD Outfall 5 - Detention basin, emergency discharge only Receives flow from Outfalls 3 and 4. Discharge is normally 0 GPD except during unusual precipitation events Outfall 1 - eliminated	Outfall 2 - Tributary to Williams Ck Outfalls 3, 4 and 5 - Meramec R

Map #	Co.	Permit	Permit Expires	Name	Industrial Treatment Description	Discharge Stream
62	STL	MO0123021	6-2018	Valley Park TCE Site Wainwright Operable Unit (Wainwright Industries) Fabricated metal products	Ground Water Remediation Treatment Unit by Air Stripping (Trichloroethylene) Design flow - 165 gallons per minute or 237,000 GPD Actual flow – 20,000 GPD	Meramec R
63 64	STL	MO0001341	6-2018	Reichhold Inc Plastic materials, synthetic resins and nonvulcanizable elastomers	Outfall 1 - Industry process water, stormwater Actual flow - 0.03 MGD Outfall 2 - Stormwater runoff retention basin Actual flow dependent on precipitation	Meramec R
70	STL	MO0001627	12-2015	Bohn & Dawson, Inc Steel pipes and tubes	Industry process water, noncontact cooling water Actual flow - 4,600 GPD	Storm sewer to Grand Glaize Ck
82 83	J	MO0123358	5-2013	Koller Craft Plastic Production	Noncontact cooling water and stormwater runoff Maximum -0.432 MGD Receiving water monitoring site	Saline Ck
90 91	J	MO0136450	6-2018	Jeffco Landfill	Outfall 1 – no discharge single cell lagoon Outfall 2 - land application leachate to landfill cap Design with 1-in-10 year net rainfall less evaporation – 12,500	Tributary to Meramec R
95 96	STL	MO0000361	N/A	Ameren Missouri – Meramec Power Plant	2 stormwater outfalls Design flow – N/A	Meramec R

Source – Missouri Department of Natural Resources

Abbreviations

STL - St. Louis County	MOAWC – Missouri American Water Company
J - Jefferson County	MGD - Million gallons per day
F – Franklin County	GPD - Gallons per day

Lower Meramec Watershed General NPDES Permits/Discharge Sites Since 2002
Map # matches up with Map 8 found in main body of text

Map #	**Co.**	**Permit**	**Permit Expires**	**Name**	**General Permit Purpose**	**Discharge Stream**
31	STL	MOG760036	7-31-2019	Radcliffe Place Subdivision Recreation Facility	Swimming pool discharge*	Hamilton Ck
41	STL	MOG760034	7-31-2019	Beaumont Scout Reservation	Swimming pool discharge	Little Antire Ck
51	STL	MOG760146	7-31-2019	Rolling Hills Swim Club	Swimming pool discharge	Tributary to Fishpot Ck
71	STL	MOG760154	7-31-2019	West County Center Corner Park	Swimming pool discharge	Tributary to Sugar Ck
76	STL	MOG760091	7-31-2019	Riverchase of Fenton Recreation Center	Swimming pool discharge	Tributary to Meramec R
78	STL	MOG760107	7-31-2019	Waterfall at Gravois Bluffs Shopping Center	Swimming pool discharge	Tributary to Fenton Ck
87	STL	MOG640236	10-31-2018	Missouri American Water Company – South County Plant	Drinking water treatment settling basins**	Tributary to Meramec R
88	STL	MOG760093	7-31-2019	City of Sunset Hills Aquatic Facility	Swimming pool discharge	Tributary to Meramec R
94	STL	MOG640237	10-31-2018	Missouri American Water Company – Meramec Plant	Drinking water treatment settling basins	Tributary to Meramec R

Source – Missouri Department of Natural Resources
*Includes discharge of filter backwash and pool drainage from swimming pools and lined ponds which use chlorine as a sanitizer and water drained from swimming pools, lined decorative ponds and fountains.
**Includes water treatment plants filter backwash water and solids and allows operation of no-discharge sludge holding systems and land application of water treatment plant sludge

N. Maps

Map 1

Map 2

Map 3

Map 4

Map 5

Map 6

Map 7

Map 8

Map 9

Map 10

Map 11

Map 12

Map 13

Map 14

Map 15

Map 16

Map 17

Map 18

Map 19

Map 20

Map 21

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APPENDIX B

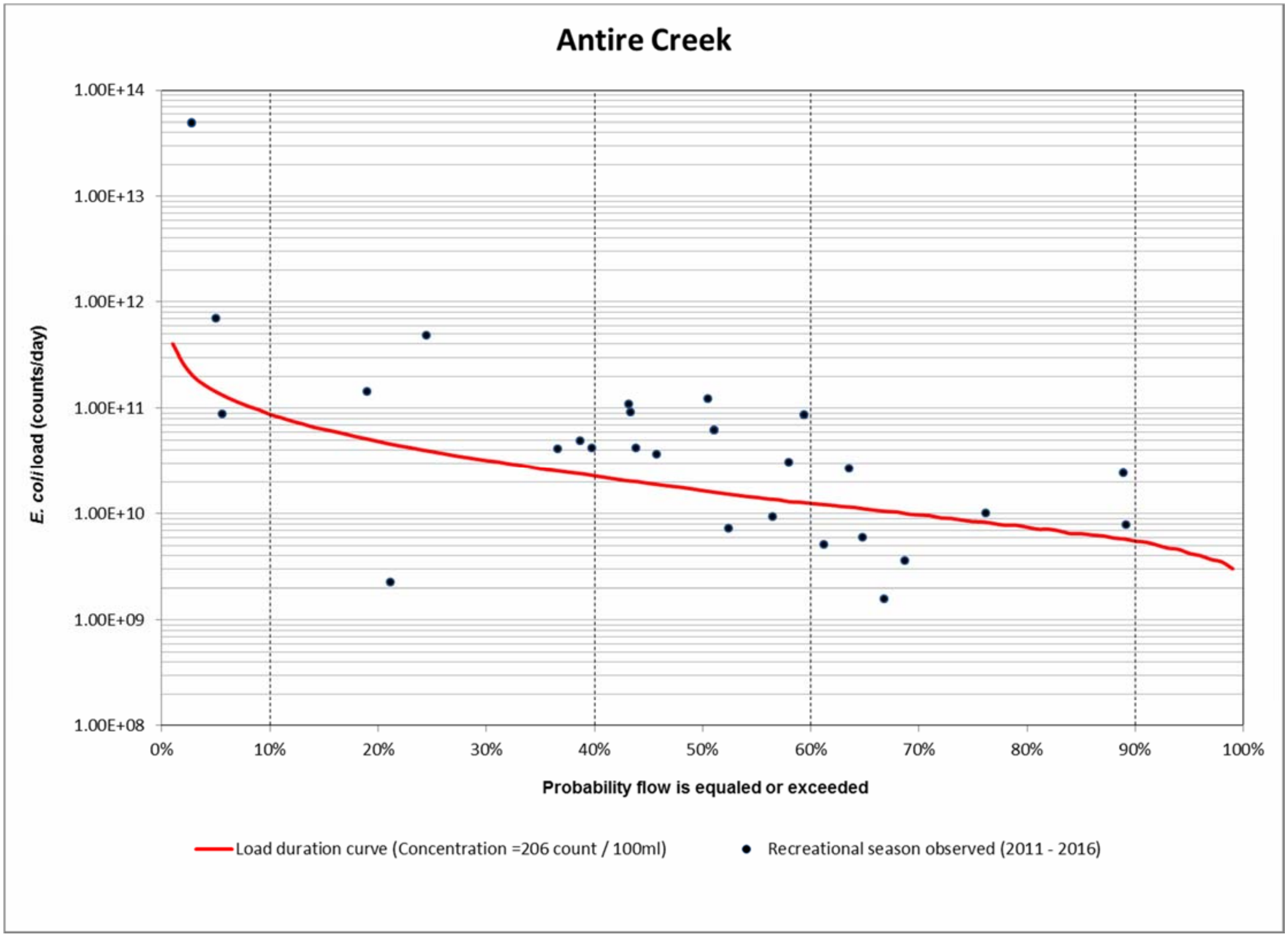
LOAD DURATION CURVES AND POLLUTANT REDUCTION ESTIMATES FOR STREAMS IN THE LOWER MERAMEC WATERSHED

Appendix B

Load Duration Curves and Pollutant Reduction Estimates for Streams in the Lower Meramec Watershed

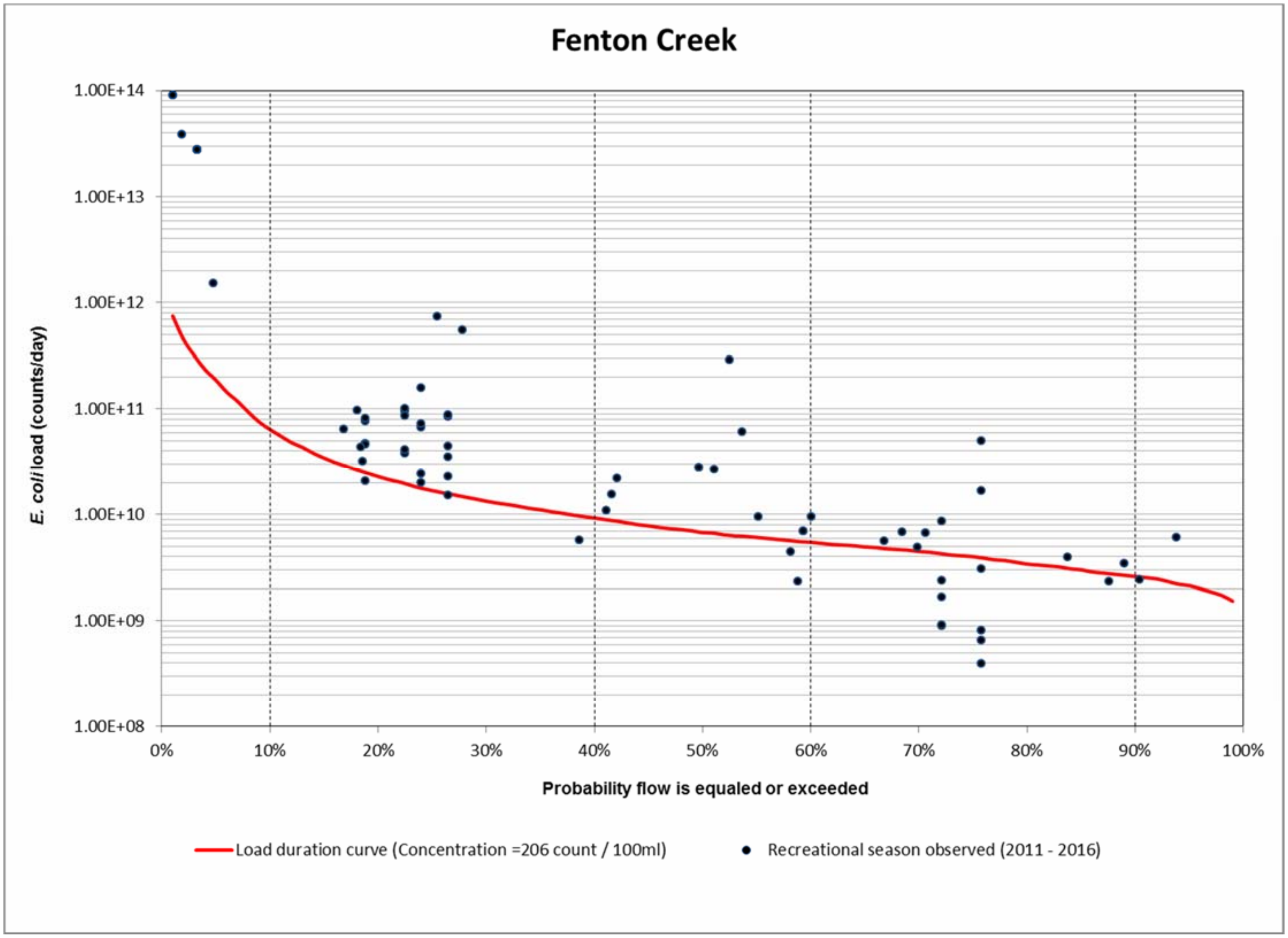
The following load duration curves and pollutant reduction estimates are being provided for informational purposes to support the development of a nine-element watershed-based plan for the Lower Meramec Watershed, which is funded, in part, by the Environmental Protection Agency, Region 7, through the department under Section 319 of the Clean Water Act. These calculations and analyses are not part of a total maximum daily load (TMDL). Percent reductions were calculated using the load duration curve and available water quality data collected from the water body. Reductions for a given flow range are geometric means and are provided to aid in the selection and placement of best management practices (BMPs). Restoration of beneficial uses will be evaluated through future monitoring and assessment of water quality standards (dnr.mo.gov/env/wpp/waterquality/303d/303d.htm). Load duration curves and load reduction estimates for *E. coli* bacteria are provided for the following six streams:

Stream Name	***Water Body ID Number***
Antire Creek	2188
Fenton Creek	3595
Grand Glaize Creek	2184
Keifer Creek	3592
Mattese Creek	3596
Williams Creek	3594



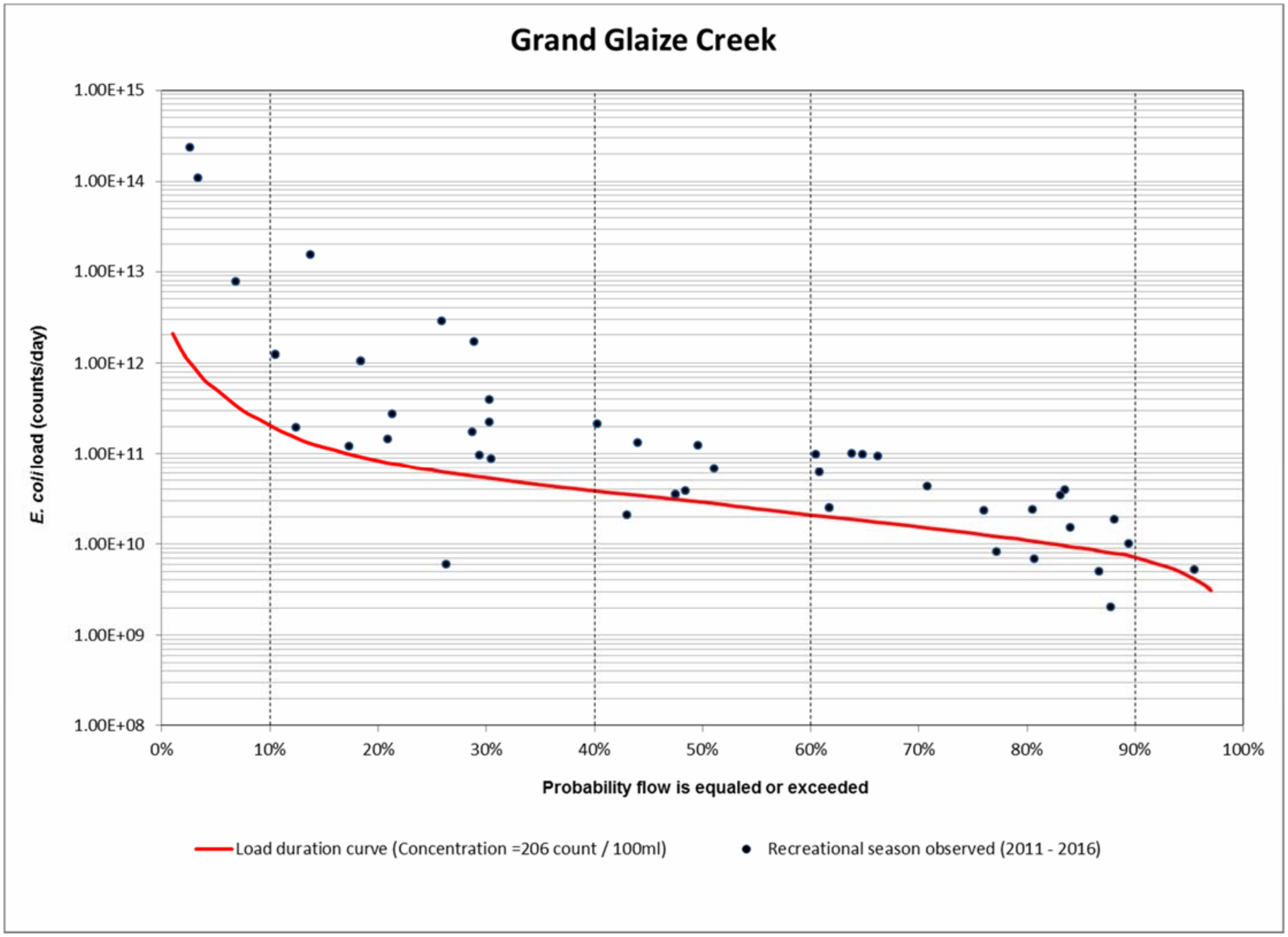
Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Antire Creek					
Percent of Time Flow is Equaled or Exceeded	**Flow (cfs)**	**Loading Capacity (counts/day)**	**Existing Loading (counts/day)**	**Reduction Needed (counts/day)**	**Reduction Needed (%)**
95	0.84	4.22E+09	No data	No data	No data
75	1.67	8.43E+09	7.38E+09	None	0.0%
50	3.28	1.65E+10	4.69E+10	3.04E+10	64.7%
25	7.71	3.89E+10	4.84E+10	9.57E+09	19.8%
10	17.38	8.76E+10	1.44E+12	1.35E+12	93.9%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range



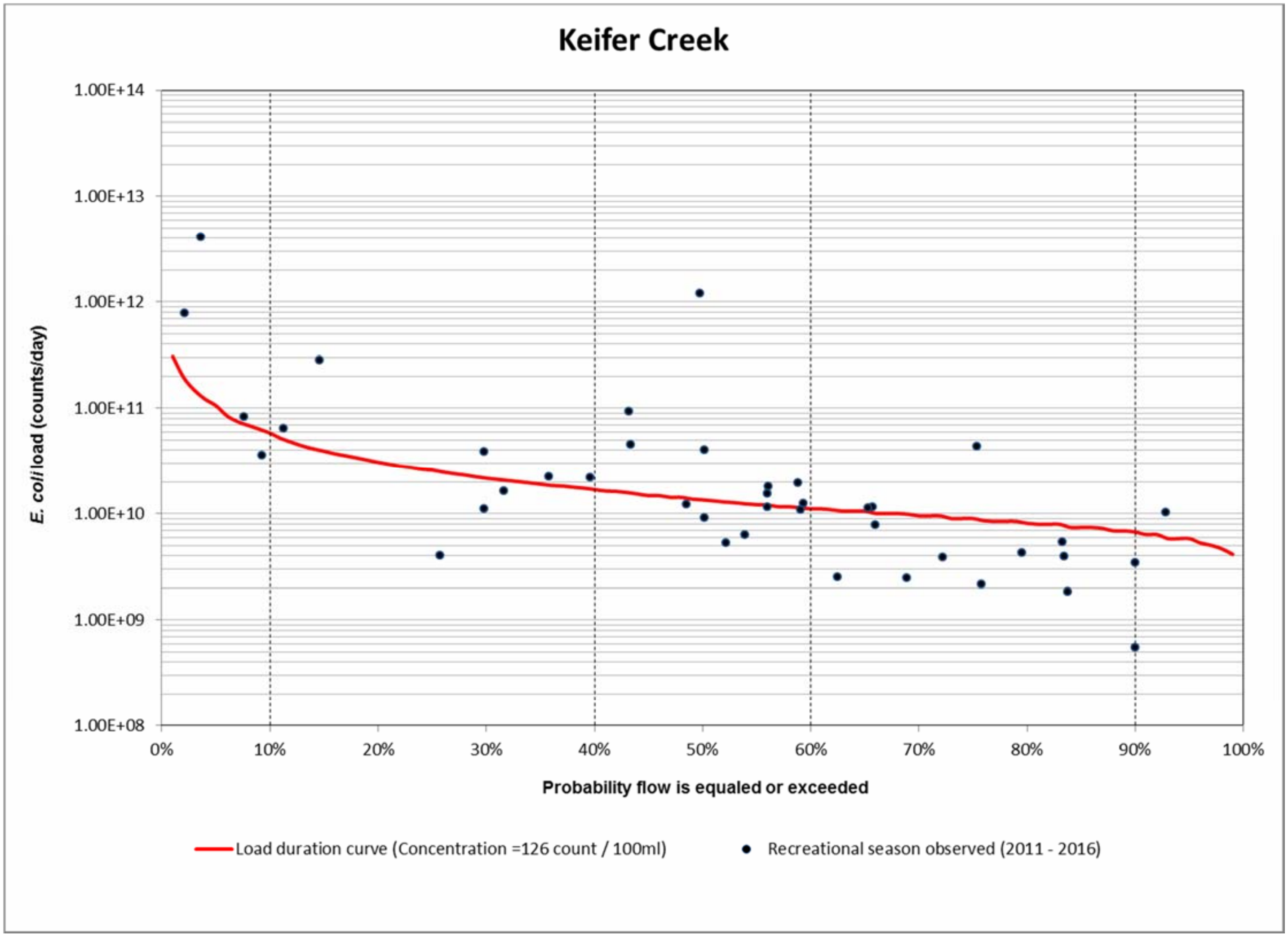
Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Fenton Creek					
Percent of Time Flow is Equaled or Exceeded	**Flow (cfs)**	**Loading Capacity (counts/day)**	**Existing Loading (counts/day)**	**Reduction Needed (counts/day)**	**Reduction Needed (%)**
95	0.42	2.14E+09	3.82E+09	1.68E+09	44.0%
75	0.80	4.01E+09	2.72E+09	None	0.0%
50	1.34	6.75E+09	1.65E+10	9.70E+09	59.0%
25	3.34	1.68E+10	5.64E+10	3.96E+10	70.1%
10	12.72	6.41E+10	2.73E+13	2.72E+13	99.8%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range



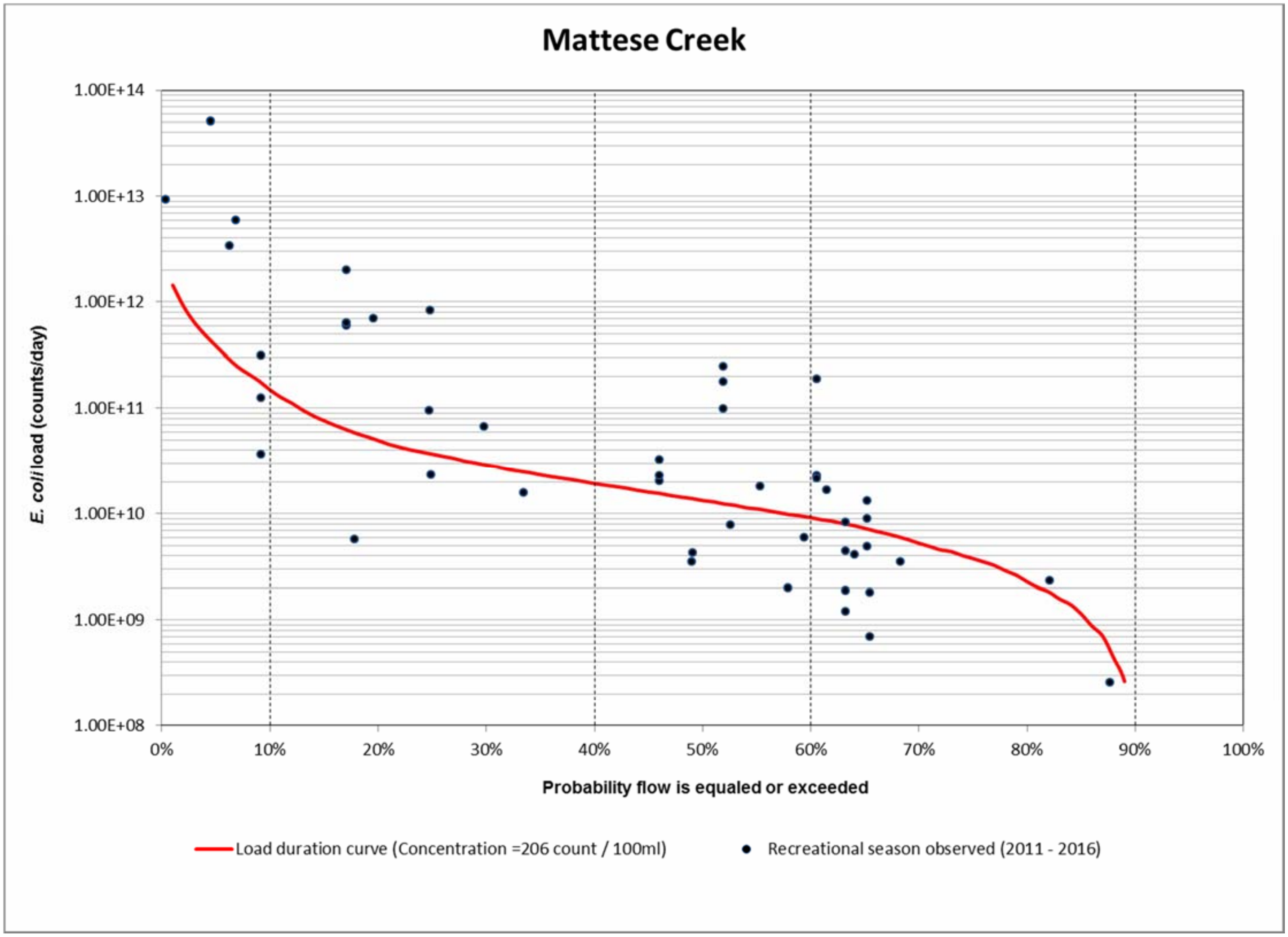
Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Grand Glaize Creek					
Percent of Time Flow is Equaled or Exceeded	**Flow (cfs)**	**Loading Capacity (counts/day)**	**Existing Loading (counts/day)**	**Reduction Needed (counts/day)**	**Reduction Needed (%)**
95	0.87	4.37E+09	5.23E+09	8.58E+08	16.4%
75	2.60	1.31E+10	2.40E+10	1.09E+10	45.3%
50	5.75	2.90E+10	6.22E+10	3.32E+10	53.4%
25	13.02	6.56E+10	3.55E+11	2.90E+11	81.5%
10	40.68	2.05E+11	5.83E+13	5.81E+13	99.6%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range



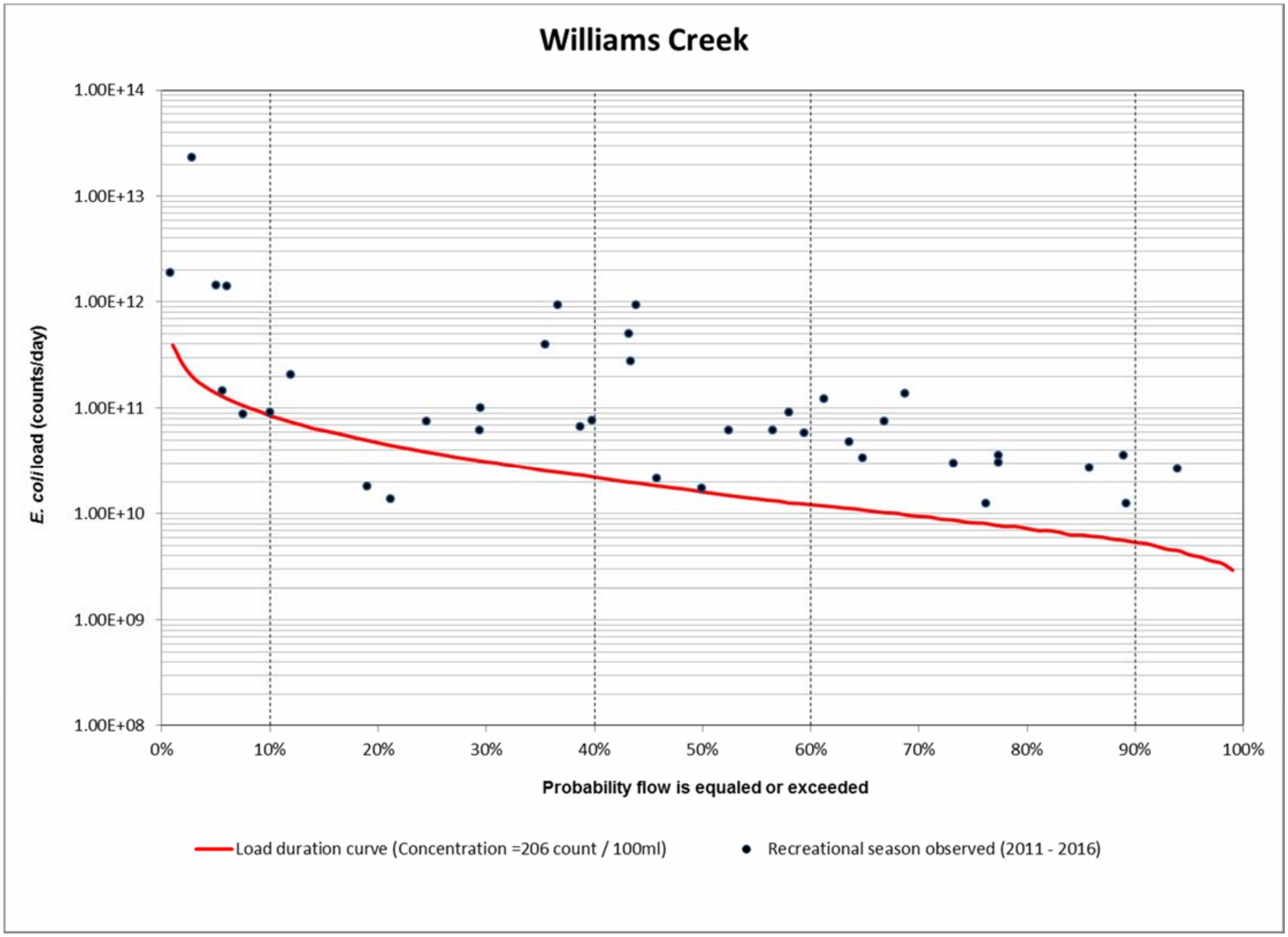
Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Keifer Creek					
Percent of Time Flow is Equaled or Exceeded	**Flow (cfs)**	**Loading Capacity (counts/day)**	**Existing Loading (counts/day)**	**Reduction Needed (counts/day)**	**Reduction Needed (%)**
95	1.89	5.83E+09	2.69E+09	None	0.0%
75	2.92	9.01E+09	5.19E+09	None	0.0%
50	4.39	1.35E+10	2.21E+10	8.58E+09	38.8%
25	8.43	2.60E+10	2.66E+10	6.18E+08	2.3%
10	18.92	5.83E+10	3.14E+11	2.55E+11	81.4%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range



Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Mattese Creek					
Percent of Time Flow is Equaled or Exceeded	Flow (cfs)	Loading Capacity (counts/day)	Existing Loading (counts/day)	Reduction Needed (counts/day)	Reduction Needed (%)
90	0.02	8.77E+07	6.81E+07	None	0.0%
75	0.75	3.77E+09	5.02E+09	1.25E+09	24.9%
50	2.64	1.33E+10	1.86E+10	5.25E+09	28.3%
25	7.31	3.68E+10	1.71E+11	1.34E+11	78.5%
10	29.58	1.49E+11	1.46E+12	1.31E+12	89.8%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range



Estimate of Bacteria Load Reductions Needed to Attain Water Quality Standards in Williams Creek					
Percent of Time Flow is Equaled or Exceeded	**Flow (cfs)**	**Loading Capacity (counts/day)**	**Existing Loading (counts/day)**	**Reduction Needed (counts/day)**	**Reduction Needed (%)**
95	0.81	4.10E+09	2.68E+10	2.27E+10	84.7%
75	1.63	8.19E+09	3.84E+10	3.02E+10	78.7%
50	3.19	1.61E+10	1.00E+11	8.40E+10	83.9%
25	7.49	3.78E+10	9.26E+10	5.48E+10	59.2%
10	16.88	8.51E+10	7.25E+11	6.40E+11	88.3%

Existing Loading = Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range

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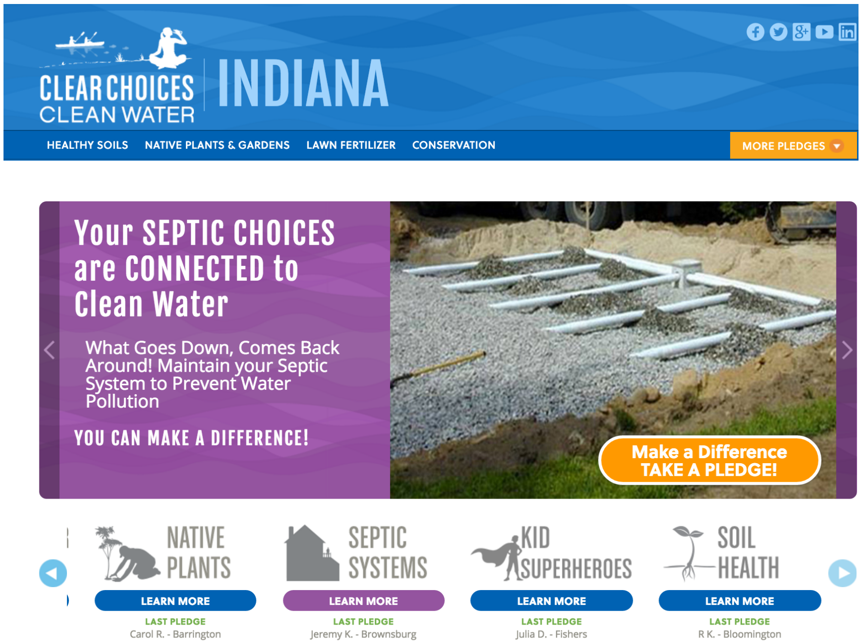
APPENDIX C

CLEAR CHOICE CLEAN WATER PROGRAM DESCRIPTION

Clear Choices Clean Water Program

Description and License Structure

Clear Choices Clean Water (*Clear Choices*) is a social marketing initiative that increases public awareness about the choices we make and the impacts those choices have on our lakes, streams, and groundwater. **The ultimate vision for the initiative is to change people's behavior while implementing a program that easily allows for the evaluation of educational successes and environmental impacts at the same time.** *Clear Choices*, as it was first developed for the Central Indiana region, has several topical, action-oriented campaigns underway (lawn fertilizer, pet waste, native plantings, septic system maintenance, water conservation, and volunteer service, as well as the new 2016 kids pledge and soil health campaign). More pledge modules are in development with new partners, including a Pollinator Protection pledge and a Forest Stewardship pledge. A vast potential exists for topics to be added to the platform. This flexibility provides for a dynamic outreach program that can grow over time or be changed seasonally or regionally to focus on 'hot topics'. *Clear Choices* staff is happy to work with Affiliates or corporate sponsors on the development of new topical pledges to fit various outreach needs. Affiliates can choose which pledge campaigns to include in their program.



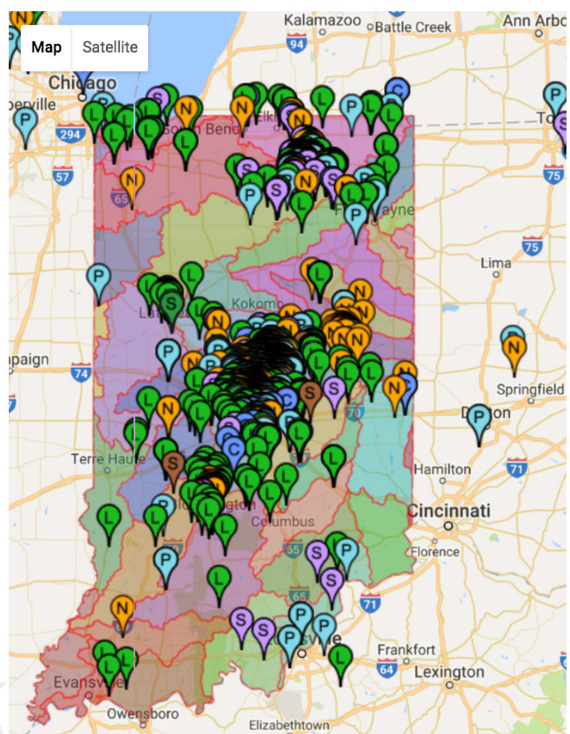
The focal point of the initiative is a modern, interactive website that includes several additional multimedia and grassroots marketing elements. Visit Indiana's site as an example (Indiana.clearchoicescleanwater.org). Individuals who take the action pledge are immediately "put on the map." The map provides immediate feedback and gratification for the participant that they are doing their part to make a difference. It helps people visualize how their pledge of action, alongside thousands of other pledges, will impact water quality in their watershed. **For the program administrators and Affiliates, the map also provides real-time evaluation of the success of the campaign.**

In addition to map recognition, the feedback participants receive includes an estimate of water quality improvements (e.g. decrease in algae or bacteria in a nearby stream, lake, or river) or an estimate of water saved based upon their "clear choice" behavior pledge. They also have the opportunity to invite others via social media or email to join them in making a difference. Follow-up emails and reminders are sent to participants following their pledge using automated email responders, thus limiting the burden on the program's administrators to maintain communication with participants.

According to social marketing research, in order to change behaviors, individuals need to feel like their actions matter and are socially acceptable, encouraged, and positively recognized. They need to be empowered to act. The *Clear Choices* program does this by providing information, access to materials, and 'how to' instructions. **The *Clear Choices* initiative breaks down knowledge and resource barriers while providing an opportunity for everyone to do something and make their mark on the watershed map.**

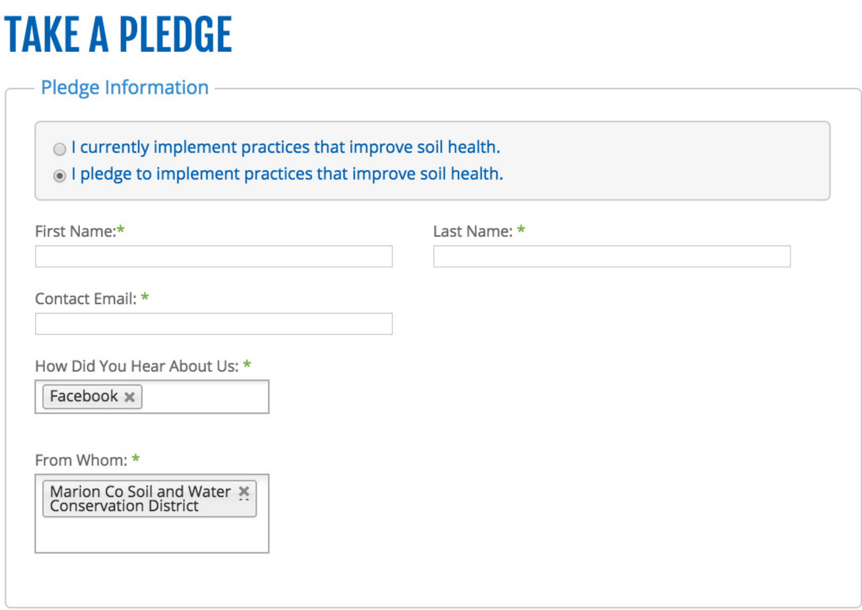
Reaching people with messages about simple behavior changes not only improves water quality by cumulative impact, but begins to incubate a culture of stewardship that transcends the family, business, or classroom. While the program was developed for Indiana, it is applicable to other states and regions and has been successfully launched in other watersheds. **Due to its success, this nationally award-winning program is now available throughout the United States and Canada. The opportunity for *Clear Choices* Affiliates to host their own site, complete with localized resources and mapping features, is perfect for organizations who want a jump start on launching a proven water stewardship program in their community. Learn more about becoming an Affiliate at Clearchoicescleanwater.org.**

CLEAR CHOICES MAP OF PLEDGES



Program History and Strategy

Created in 2009 by the leadership of two Indiana watershed organizations, *Clear Choices* has worked to increase awareness about various choices individuals can make that will have positive impacts on streams and lakes. This is evidenced by the thousands of pledges currently visible on the Indiana *Clear Choices* website. Annual marketing initiatives that include the use of themed postcards and banner displays, radio promotions, TV commercials, billboards, and social media outreach have been responsible for many of the pledges to date. Likewise, small group presentations and the use of local partners' grassroots communication venues have also proven to be successful outreach strategies. **Having multiple trusted voices lift up the same messages and promote the same call-to-action platform not only leverages outreach resources,**


TAKE A PLEDGE

Pledge Information

- I currently implement practices that improve soil health.
- I pledge to implement practices that improve soil health.

First Name:* Last Name: *

Contact Email: *

How Did You Hear About Us: *
Facebook

From Whom: *
Marion Co Soil and Water Conservation District

but ensures a consistent message throughout a community.

Under the direction of Purdue University, *Clear Choices'* founders conducted several social indicator surveys whose results provided the core foundation for the campaign's messages and delivery mechanisms within the social context of Indiana communities. **With the help of national experts, key elements of social marketing were then woven into the program to ensure the campaign's messages would strike an emotional cord and be relatable to the target audiences.** The social indicator survey serves as an important baseline measurement. A follow-up survey was conducted in 2015 in central Indiana. *Clear Choices* Affiliates are provided a template social indicator survey and implementation guidance if they would like to consider conducting a survey in their area. It is not necessary to conduct such a survey to use the *Clear Choices* platform or materials, but it may provide some insight about the local social context that could help tailor messages, images, and delivery venues for even greater impact. Social indicator surveys also provide valuable baseline data with which to measure future outreach successes.

The pledge form itself, by way of the information it collects from the pledge taker, is also an invaluable mechanism for outreach planning, strategy, and evaluation. Program administrators can review how pledge takers arrived at the site, as well as gain access to pledge takers emails that can be used to reach them in the future. Another important evaluation feature is the ability to measure outcomes achieved from the various calls-to-action. **Underpinning the program are strong scientific and technical resources that provide invaluable, measureable results related to pollution reduction and water saved.** These reductions show the impact the individual, as well as the program as a whole, have on the environment. These data provide important outcome measurables that can be used in grant or permit reporting. The pollution-reduction data also help to empower the individual by providing immediate feedback regarding the positive impact their contribution ('choice') has on local water quality. Pledge takers know they are making a difference!

In its first few years alone, *Clear Choices* has developed a reputation as a fun, engaging, easy, and impactful outreach program. The results speak for themselves as the program sees more pledges, National Affiliates, Sponsors, and Outreach Partners each year, along with the potential for preventing large amounts of pollution from reaching local waterways. As the first and only program of its kind, *Clear Choices* has been sought out by watershed groups and utilities from several other states and has leveraged hundreds of thousands of dollars in outreach funding since its inception in 2009. **With this support, a diverse cache of multimedia assets and a robust portfolio of social media resources exist to support program messages, all of which are shared among all Sponsors and Affiliates.**

In Indiana, the *Clear Choices* program is licensed by official sponsors and has a growing Giving Circle of supporters, as well as a strong network of local outreach partners. It provides the platform for many community partners to rally around common messages and a united call to action campaign that together leverage and amplify education dollars. *Clear Choices* is the perfect fit for stormwater, wastewater, and drinking water programs, as well as watershed outreach activities and corporate stewardship efforts.

Clear Choices Clean Water is a single-member LLC of the White River Alliance based in Indianapolis, Indiana and is protected by trademark. All Sponsors and Affiliates enter into license agreements with *Clear Choices Clean Water, LLC.* These license agreements help guide resource sharing, program implementation, and brand protection.

Evaluation Tools

The interactive map and pollution reduction estimates are the keys to what makes this strategy different. First, participants see at a glance how many individuals have made a pledge and where they live. When they take a pledge, the map provides immediate feedback and gratification that they are doing their part in a very tangible, relatable way. Since the information is public, it helps insure follow-through on pledge commitments. For the Affiliates and sponsors, the map provides a real-time evaluation of the success of the campaign. Additional valuable data can also easily be mined out of the program's database and Google analytics. Some of this includes:

- # Pledges Taken
- All information on each pledge taker including name, address, pledge taken, pollution reduction numbers, and 'how did you hear about' details
- # Visitors to Website and Website Analytics
- "Shares" on Social Media and Sharing Analytics
- Additional basic metrics available via the back-end administrator's site

All *Clear Choices* Affiliates will receive an annual report of program metrics and key analytics for their unique sub-domain, as well as information on the national program. As noted above, sample social indicator surveys will be provided for optional use in Affiliate communities to help refine program messages and measure knowledge and behavior change in the public. Basic website set-up, as well as best practice social marketing and evaluation tools will be made available to all Affiliates in order to help make *Clear Choices Clean Water* a huge success in each community.

Clear Choices Clean Water Components

Website

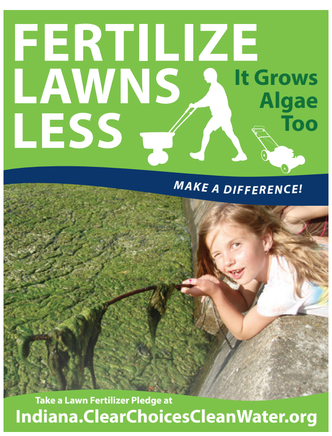
The heart of the *Clear Choices* program is an award-winning website. Clearchoicescleanwater.org is the gateway webpage for all *Clear Choices* domains, which includes all national Affiliate locations. Each officially-licensed Affiliate will also have a unique sub-domain, as well as the capacity to customize their website to best serve their geographic area. This includes a unique pledge map, Affiliate and sponsor recognition, localize technical resources, and more.

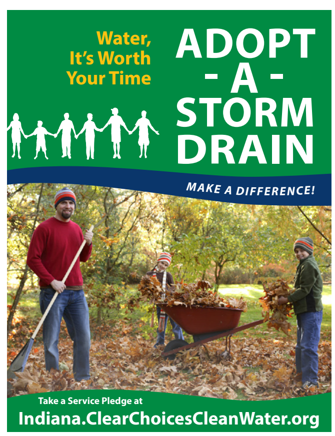
Examples of unique sub-domains:

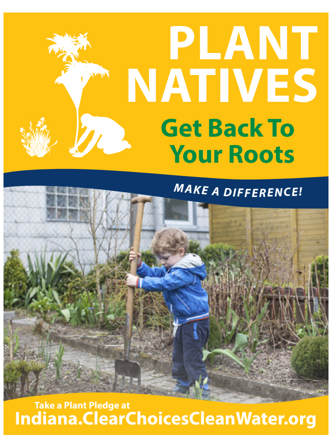
www.toledo.clearchoicescleanwater.org

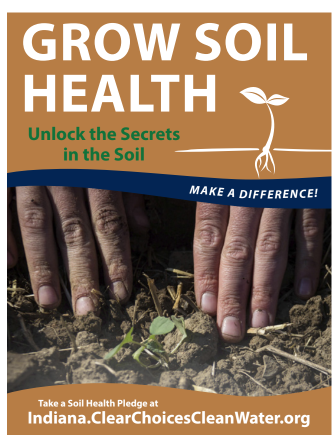
www.mydelawareriver.clearchoicescleanwater.org

www.maricopacounty.clearchoicescleanwater.org









Each sub-domain and included pledges are able to be tailored to the specific geographic area of each Affiliate. The specific set of pledges included under each Affiliate's sub-domain will consist of whatever combination of pledges they chose to include in their own *Clear Choices* program (or new pledges they choose to create in coordination with the *Clear Choices* team). Each licensed Affiliate will then be provided with information, materials, and training to administer their website. Pledges, pledge taker information, and metrics associated with each pledge will be available to the Affiliate through the administrator portion of the sub-domain website.

Affiliates are immediately provided access to a variety of marketing and collateral pieces that they can easily customize for their audiences or simply add their logo and use them as they are. Some of these include:

Mass Media: Access to billboard design files, TV and radio spots
Social Media: Facebook and Twitter posts, annual content calendar
Printed Materials: Access to design files for postcards, bookmarks, stickers, youth "Clean Water Superhero" guide, etc.
Branded Products: Access to promotional items such as native seed packets, pet waste bags, rain gauges, water clocks, water bottles, pint cups, sun visors, and similar products as available.
Social Indicator Survey: Access to survey template and implementation guidance

Similarly, by being a licensed Affiliate, any new materials created by any Affiliate nation-wide will be available for any other Affiliate to utilize during their license period. *Clear Choices Clean Water* is somewhat of an intellectual cooperative in this regard by providing the framework for sharing and leveraging resources among all Affiliates.

License Agreement
A license agreement will be entered into between *Clear Choices Clean Water* LLC and each licensee. Individual entities and organizations may (and are encouraged to) enter into an agreement as a single licensee if they have an MOU or other partnership agreement with each other (verses each MOU participant entering into a separate *Clear Choices* license). If more than one entity enters into a single license agreement, a single organization will be listed at the sole point of contact for the *Clear*

Tim Stottlemyer
MS4 Program Manager
City of Noblesville

"*Clear Choices Clean Water* is the best stormwater public education program I have used in the past 10 years. Having a program that is based on solid science and professionally built was way beyond my reach of my local stormwater program however; by partnering with others we leveraged not only our own funds but also other industries who also benefit from water quality education."

Choices Affiliate license, but all partners will be considered licensees and receive recognition as official sponsors on the Affiliate site.

All start-up license agreements are for a two year (24 month) period. Two-year renewal agreements will follow. Fees are based in part on the number of pledge campaigns selected, the population of the area served, and a base set-up fee (see details below). For more information or questions, please contact Jill Hoffmann at jill@clearchoicescleanwater.org or 317-672-7577.

Pricing & Materials

- Initial license fee for 24-month service period: $10,000 plus $30 per 1,000 of population within a specified service or geographic area.
- License renewal fees for an additional 24-month service period: 50% of the original fee with a minimum fee of $6000 ($3000/yr).

Affiliates will have access to any collateral materials design files or AV resources that are developed by any other Affiliate *within active license periods.* Additional fees may apply depending upon the Affiliate's desire for additional materials and/or program growth (new pledges, coverage area expansion, etc.).

Please see the table of benefits for Licensed Affiliates on the following page.

National Affiliates

Licensed National Affiliate Benefits

Your choice of 1 to 4 pledges (additional pledges can be added, see pricing below)* **
Creation of a unique and personalized sub-domain of *Clear Choices Clean Water* and up to 12 hours of material customization support and training
Initial licensee consultation and help incorporating *Clear Choices* into existing education programs and/or websites (up to 12 hrs)
Inclusion of Affiliate's web link on Clear Choices master sponsors page; sub-domain and Affiliate location included on national map (national homepage) providing additional exposure and promotion
Right to use all existing collateral materials that support individual pledges and the program as a whole; these can be customized with modified text, maps, or photos and can be tagged with Affiliates' logos (eg. postcards, posters, billboards, banners, youth education packet materials, etc.); design adjustments can be done in-house by the Affiliate (design files provided) or by *Clear Choices* staff (prices below**); adjustments must follow procedures outlined in the license agreement
Right to use audio-video files such as radio and TV spots; these can be used to when making media buys or used in a variety of electronic outreach strategies; it is also possible to modify these to include Affiliates' name(s)/logo(s) at the conclusion of the spot (please call for pricing about such a modification)
Right to use any new materials developed within the license period; *Clear Choices* staff is available to help customize and coordinate production of materials as needed (prices below**); adjustments must follow procedures outlined in the license agreement
Right to use logos, taglines, etc. on promotional materials as well as access to existing design files for promotional materials; these can be customized with Affiliates' logo(s) (eg. seed packets, rain gauges, bookmarks, pet waste bags, etc.); design adjustments can be done in-house by the Affiliate (design files provided) or by *Clear Choices* staff (prices below**)
Prepared social media posts for use in social media venues to promote the program year round; posts organized by season in a content calendar
Opportunity to participate in annual 'bulk-buy' purchases of select promotional material for material cost-savings (no individual logos, general program branding)
Basic social indicator survey template to measure and gauge local audience knowledge and values; additional survey development or customization support available from *Clear Choices* staff (prices below**).
Annual report of pledges, pollution reduction numbers, and website analytics
Quarterly customer service support calls to provide program support and share content, strategy, and/or product updates

**Additional existing pledges may be purchased for $3000. Mechanics/web architecture are provided as-is. Any changes to pledge mechanics/web architecture will require additional fee.*

***Additional hours of IT and content support for customizing pledges, creating supporting materials, outreach consulting, or developing new pledges are available for $75 per hour.*

APPENDIX D

PRIVATE LAND SERVICES – LANDOWNER ASSISTANCE PROGRAM – MISSOURI DEPARTMENT OF CONSERVATION

Missouri Department of Conservation

PRIVATE LAND SERVICES

Landowner Assistance Program

Serving nature and you™

Did you know…
93% of Missouri lands are currently in private ownership
2% of Missouri lands are owned or managed by the Department

Connecting Communities to Nature

The Missouri Department of Conservation offers financial assistance to communities interested in habitat and natural resource management every year.

Examples of applicable projects include:

- Green infrastructure planning & installation
- Native landscaping
- Invasive plant species management
- Turf to prairie conversion
- Prescribed burning
- Riparian corridor enhancement
- Wetland development

Native plants provide important food sources to pollinators such as birds, bees, and butterflies.

Permeable pavement, rain gardens, and native landscaping absorb stormwater and filter pollutants which improves the water quality in our rivers and streams.

Nonprofits, city/county units of government and non-government entities are eligible to apply. Assistance is available on a first come, first served basis with budget cycles beginning on July 1 each year. All applicable projects are subject to reimbursement caps per cooperator per year. Most projects will be reimbursed at a rate of 50% of total costs up to a maximum limit but some restrictions apply. Availability of funded practices may vary annually.

For additional information regarding landowner assistance and project eligibility, please contact Josh Ward, Private Land Conservationist at: 636-441-4554 or Josh.Ward@mdc.mo.gov

Private Land Services Division – What We Do

Almost 93 percent of Missouri's land is owned by private citizens. Consequently, the fate of Missouri's forest, fish, and wildlife resources rests largely in the hands of private landowners. These landowners are vital partners in the Department of Conservation's efforts to conserve the state's valuable natural resources.

The Department of Conservation has assisted Missourians in managing their land for more than 75 years, and both the need and demand for these services continues to grow.

The staff of the Private Land Services Division are experienced professionals who identify solutions compatible with landowner and community goals for the sound management of local fish, forest, and wildlife resources.

Green Infrastructure

We can provide technical assistance on streetscape design, trail development, and bioretention projects. In addition, we can help planners and municipal officials identify the natural resources in their communities that should be conserved during new development projects.

Native Landscaping

We can offer native plant and tree recommendations to design formal landscapes that are aesthetically pleasing and functional; providing both urban wildlife habitat and onsite stormwater management.

Forests

We can show you how to use forest management practices—such as timber stand improvement, tree planting, and alternative forest crops—to benefit wildlife and maximize profits.

Wildlife

We can help draft a management plan to improve your property's food and cover for wildlife. And if wildlife become a nuisance or cause damage, we can suggest ways to solve the problem.

Natural Communities

We can help you identify and restore native natural communities—including prairies, glades, and savannahs—by establishing or enhancing native plants, using prescribed burns, and controlling invasive vegetation.

Wetlands and Aquatic Resources

We can help you restore proper hydrology in areas adjacent to rivers and streams to improve water quality and provide habitat for waterfowl and other species. We can also design filter and buffer strips to control erosion while also improving water quality and wildlife habitat. In addition, we can advise you regarding small impoundment management issues, such as nuisance aquatic plant control in ponds and lakes.

Private Land Services Division…

Helping landowners meet their land management objectives

in ways that enhance fish, forest, and wildlife conservation

CONSERVATION DEPARTMENT MISSOURI

APPENDIX E

PROPOSED LONG-TERM STREAMFLOW AND WATER-QUALITY MONITORING OF RESTORTATION EFFORTS IN THE KIEFER CREEK WATERSHED AND COST ESTIMATES – U.S. GEOLOGICAL SURVEY, MISSOURI WATER SCIENCE CENTER

Appendix E1

Proposed Long-Term Streamflow and Water-Quality Monitoring of Restoration Efforts in the Kiefer Creek Watershed

Final Version 1.5 9-19-2017

Background:

Kiefer Creek is on the Missouri Department of Natural Resources (MDNR) 2018 proposed listed of impaired waters (303d list) as being impaired for the fecal indicator bacteria *Escherichia coli* (*E. coli*) and having chloride concentrations exceeding the chronic aquatic life standard. Kiefer Creek is a small (6.7-mi^2) watershed that drains into the Meramec River. The Creek has two main branches; Kiefer Spring branch on the north (about 3.9 mi^2), and Sontag Spring branch on the south (about 2 mi^2), these two tributaries join about 1.3 miles (mi) upstream from the Meramec River to form Kiefer Creek. The Kiefer Spring branch watershed is mostly developed with suburban neighborhoods and some retail land use in the uppers parts of the watershed. The Kiefer Spring branch watershed has a large number of stormwater sewers draining these developed areas, and much of the watershed is served by sanitary sewers. In contrast, the Sontag Spring branch watershed is a mixture of mostly low-density, older, residential, rural hobby farms, and undeveloped land. There are few stormwater sewers, and most of Sontag Spring watershed is not served by sanitary sewers, and presumably septic tanks are abundant in non-sewered areas. The lower 1-mile reach of the Creek within Castlewood State Park is popular for wading and swimming.

Fecal bacteria samples have been collected at three main locations in the watershed since the mid-1990s. A U.S. Geological Survey (USGS) streamgage was installed during 1996 on the Kiefer Spring branch at Castlewood Road about 0.2-mi upstream from the confluence of Sontag Spring branch (Site A; figure 1). The streamgage continues to be in operation (funded by the St. Louis Metropolitan Sewer District [MSD]) and the USGS collected water-quality samples at this site from 1996 through 2004. Since about 2005, the MSD has collected bacteria samples from the lower part of the creek at Kiefer Creek Road in Castlewood State Park (Site C). The Missouri Coalition for the Environment (MCE) Kiefer Creek Draft Watershed Plan (http://kiefercreekwatershed.weebly.com/) also indicates bacteria samples were collected at a third site (Site B) on Sontag Spring branch at New Ballwin Road (about 0.1-mile upstream from the confluence with the Kiefer spring branch) from 2005-2012 although this data is not contained in the web-based Missouri DNR 2018 proposed 303d list worksheets (http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm). Data in the MCE draft watershed plan also contains additional bacteria samples collected during 2012 from the USGS streamgage (Site A).

The MCE draft watershed plan noted that *E. coli* densities at the MSD site downstream in Castlewood State Park (Site C) were smaller than those at the USGS streamgage (Site A) mostly because the USGS collected samples over a wider range of flow conditions (sampling focused on obtaining higher flow samples) compared to the MSD sampling that tended to occur at low or stable flow conditions. The MCE draft plan also presented data on *E. coli* densities in samples from the Sontag Spring branch (Site B) that tended to be larger than those from the downstream MSD site (Site C), but perhaps not having the extreme range as those from the Kiefer Spring branch (Site A). A comparison of *E. coli* samples from site B to the discharge at the USGS streamgage (Site A) in the MCE draft plan indicated that the bacteria samples at Site B tended to be collected mostly during low flow conditions (e.g. only one sample was collected at a Site A discharge of greater than 10 ft^3/s). A review of the MDNR 2018 proposed 303d list data for Kiefer Creek indicates that since 2007, *E. coli* concentrations exceeded the standard during 2016 (geometric mean of 218.7 colonies per 100 milliliters [col/100mL]), 2012 (geometric mean of 513.9

col/100mL), and 2009 (geometric mean of 200.2 col/100mL) at the downstream MSD sampling site (Site C).

Kiefer Creek also contained increased chloride concentrations that present a threat to aquatic life. Water-quality samples collected by the USGS (1996-2005) at the Kiefer spring branch streamgage (Site A) had elevated chloride concentrations during winter months (52 to 1,300 milligrams per liter [mg/L]; median of 245 mg/L) that were above aquatic standards, increased concentrations of total phosphorus (<0.02 to 3.5 mg/L; median of about 0.05 mg/L), and detection of the pesticide diazinon (>0.02 to 0.99 ug/L). The USGS sampling protocol was focused on ensuring the collection of samples during higher flow events. More recent MSD sample results (2014-2016) at site C were used by the MDNR to place Kiefer Creek on the proposed 2018 list of impaired waters for exceeding the chronic criterion for chloride (230 mg/L) more than once in the last three years.

Watershed Project Efforts

The draft bacteria section of the MCE Kiefer Creek Watershed plan indicated that septic systems were the largest non-point loading of bacteria (more than 80%) in the watershed. This percentage is based upon a series of general assumptions, but compared to domestic animals (including livestock), human sources and especially the number of older and likely failing septic tanks seem to be an important possible source of bacteria to Kiefer Creek. The draft plan indicated the majority of the estimated bacteria load (about 55%) is from the Sontag Spring branch watershed and less than 30% load from the Kiefer spring branch.

The first phase of watershed restoration efforts will focus on channel and streambank stabilization efforts on the lower section of Kiefer Creek mostly within the State Park and are projected to begin 2018-2020. A second phase of intense public outreach and education is planned 2019-2025 that will include teacher education. The USGS is interested in assisting and participating in these efforts as they align with local watershed group activates in this proposed monitoring. A third phase of effort will focus on raising awareness on stream health and water protection and include continued stream monitoring for pollutants at three suggested sites and address onsite septic systems (2019-2025).

Proposed Monitoring Scope of Work (revised Sept 15, 2017)

The draft bacteria section of the watershed plan indicates enhanced monitoring for fecal bacteria is needed and that monitoring should ensure that samples are collected across the range of hydrologic conditions. Efforts to address *E. coli* standard exceedances in Kiefer Creek will be most successful if restoration efforts can be focused on the primary non-point sources and specific areas or stream reaches contributing substantial *E. coli* loading in the watershed. Interpreting the existing *E. coli* data collected from the three sites is problematic because samples were not collected in a methodical manner and there are inconsistent sampling periods with limited flow data for some samples, and samples from the various sites did not span equivalent ranges of hydrologic conditions. In addition, data are available from only three sites in the watershed and data density is not large (seven or fewer samples per year since 2005).

The proposed monitoring plan focuses on a two-year baseline intensive sampling effort that establishes fixed and consistent sampling at six sites combined with distributed sampling across the watershed under various hydrologic conditions via sanitary/seepage surveys. A continuous stage-only gage will be installed on the Sontag Spring branch. Results from this intensive effort will be augmented with microbial source tracking (MST) at selected stream and sediment sites. The results of the baseline intensive effort will be summarized in year three to inform future restoration efforts, provide a baseline from which to assess efficacy of future restoration activities, and optimize longer-term but less-intensive subsequent monitoring.

During the initial baseline intensive effort, routine monthly sampling will be done at four primary sites (A, B, C, and E [Kiefer Creek upstream from the USGS gage at New Ballwin Road]), recreational season sampling at a new site (Site D) near the railroad bridge in Castlewood State Park, and quarterly monitoring of Kiefer Spring (Site F) just upstream from the existing streamgage. Samples will be analyzed for *E. coli* bacteria, suspended sediment, and quarterly for major ions and nutrients. To assist with identification of *E. coli* sources and corroborate the modeled loading presented in the draft watershed plan, distributed sampling will be done as a series of sanitary survey/seepage surveys along the Kiefer Spring branch, the Sontag Spring branch, and the main steam of Kiefer Creek. During the surveys, the stream will essentially be walked (where access can be obtained) and samples collected from multiple locations across the watershed within a one- or two-day period. By noting and sampling all inflows (tributaries, small springs, and seeps) and measuring field parameters (discharge, temp, pH, dissolved oxygen, and specific conductance) and collecting samples at intervals along the main branches and screening for chloride and optical brighteners, the spatial footprint of *E. coli* concentrations can be obtained and perhaps elucidate obvious *E. coli* sources such as septic influences. These studies will be conducted four times during the first two years at various hydrologic conditions (such as summer low flow, spring stable but “wet” condition flow, fall, and winter) to provide additional data on the effect of overall hydrologic conditions on the variability of *E. coli* and chloride concentrations (selected samples will be analyzed for major ions). The routine monitoring and sanitary/seepage surveys will inform microbial source tracking (MST) sampling of selected sites (sediment and water) to assess the predominance of human genetic *E. coli* markers in the samples.

The monitoring plan contains specific work tasks that can readily be modified upon discussions with stakeholders and local volunteer groups, and flexibility is paramount to allow for incorporation of local stream teams or other partners to participate in the monitoring effort to the level of their ability and interest. Involvement of local partners will allow increased local ownership in the process, increase awareness, provide for USGS to educate local partners, teachers, and students in water-quality monitoring efforts, and optimize resources. The USGS will provide a backbone of routine and event-based data and sampling efforts can be adjusted over time as best management practices (BMPs) are implemented and local groups are engaged.

<u>Proposed Monitoring Tasks:</u>

In addition to the existing MSD funded streamgage on the Kiefer spring branch at Site A, a continuous stage-only gage is proposed to be installed at site B on the Sontag Spring branch. After an intensive baseline sampling and data summary report are completed in year three, a continuous water-quality monitor is proposed to be installed at either Site A or site B. The framework of the existing streamgage at Site A and stage gage at Site B will provide a foundation on which local groups can build additional local driven educational and sampling efforts. The USGS will provide a backbone of routine and event-based data and sampling during years 1 and 2, and then reduced efforts in subsequent years with periodic intensive monitoring. This approach should allow for the expected lag time for restoration efforts to manifest themselves in water quality. Specific monitoring tasks are:

1. <u>Continue the existing streamgage</u> on the Kiefer spring branch that is supported by the MSD (USGS station 07019072; Site A).
2. <u>Install a new continuous stage-only gage</u> on the Sontag Spring branch (Site B). Continuous stage will allow context for sampling efforts done by others at this site that may not have the ability to measure flow. Having continuous stage also will allow assessment of the hydrologic condition of samples collected (e.g., rising stage, falling stage, peak stage, stable for 72 hrs, etc.).
3. <u>Establish additional routine sampling</u> sites on Kiefer Creek near the railroad bridge in Castlewood State Park (Site D), upstream of the Kiefer Spring branch streamgage near the intersection of Kiefer Creek Road and New Ballwin Road (Site E), and at Kiefer spring (Site F). Sampling also will be done at the current MSD site in Castlewood State Park (Site C) and on the Sontag Spring branch (Site B).

4. Monthly sampling at sites A, B, C, and E, and quarterly sampling of Kiefer spring (Site F). All samples will be analyzed for *E. coli* and suspended sediment, with major cations and anions and nutrients done quarterly.
5. Monthly Swim Area sampling along lower reach of Kiefer creek near RR bridge (Site D) for bacteria and suspended-sediment concentration (SSC) only during the recreational season (April-Oct).
6. Event sampling- During years 1, 2, 4, 5 and 9 USGS runoff event sampling will be done at sites A,B, and C. Three to five events per year and up to 5 samples per event will be collected and analyzed for bacteria and SSC. Up to 3 samples from each event also will be analyzed for nutrients. If a sampled event occurs during the winter after road salt application, samples will be analyzed for major ions. Sampling should cover the rise and falling limb of the hydrograph with samples from at least one event to include the tail-end of the hydrograph (flow at Kiefer spring streamgage at or below the 50^{th} percentile flow or about 2.5 ft^3/s).
7. Winter event sampling to target road salt effects. The USGS would provide training and supplies for the collection and analyze up to 27 samples collected by local volunteer/stream teams. This will reduce overall monitoring cost and provide for initial engagement of local citizens.
8. Sanitary/seepage surveys- Four surveys of the lower and middle reach of the Kiefer Spring branch and Sontag spring branches, and the lower section of Kiefer Creek are planned. The surveys are a literal “walk” of the stream with periodic flow and water-quality field measurements, sampling for bacteria, and screening for chloride and optical brightener concentrations (up to 60 sites) with up to 15 sites sampled for major ions. Surveys will be done during summer low-base flow, spring high-base flow “wet conditions”, mid-winter following snowmelt, and fall. It is proposed that during years 1-2, some local stream team participation during the surveys will occur as a training and outreach activity, and knowledgeable local residents can assist in survey planning efforts. When possible, the initial surveys should be done in conjunction with local outreach/volunteers and coordinated with MSD staff. The objective is to determine if selected stream reaches having inordinate bacteria or chloride loading can be identified. Subsequent periodic surveys could be completed by stream teams.
9. In-situ streambed sediment reconnaissance. Information from year 1 will inform year 2 reconnaissance streambed sediment sampling for *E. coli* that may be harbored in fine sediments that are mobilized during runoff conditions. This will focus on 8-12 previously identified areas of finer sediment accumulation, but will likely include samples from or near sites A, B,C, several locations within the swim/wading area within Castlewood State Park, and selected areas of concern identified during sanitary/seepage surveys. Sampling will be done twice during the recreational season.
10. Microbial source tracking (MST) to identify the primary origin of *E. coli*. This analysis would be done in year 2 on up to 24 samples. Possible samples submitted for MST would be two samples collected during moderate to base-flow conditions at sites A, B, and C, two samples from each of the main sites during an event, several samples from lower Kiefer Creek sediment and swim areas, or areas of high *E. coli* densities observed during the sanitary/seepage surveys. The MST will be bias to water samples having among the largest *E. coli* densities. Samples will be analyzed by the USGS Ohio microbiology laboratory for generic *E. coli*, human-specific, and possibly ruminant genetic markers.
11. Data Summary/reporting – The USGS will prepare a baseline report in year 3 summarizing all data collected during the first two years of intensive sampling. This will include a web-based data release for data not stored in the USGS National Water Information System (NWIS).
12. Continuous water-quality monitor at the existing MSD streamgage (Site A or B). Near the end of year 3, a continuous water-quality monitor will be installed to monitor temperature,

specific conductance, and turbidity. Beginning in year 4, USGS sampling will be reduced to recreational season sampling for *E. coli* and suspended sediment only at sites A, B, and C. During years 6, 10, and 15, regression equations will be developed to estimate *E. coli* from turbidity/suspended sediment concentrations. Changes in these relations will be useful in assessing the efficacy of *E. coli* BMPs.

13. Reduced USGS monitoring will be done during years 4-9, 11-14, 16-19, and consist of that specified in task 12 or task 6. Routine stream team monitoring will be done during years where USGS monitoring is reduced (*E. coli* only), and winter stream team chloride sampling will be done during years 1-5, 10, 15, and 20.

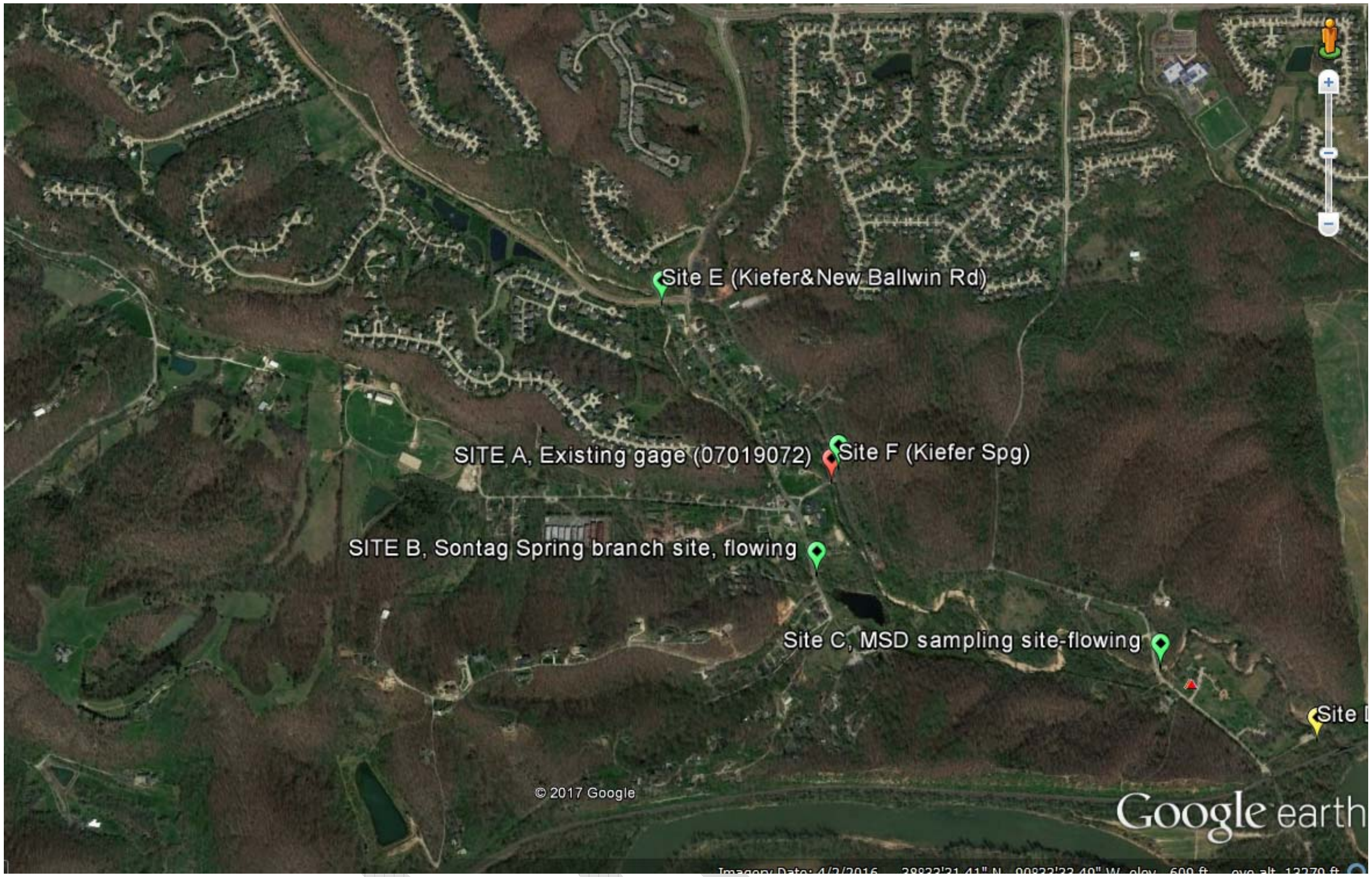


Figure 1. Location of proposed fixed monitoring sites in Kiefer Creek watershed.

Option F (orange shade indicates volunteer activity). Estimated costs based on year 1 beginning 2018.

Appendix E-2

Initial 2-year intensive focus on sanitary/seepage surveys of Kiefer and tributaries, new stage gage on Sontag Spring branch, and framework of fixed and events sampling at 6 sites with sediment and E.coli tracking (MST) in year 2 with USGS report in year 3. Then installation of QW monitor at existing gage and framework of streamsteam sampling and periodic USGS internsive monitoring efforts. Develop and update E.coli turbidity relation in year 7 and with periodic updates.

	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	Existing MSD streamgage (Site A) & QW sampling at site C (in-kind value).	$19,600	$19,992	$20,392	$20,800	$21,216	$21,640	$22,073	$22,514	$22,965	$23,424
Infrastructure (streamgage or Water quality monitor)	Install Continuous Water Quality monitor (Turbidity, Cond, Temp) at exiting streamgage (Site A) or Site B at end of Federal FY			$23,330							
	Install stage only gage on Sontag Spring branch and annual O&M	$20,239	$5,314	$5,420	$5,529	$5,639	$5,752	$5,867	$5,985	$6,104	$6,226
	12 month O&M for QW monitor (includes April-Oct E.coli & SSC sample after Year 4 at QW monitor & sites B & C)				$25,637	$32,272	$32,917	$33,576	$34,247	$34,932	$35,631
Routine and Event Sampling	Monthly monitoring 3 primary sites (A,B,C), additional upstream site on Kiefer springs branch (Site E), quarterly at Kiefer Spg (Site F), and recreational season sampling in Castlewood Park (D). Majors, nutrients, E.coli.	$23,247	$23,712			$25,134					$27,648
	Stream team routine monitoring (Sites A, B,C,D) E.coli only			$6,579	$6,711		$6,979	$7,119	$7,261	$7,406	
	Runoff event sampling (Sites A,B,C) 5 events, 3-5 samples/event). E.coli, major ions, nutrients.	$23,515	$23,985		$24,944	$25,443				$27,479	
	Stream team runoff event sampling (up to 9 samples from 3 sites), team runs E.coli only			$2,765		$2,876					$3,164
	Stream team winter chloride sampling (up to 9 samples at 3 sites (A,B,C), USGS analytical years 1,2,3.	$3,411	$3,479	$3,549	$5,240	$5,345					$5,879
	Support for local citizen science winter road salt monitoring (USGS analyze 27 samples for major ions) through year 3.	$6,871	$7,009	$7,149							
Bacteria sources	Two sanitary/seepage surveys per year(turn over to citizen science in year 3). USGS E.coli, major ions, flow, nutrients	$16,317	$16,643			$17,622					
	Stream team sanitary survey sampling at select USGS locations	$3,475	$3,544	$3,615		$3,760		$3,904		$4,060	
	In-situ streambed-sediment bacteria assessment		$8,102								
	Microbial source tracking		$36,403								
Bacteria predicative model	USGS Summary report year 3, then Develop SSC/E.coli/turbidity regression equations at gage site and periodic update of regression with USGS samples. USGS web model archive and summary report. Year 12 is summary of Year 11			$52,266			$40,448				$43,684
Subtotals	Gage/QW monitor subtotal	$20,239	$5,314	$28,751	$31,166	$37,911	$38,669	$39,443	$40,232	$41,036	$41,857
	Routine and event sampling subtotal	$57,044	$58,185	$20,042	$36,895	$58,798	$6,979	$7,119	$7,261	$34,885	$36,691
	Sanitary survey, sediment survey, microbial source tracking subtotal (data release)	$19,792	$64,692	$3,615	$0	$21,382	$0	$3,904	$0	$4,060	$0
	Turbidity/E coli regression model development subtotal (Model release)	$0	$0	$52,266	$0	$0	$40,448	$0	$0	$0	$43,684
	Total Estimated costs	$97,074	$128,191	$104,674	$68,061	$118,092	$86,097	$50,466	$47,493	$79,982	$122,232
	Value of MSD in-kind (gage & QW)	$19,600	$19,992	$20,392	$20,800	$21,216	$21,640	$22,073	$22,514	$22,965	$23,424
	TOTAL Project Value	$116,674	$148,183	$125,066	$88,861	$139,307	$107,737	$72,539	$70,007	$102,946	$145,656
	Stream team in-kind	$6,886	$7,024	$16,509	$11,951	$11,981	$6,979	$11,023	$7,261	$11,467	$9,043
	USGS Matching Contribution (1)	$20,200	$32,300	$13,126							
	Total In-kind/match	$46,686	$59,316	$50,026	$32,750	$33,196	$28,619	$33,096	$29,775	$34,431	$32,467
	Additional $ need for 40% 319 match	**$0**	**$0**	**$0**	**$2,794**	**$22,527**	**$14,476**	**$0**	**$0**	**$6,747**	**$25,795**

(1) USGS Match in Year 1 includes a $15,000 credit toward installation of stage gage on Sontag Spring branch and $5,200 in matching funds.

Option F (orange shade indicates volunteer activity). Estimated costs based on year 1 beginning 2018.

Appendix E-2

Initial 2-year intensive focus on sanitary/seepage surveys of Kiefer and tributaries, new stage gage on Sontag Spring branch, and framework of fixed and events sampling at 6 sites with sediment and E.coli tracking (MST) in year 2 with USGS report in year 3. Then installation of QW monitor at existing gage and framework of streamsteam sampling and periodic USGS internsive monitoring efforts. Develop and update E.coli turbidity relation in year 7 and with periodic updates.

	Description	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	Existing MSD streamgage (Site A) & QW sampling at site C (in-kind value).	$23,892	$24,370	$24,858	$25,355	$25,862	$26,379	$26,907	$27,445	$27,994	$28,553
Infrastructure (streamgage or Water quality monitor)	Install Continuous Water Quality monitor (Turbidity, Cond, Temp) at exiting streamgage (Site A) or Site B at end of Federal FY										
	Install stage only gage on Sontag Spring branch and annual O&M										
	12 month O&M for QW monitor (includes April-Oct E.coli & SSC sample after Year 4 at QW monitor & sites B & C)	$36,343	$37,070	$37,811	$38,568	$39,339	$40,126	$40,928	$41,747	$42,582	$43,433
Routine and Event Sampling	Monthly monitoring 3 primary sites (A,B,C), additional upstream site on Kiefer springs branch (Site E), quarterly at Kiefer Spg (Site F), and recreational season sampling in Castlewood Park (D). Majors, nutrients, E.coli.					$30,412				$32,624	
	Stream team routine monitoring (Sites A, B,C,D) E.coli only	$7,703	$7,857	$8,014	$8,174	$8,337	$8,504	$8,674	$8,848	$9,025	
	Runoff event sampling (Sites A,B,C) 5 events, 3-5 samples/event). E.coli, major ions, nutrients.										
	Stream team runoff event sampling (up to 9 samples from 3 sites), team runs E.coli only										$3,480
	Stream team winter chloride sampling (up to 9 samples at 3 sites (A,B,C), USGS analytical years 1,2,3.					$6,467					$7,114
	Support for local citizen science winter road salt monitoring (USGS analyze 27 samples for major ions) through year 3.										
Bacteria sources	Two sanitary/seepage surveys per year(turn over to citizen science in year 3). USGS E.coli, major ions, flow, nutrients	$19,737									
	Stream team sanitary survey sampling at select USGS locations	$4,223		$4,392		$4,567		$4,750		$4,940	
	In-situ streambed-sediment bacteria assessment										
	Microbial source tracking										
Bacteria predicative model	USGS Summary report year 3, then Develop SSC/E.coli/turbidity regression equations at gage site and periodic update of regression with USGS samples. USGS web model archive and summary report. Year 12 is summary of Year 11		$28,000			$48,053					$0
Subtotals	Gage/QW monitor subtotal	$36,343	$37,070	$37,811	$38,568	$39,339	$40,126	$40,928	$41,747	$42,582	$43,433
	Routine and event sampling subtotal	$7,703	$7,857	$8,014	$8,174	$45,217	$8,504	$8,674	$8,848	$41,649	$10,594
	Sanitary survey, sediment survey, microbial source tracking subtotal (data release)	$23,960	$0	$4,392	$0	$4,567	$0	$4,750	$0	$4,940	$0
	Turbidity/E coli regression model development subtotal (Model release)	$0	$28,000	$0	$0	$48,053	$0	$0	$0	$0	$0
	Total Estimated costs	$68,006	$72,927	$50,217	$46,742	$137,176	$48,630	$54,353	$50,595	$89,171	$54,027
	Value of MSD in-kind (gage & QW)	$23,892	$24,370	$24,858	$25,355	$25,862	$26,379	$26,907	$27,445	$27,994	$28,553
	TOTAL Project Value	$91,898	$97,297	$75,074	$72,096	$163,038	$75,009	$81,259	$78,039	$117,165	$82,581
	Stream team in-kind	$11,925	$7,857	$12,405	$8,174	$19,372	$8,504	$13,424	$8,848	$13,965	$10,594
	USGS Matching Contribution [1]										
	Total In-kind/match	$35,818	$32,227	$37,263	$33,529	$45,234	$34,883	$40,331	$36,293	$41,959	$39,147
	Additional $ need for 40% 319 match	**$941**	**$6,692**	**$0**	**$0**	**$19,981**	**$0**	**$0**	**$0**	**$4,907**	**$0**

[1] USGS Match in Year 1 includes a $15,000 credit toward installation of stage gage on Sontag Spring branch and $5,200 in matching funds.

APPENDIX F

BACTERIA LOAD AND BACTERIA REMOVAL EFFICIENCY BY BEST MANAGEMENT PRACTICE

Appendix F - Bacteria Loading Information

Land Use	Bacteria Event Mean Concentration (colony forming units/100 mililiters)	
	E. coli	Fecal Coliform
Commercial	3,958	4,500
Industrial	3,123	2,500
Institutional	2,666	3,100
Multi-use	4,502	5,081
Municipal	4,502	5,081
Open space	2,666	3,100
Residential – high density	7,043	7,750
Residential – low density	7,043	7,750
Residential – medium density	7,043	7,750
Transportation	1,410	1,700

Minnesota Pollution Control Agency Estimator for TMDL Annual Reporting

Assumed bacteria loadings for single-family and multi-family residential categories would be the same as the Minnesota residential bacteria loading. Assumed bacteria loadings for roads would be same as Minnesota transportation bacteria loading.

Best Management Practices Bacteria Removal Efficiency

Best Management Practice	Removal Fraction	
	E. coli	Fecal Coliform
Biofiltration*	0.75**	0.75
Infiltration (basin, trench, vault, bioinfiltration)	0.00	0.00
Filter strip	0.25	0.25
Landscaped roof (green roof)	0.90	0.90
Permeable pavement	0.70	0.70
Sand filter	0.75	0.75
Swale	0.00	0.00
Wet basin	0.70	0.70
Wetland	0.70	0.70

Minnesota Pollution Control Agency Estimator for TMDL Annual Reporting

*Biofiltration assumed to be same as bioretention (large properties and individual raingardens).
**A value of 0.50 means that the Best Management Practice removes half of the pollutant/bacteria. The values for infiltration BMPs is 0 because it is assumed that all pollutant/bacteria in infiltrated water is removed.

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APPENDIX G

KIEFER CREEK STREAM RESTORATION MASTER PLAN – STANTEC CONSULTING SERVICES FOR THE NATURE CONSERVANCY

Appendix G

Kiefer Creek Stream Restoration Master Plan

Stantec

Prepared for:
The Nature Conservancy,
Missouri Chapter

Prepared by:
Stantec Consulting Services Inc.

September 19, 2016

WORKSHEET 3-13: KIEFER CREEK BANCS MODEL SUMMARY								
Photo Point	Bank	BEHI	NBS	NC Erodibility Curve Erosion Rate (ft/yr)	Bank Height (ft)	Bank Length (ft)	Erosion Subtotal (ft^3/yr)	Sub-Total (tons/ft/yr)
B-1	Right	H	H	0.20	4.4	213.8	191.9	0.043
B-1	Left	VL	VL	0.00	1.0	188.6	0.0	0.000
B-2	Right	VL	VL	0.00	2.0	337.6	0.0	0.000
B-2	Left	M	M	0.06	2.7	146.7	23.8	0.008
B-3	Left	L	L	0.00	2.3	122.6	0.8	0.000
B-4	Right	VH	E	1.50	5.0	276.3	2071.9	0.361
B-5	Right	VL	VL	0.00	1.0	161.2	0.0	0.000
B-4, B-5	Left	VL	VL	0.00	1.0	365.7	0.0	0.000
B-6	Left	E	VH	5.20	6.8	176.0	6179.4	1.690
B-7	Right	VH	M	0.27	4.0	151.1	163.2	0.052
B-7	Left	M	M	0.06	6.5	230.3	89.8	0.019
B-8	Right	L	M	0.03	3.0	203.1	18.3	0.004
B-8	Left	M	L	0.01	1.0	187.4	1.9	0.000
B-9	Left	M	L	0.01	4.0	127.7	5.1	0.002
B-9 to B-11	Right	VL	VL	0.00	0.5	349.3	0.0	0.000
B-10	Left	H	M	0.11	12.0	93.4	117.7	0.061
B-11	Left	H	E	0.50	3.0	177.5	266.2	0.072
B-12	Right	M	VH	0.73	7.0	108.9	556.2	0.246
B-12	Left	L	L	0.00	2.0	39.2	0.2	0.000
B-13	Right	L	L	0.00	1.0	96.1	0.3	0.000
B-13	Left	L	L	0.00	3.0	79.2	0.7	0.000

Photo Point	Bank	BEHI	NBS	NC Erodibility Curve Erosion Rate (ft/yr)	Bank Height (ft)	Bank Length (ft)	Erosion Subtotal (ft^3/yr)	Sub-Total (tons/ft/yr)
B-14	Right	H	M	0.11	2.0	147.1	30.9	0.010
B-14	Left	M	H	0.16	3.0	132.7	63.7	0.023
B-15	Right	VL	VL	0.00	0.5	216.8	0.0	0.000
B-15	Left	H	H	0.20	4.0	237.5	190.0	0.039
B-16	Right	H	VH	0.98	3.0	125.1	367.9	0.142
B-16 to B-20	Left	VL	VL	0.00	2.0	535.5	0.0	0.000
B-17	Right	H	H	0.20	3.5	193.8	135.7	0.034
B-18	Right	L	M	0.03	3.5	148.2	15.6	0.005
B-19	Right	H	H	0.20	6.0	138.6	166.3	0.058
B-20	Right	VH	E	1.50	6.5	187.9	1832.0	0.469
B-21	Left	M	H	0.16	3.0	230.3	110.5	0.023
B-21to B-23	Right	VL	VL	0.00	1.0	340.1	0.0	0.000
B-22	Left	E	VH	5.20	10.0	145.7	7576.2	2.504
B-23	Left	H	M	0.11	10.0	94.1	98.8	0.051
B-24	Right	H	H	0.20	3.0	75.3	45.2	0.029
B-24 to B-26	Left	VL	VL	0.00	0.5	260.5	0.0	0.000
B-25	Right	VH	VH	1.20	5.0	104.7	628.5	0.289
B-26	Right	M	M	0.06	3.0	68.6	12.3	0.009
B-27	Right	L	VL	0.00	3.0	68.0	0.1	0.000
B-27, B-28	Left	VH	H	0.30	7.0	234.7	492.8	0.101
B-28	Right	H	M	0.11	3.0	113.0	35.6	0.015
B-29	Right	VL	VL	0.00	1.0	181.0	0.0	0.000

Photo Point	Bank	BEHI	NBS	NC Erodibility Curve Erosion Rate (ft/yr)	Bank Height (ft)	Bank Length (ft)	Erosion Subtotal (ft^3/yr)	Sub-Total (tons/ft/yr)
B-29	Left	L	M	0.03	3.0	165.3	14.9	0.004
B-30	Right	M	H	0.16	3.5	247.6	138.7	0.027
B-30, B-31	Left	VL	VL	0.00	0.5	307.5	0.0	0.000
B-31	Right	H	H	0.20	7.0	85.7	120.0	0.067
B-32	Right	M	M	0.06	3.0	261.4	47.1	0.009
B-32	Left	L	M	0.03	3.0	241.8	21.8	0.004
B-33	Right	E	M	0.50	5.0	102.0	255.1	0.120
B-33	Left	L	L	0.00	3.0	81.4	0.7	0.000
B-34	Right	H	M	0.11	5.0	235.5	123.7	0.025
B-34	Left	L	M	0.03	4.0	215.5	25.9	0.006
B-35	Right	M	VH	0.73	5.0	154.6	564.4	0.176
B-35, B-36	Left	VL	VL	0.00	1.0	318.7	0.0	0.000
B-36	Right	H	VH	0.98	5.0	143.7	704.0	0.236
B-37	Left	VH	VH	1.20	11.0	138.4	1826.6	0.636
B-37, B-38	Right	VL	VL	0.00	2.0	179.3	0.0	0.000
B-38	Left	M	H	0.16	7.0	152.4	170.7	0.054
B-39	Right	H	VH	0.98	5.5	380.9	2053.3	0.260
B-39	Left	VL	VL	0.00	1.0	352.0	0.0	0.000
B-40	Right	VL	VL	0.00	3.0	76.0	0.0	0.000
B-40	Left	VH	E	5.20	10.0	222.2	11554.5	2.504
B-41	Right	VH	H	0.30	2.0	167.6	100.6	0.029
B-41	Left	M	L	0.01	5.0	105.1	5.3	0.002

Photo Point	Bank	BEHI	NBS	NC Erodibility Curve Erosion Rate (ft/yr)	Bank Height (ft)	Bank Length (ft)	Erosion Subtotal (ft^3/yr)	Sub-Total (tons/ft/yr)
B-42	Right	VL	VL	0.00	1.0	66.7	0.0	0.000
B-42	Left	VH	M	0.27	1.5	48.1	19.5	0.020
B-43	Right	VH	VH	1.20	7.0	275.1	2311.1	0.404
B-43 to B-45	Left	VL	VL	0.00	1.0	351.1	0.0	0.000
B-44	Right	E	VH	1.50	12.0	128.2	2307.2	0.867
B-45	Right	VH	H	0.30	10.0	137.8	413.4	0.144
B-46	Right	VL	VL	0.00	3.0	64.1	0.0	0.000
B-46	Left	VH	E	5.20	12.0	167.9	10477.8	3.004
B-47	Right	H	L	0.04	8.0	123.1	39.4	0.015
B-47	Left	M	M	0.06	20.0	138.6	166.3	0.058
B-48	Right	H	H	0.20	7.0	351.7	492.3	0.067
B-48	Left	H	M	0.11	10.0	366.9	385.2	0.051
B-49	Right	L	L	0.00	3.0	148.3	1.3	0.000
B-49	Left	H	M	0.11	7.0	137.3	100.9	0.035
B-50	Right	VH	M	0.27	3.0	137.0	111.0	0.039
B-50	Left	H	H	0.20	5.0	105.6	105.6	0.048
B-51	Right	VH	VH	1.20	6.0	188.2	1354.8	0.347
B-51, B-52	Left	VL	VL	0.00	1.0	290.3	0.0	0.000
B-52	Right	E	VH	1.50	18.0	174.4	4709.0	1.300
B-53	Right	VL	VL	0.00	1.0	77.9	0.0	0.000
B-53	Left	H	M	0.11	15.0	95.4	150.2	0.076
B-54	Left	H	M	0.11	7.0	310.2	228.0	0.035

Photo Point	Bank	BEHI	NBS	NC Erodibility Curve Erosion Rate (ft/yr)	Bank Height (ft)	Bank Length (ft)	Erosion Subtotal (ft^3/yr)	Sub-Total (tons/ft/yr)
B-54	Right	VH	M	0.27	6.0	307.7	498.5	0.078
					TOTAL	**16337.0**	**63088.1**	**17.108**

APPENDIX H

PROPOSED TASKS FOR MATTESE CREEK WATERSHED MASTER PLAN AND GEOMORPHIC STUDY

Appendix H - Proposed tasks for Mattese Creek Watershed Master Plan and Geomorphic Study

1.0 Request for Proposal

EWG to prepare a RFP to seek a qualified environmental professional to conduct the watershed master plan and geomorphic study. The following tasks are proposed as part of carrying out the preparation of the plan and undertaking the geomorphic study:

2.0 Project Stakeholder Group

Identify, coordinate and meet a minimum of three times with stakeholders in the watershed. Stakeholders may include, but are not limited to, representatives from St. Louis County, DNR, MDC, MSD, US Army Corps of Engineers, Homeowners Associations and others.

3.0 Mattese Creek Basin Inventory

3.1 Data Collection and Coordination

Collect, compile and evaluate existing data sets (GIS data, Reports, etc.) in a report:

- Descriptive narrative of watersheds
- TMDL information
- 303d information
- Biodiversity and habitat information
- Open stream channels and minimum flood corridors
- Watershed boundaries
- Unique environmental resources
- Existing and future trails
- Parks and other publicly owned lands, conservation easements
- Urban storm drain system and detention/retention ponds
- Land uses
- Existing hydrology and hydraulics
- Hydraulic structural data
- Potential pollutant
- Municipal and public school facilities

3.2 Stakeholder review

- Distribute draft report to Stakeholders for review
- Incorporate comments into revised version of report

4.0 Public Involvement

4.1 Website

Create project website for public outreach.

- Website Content
- GIS interactive Mapping
- Public involvement published material distribution
- General information regarding masterplan
- Links to Stakeholder Websites

4.2 Public Open Houses

- Coordinate a minimum of three open house dates, time, locations, and content with stakeholders
- Open Houses will be announced on the Website and via changeable message signs in the watersheds. EWGCC will coordinate website and changeable message signs methods of announcing the Open Houses.
- Prepare all open house materials including a PowerPoint presentation, display boards, sign-in sheets, and comment card.
- Hold open house to inform public and gather feedback
- Write the public involvement report section summarizing the public participation process and results.

5.0 Geomorphic Evaluation

5.1 Perform a Geomorphic rapid assessment

- EWG to notify effected parcel owners of field work
- Walk the open channels

5.2 GIS Reach Setup

- Set up the field work in GIS which includes, but is not limited to delineate reaches, locate utilities, locate at risk structures, locate complaint site, locate data point prompts, locate special areas, and more.

5.3 Field Data Collection

- Walk each reach, take notes and photographs of observations, take Channel Condition Data Points, Reach Summary Data Points and Capital Improvement Project Data Points.

5.4 Geomorphic Project Identification

- Develop a list of geomorphic projects based on the results of the field data collection. Project will include those necessary for general reach management as needed.

5.5 Draft Report Sections

- Develop and submit a map of existing channel processes (e.g. stable, degrading, aggrading, etc.) based on the opinion of dominant process for each reach.
- EWG will distribute draft report section to Stakeholders for review. EWG will compile and email comments.
- Revise report section

6.0 Hydrology and Hydraulics

- Provide a summary of the existing Hydrologic and Hydraulic (H&H) information available for these study areas. The H&H information will be collected during the Basin Inventory effort.
- Using the H&H data, summarize flow rates and flow depths, as available, for the main stem and major tributaries in each study area.
- Draft report and distribute to stakeholders for comments and review
- Revise report sections

7.0 Water Quality

7.1 Data Summary

Summarize existing water quality data for Mattese Creek. Provide mapping of impaired streams, potential pollutant sources and other data as available:

- Sediment (from background data and Geomorphic)
- TMDL Bacteria and Chloride

7.2 Discussion

- Draft report of Potential Capital Improvement Projects
- Submit report to stakeholders for review
- Revise report section

8.0 Species Diversity

8.1 Data Summary

Summarize existing species diversity data for Mattese Creek. Provide mapping and data as available.

8.2 Discussion

- Draft report of Potential Capital Improvement Projects
- Distribute draft report section to Stakeholders for review.
- Revise report section

9.0 Habitat

9.1 Data Summary

Summarize existing Habitat data for Mattese Creek. Provide mapping and data as available.

9.2 Discussion

- Draft report of Potential Capital Improvement Projects
- Distribute draft report section to Stakeholders for review. EWGCC will compile and email comments.
- Revise report section

10.0 Capital Improvement Projects (CIP) and Program

10.1 Draft CIP

- Prepare CIP list to include project scope, estimated limits of construction, priority, initial cost opinion and draft concept plan and description, including a map of the watersheds with the locations of projects.
- Submit a draft CIP list for stakeholder review and comment. The list will include project description, recommendation, and location map.

10.2 Determine Project Prioritization

- Use existing local prioritization methodology

10.3 Develop Opinion of Probable Cost for each project

10.4 Develop Project Sheets for each project

- Project sheets shall include problem description, recommendation, discussion, cost estimate, project location map with proposed access and easements, and project site photo, among other items.

10.5 Other & Private Projects

- CIP section shall include project sheets for other projects which are not eligible for consideration as a CIP but address private or other problems that were identified during the master planning process.

10.6 Implementation

- Develop recommended implementation of CIP and programs including concept description of any recommended guidelines and programs

10.7 Draft Report Section

- Distribute draft report section for Stakeholder review
- Revise sections

11.0 Masterplan Deliverable

The Master Plan will include the reviewed sections from each of the above tasks as follows:

Table of Contents
Executive Summary
Section 1 - Introduction and Purpose
Section 2 - Approach
Section 3 - Basin Inventory
Section 4 - Geomorphology
Section 5 - Hydraulics & Hydrology
Section 6 - Water Quality
Section 7 - Species Diversity

Section 8 - Habitat
Section 9 - Capital Improvement Projects
Section 10 - Implementation
Section 11 - Glossary of Terms and References
Appendix A - Digital Deliverables
Appendix B - Public Participation Materials
Appendix C - Hydraulic & Hydrology
Appendix D - Channel Condition Data
Appendix E - Reach Data
Appendix F - Project Data Sheets
Appendix G - Project Cost Sheets
Appendix H - Prioritization Ranking Sheets
Appendix I - Water Quality
Appendix J - Species Diversity
Appendix K - Habitat

11.1 Stakeholder review

- Distribute masterplan to stakeholder for review
- Revise masterplan

11.2 Final publication

- Publish Masterplan on project website
- Showcase Masterplan at Open House meeting

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APPENDIX I

DRAFT DESCRIPTION OF PROPOSED WATER-QUALITY MONITORING OF MATTESE CREEK –
U.S. GEOLOGICAL SURVEY, MISSOURI WATER SCIENCE CENTER

Appendix I

Draft Description of Proposed Water-Quality Monitoring of Mattese Creek Watershed

Prepared by the U.S. Geological Survey, Missouri Water Science Center

Contact: Amy Beussink ambeussi@usgs.gov

Background:

The Mattese Creek watershed drains parts of southern St. Louis County. The creek runs about 8 miles southeastward from its headwaters near Gravois Road to the Meramec River. Land use within the watershed is primarily urban residential with some commercial development in the upper parts of the watershed and occasional industrial.

The lower 1.1 miles of Mattese Creek was placed on the 2014 303(d) list as impaired by chloride. The listing is the result of samples collected at two locations (Site A and Site B) along the lower reach of the creek (fig. 1). Of the 28 samples collected from these two sites during 2014-16 by the St. Louis Metropolitan Sewer District (MSD) or the local Stream Team, one sample had a chloride concentration of 1,040 milligrams per liter (mg/L). During 1997-2004 the USGS also analyzed chloride in water samples collected at the USGS streamgage (07019317) and chloride data also is available for site B during the early 2000s. Unfortunately, there is little overlap in the chloride data from the three sites that might allow inference of relative contributions of chloride along various reaches of Mattese Creek (fig. 2).

Although chloride is non-toxic at lower concentrations, it can be considered toxic to aquatic life in freshwater systems such as rivers, stream, lakes, and ponds. Increased chloride levels can cause stratification in lakes causing a decrease in available oxygen to fish. Greater chloride levels also can affect water quality for industrial uses and water treatment for human consumption and agriculture. Chloride is the primary component of road salts. It is highly soluble and enters water bodies and groundwater easily through runoff from roads, bridges, parking lots, ditches, salt storage piles, snow piles, wastewater treatment facilities, and other urban sources.

Mattese Creek is also on the proposed 2018 303(d) list as impaired by fecal indicator bacteria (*E. coli)*. Bacteria density data are available at four locations (Sites A, B, C, and D) along the creek and some samples date back to 1997. Sampling frequency and periods differed among the sites over the years but all four sites were consistently sampled in 2014. During 2014, the geometric mean *E. coli* densities of 487.2 colonies per 100 milliliters (col/100mL) computed from 29 samples collected from four sites along the creek exceeded the recreational season standard for whole body contact (WBC-B) of 206 col/100 mL.

Densities of *E. coli* are extremely variable in streams because of the complex number and often episodic nature of potential sources, and their association with sediments and flushing during runoff events. The USGS collected *E. coli* samples at the streamgage (Site C) from 1997 through 2004 and all samples were associated with a hydrologic condition code that the collector assigned at the time of sampling (4= stable low base flow; 5= falling stage; 6=stable high stage; 7=peak stage; 8=rising stage; 9= stable normal stage). A plot of *E. coli* density and hydrologic condition code indicates the largest *E.coli* densities at site C generally were in samples identified as collected on peak stage (fig. 3).

Cooperative Stream Investigation (CSI) and Stream Team efforts
Weekly bacteria samples (late April through early June) were collected by trained Stream Team volunteers at three locations (sites B, C, D) along Mattese Creek during 2014 under the Missouri DNR Volunteer Water Quality Monitoring Program. The Stream Team also collected four samples that were analyzed for chloride at Site B during 2014. Data provided by the CSI effort combined with monthly samples collected by the MSD at the downstream site (Site A, DNR 3596/0.3) were used by the MDNR to calculate the 2014 geometric mean of 487.2 col/100mL that exceeded the standard.

Stream Team 168 is active in the watershed and has expressed an interest in continued work on Mattese Creek and adopting about a ½-mile reach downstream from the USGS gage (Site C) on Ringer Road and performing monitoring and biological and chemical sampling. This proposed draft monitoring plan was developed assuming integration of the local groups' efforts into a broader cooperative USGS-Stream Team program.

Proposed Monitoring Scope of Work

The proposed scope of monitoring includes several options to allow for scaling to available resources and level of potential local Stream Team involvement.

In general, the plan consists of several seepage studies done during the first part of the effort (year 1), installation and operation of a continuous water-quality monitor (CWQM) on the lower reach of Mattese Creek, routine monthly sampling at the existing USGS streamgage and CWQM, storm event sampling, and microbial source tracking. Allowance is made to incorporate Stream Team efforts (assistance with storm sampling and seepage studies).

The purpose of a seepage study is to understand the surface water-groundwater relationship by determining gain and loss of streamflow and identifying locations of pollutants. During seepage studies, discharge and field properties are measured along with visual observations of the stream and adjacent floodplain, and water quality samples will be collected at various locations along the main steam of Mattese Creek at the mouth of primary tributaries during several seasons (allowance for additional sites is included). A seepage study in the winter/early spring is intended to focus on the distribution of chloride primarily resulting from road salt use. A low-base flow seepage study during the summer will focus on assessing the spatial extent of *E. coli* exceedences from base flow and shallow subsurface sources (such as groundwater seeps, localized septic sources, leaking sanitary sewer etc.). A planned high base flow seepage study in the fall or early winter is focused on assessing *E. coli* sources during wet periods other than wintertime that are not necessarily resulting from recent runoff but could be from saturated septic leach fields, sewer overflows, etc.

In general water samples will be analyzed for *E. coli*, major ions including chloride, and suspended sediment. The suspended sediment concentrations will assist in interpreting *E. coli* density and overall stream quality. Because the chloride standard is based on water hardness and sulfate concentration, a suite of major ions (calcium, magnesium, sodium, chloride, sulfate) will be analyzed. In addition, bromide is included as ratios of chloride/bromide have been useful in discriminating chloride originating from road salt from other sources such as wastewater. All chemical constituents will be sent to the USGS National Water Quality Laboratory in Denver, Colorado for analyses. Suspended sediment will be analyzed by the USGS Missouri Water Science Center Sediment Laboratory in Rolla, Missouri. The *E. coli* analyses will be performed by USGS Missouri Water Science Center staff with possible assistance from the Stream Team.

Microbial source tracking (MST) studies are performed to assist in the identification of E. coli sources in a water sample. The USGS Microbial Laboratory has an extensive source library of warm-blooded species common across the Nation, including humans, to compare DNA of fecal bacteria indicators against. Results of a MST do not determine the amount of a particular source, but can determine presence or absence of a source, such as human, geese, deer, or other wildlife species. Understanding the source of E. coli in conjunction with the density of the bacteria can assist in remediation and restoration efforts.

Stormflow event samples will be collected with the assistance of the Stream Team and with the use of passive samplers. The passive samplers will be placed in the stream at a designated river stage above baseflow, to collect the rising limb of a stormflow event (also known as the “first flush” when constituents are of an elevated concentration). Passive samplers are ideal in sampling rising conditions on smaller streams that peak quickly, and can assist in accessing a stream when conditions are not suitable for wading or approaching the streambank. The budget assumes that runoff samples will be collected by Stream Team, and the USGS will process the samples and ship to the USGS laboratory.

The proposed study is a three year effort. Routine monthly sampling of the two sites (Site C and CWQM location), CWQM operation, and storm event sampling are planned for three years. Seepage studies should be completed within the first 12 months of the project and microbial source tracking likely would be done during year 2-3. Development of a chloride regression model would be done during year 3.

Possible monitoring approaches:

Option A: Includes a continuous water-quality monitor (CWQM) to be located on the lower reach of Mattese Creek (either site B and B1), three seepage studies under variable hydrologic conditions, and monthly routine sampling (*E.coli* and major ions including bromide) at two main stem sites (streamgage at site C and at the CWQM location). This option also includes runoff sampling, target microbial source tracking of *E. coli* to assess the prevalence of human *E. coli* markers, and the development of a regression model to determine chloride concentrations and in real-time using the specific conductance and pH data measured in real-time with the CWQM.

Specific USGS monitoring tasks are:

1. Continue the existing streamgage on Ringer Road that is supported by MSD (station 07019317; SITE C)
2. Install a stage and continuous water-quality monitor (CWQM) on the downstream reach of Mattese Creek (likely site B or B1) with water temperature, specific conductance, and pH.
3. Begin routine monitoring (12 samples/year) at site C and the CWQM location. Samples analyzed for *E. coli*, major ions plus bromide, and nutrients).
4. Establish and reconnaissance visit to synoptic sites at the mouth of selected tributaries.
5. Late winter seepage study (approximately December-March) and water quality samples and flow measurements at all synoptic sites (A, B, B1, C, Ta, T1a,T1b, T2, T3, T5, T5, T6). Water samples collected and analyzed for major ions plus bromide and *E. coli* (no suspended sediment or nutrients). Stream Team can assist with this effort and sampling of up to 7 additional sites.
6. Summer seepage study (June-August) and water quality and flow measurements at all synoptic sites and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.
7. Late fall early winter seepage study (October-December or other wet period where road salt application has not occurred) and water quality and flow measurements at all synoptic sites and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.
8. Develop chloride/conductance/pH regression model to interpolate chloride concentrations from CWQM data (year 3).

9. Storm event monitoring. 3 events per years at 2 sites using passive samplers serviced by Stream Team. Up to 3 samples per event (combination of passive and manual grab samples).
10. Microbial source tracking (MST) to identify primary origin of excessive *E. coli*, if found, at selected sites. Up to 27 samples to be analyzed (year 2).

Option B This is similar to option A but cost savings by excluding all real-time monitoring and data computations (no CWQM installation and operation or chloride regression model development). Specific USGS monitoring tasks are:

1. Continue the existing streamgage on Ringer Road that is supported by MSD (station 07019317; SITE C)
2. Begin routine monitoring (12 samples/year) at site C and site B. Samples analyzed for *E. coli*, major ions plus bromide, and nutrients).
3. Establish and reconnaissance visit to synoptic sites at the mouth of selected tributaries.
4. Late winter seepage study (approximately December-March) and water quality samples and flow measurements at all synoptic sites (A, B, B1, C, Ta, T1a,T1b, T2, T3, T5, T5, T6). Water samples collected and analyzed for major ions plus bromide and *E. coli* (no suspended sediment or nutrients). Stream Team can assist with this effort and sampling of up to 7 additional sites.
5. Summer seepage study (June-August) and water quality and flow measurements at all synoptic sites and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.
6. Late fall early winter seepage study (October-December or other wet period where road salt application has not occurred) and water quality and flow measurements at all synoptic sites and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.
7. Storm event monitoring. 3 events per years at 2 sites using passive samplers serviced by Stream Team. Up to 3 samples per event (combined passive and manual grab samples).
8. Microbial source tracking (MST) to identify primary origin of excessive *E. coli*, if found, at selected sites. Up to 27 samples to be analyzed (year 2).

Option C. Similar to Option B but further cost savings by no microbial source tracking.
USGS monitoring tasks are:

1. Continue the existing streamgage on Ringer Road that is supported by MSD (station 07019317; SITE C)
2. Begin routine monitoring (12 samples/year) at site C and site B. Samples analyzed for *E. coli*, major ions plus bromide, and nutrients).
3. Establish and reconnaissance visit to synoptic sites at the mouth of selected tributaries.
4. Late winter seepage study (approximately December-March) and water quality samples and flow measurements at all synoptic sites (A, B, B1, C, Ta, T1a,T1b, T2, T3, T5, T5, T6). Water samples collected and analyzed for major ions plus bromide and *E. coli* (no suspended sediment or nutrients). Stream Team can assist with this effort and sampling of up to 7 additional sites.
5. Summer seepage study (June-August) and water quality and flow measurements at all synoptic sites and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.
6. Late fall early winter seepage study (October-December or other wet period where road salt application has not occurred) and water quality and flow measurements at all synoptic sites

and other sites as determined by field measurements/observations. Water samples collected and analyzed for major ions plus bromide and *E. coli*). Stream Team can assist with this effort and sampling of up to 7 additional sites.

7. Storm event monitoring. 3 events per years at 2 sites using passive samplers serviced by Stream Team. Up to 3 samples per event (combined passive and manual grab samples).

Option D. Similar to Option C but further cost savings by no event (similar to USGS-MDNR ambient network operation with added event monitoring in collaboration with Stream Team).
USGS monitoring tasks are:

1. Continue the existing streamgage on Ringer Road that is supported by MSD (station 07019317; SITE C)
2. Begin routine monitoring (12 samples/year) at site C and site B. Samples analyzed for *E. coli*, major ions plus bromide, and nutrients).
3. Storm event monitoring. 3 events per years at 2 sites using passive samplers serviced by Stream Team. Up to 3 samples per event (combined passive and manual grab samples).

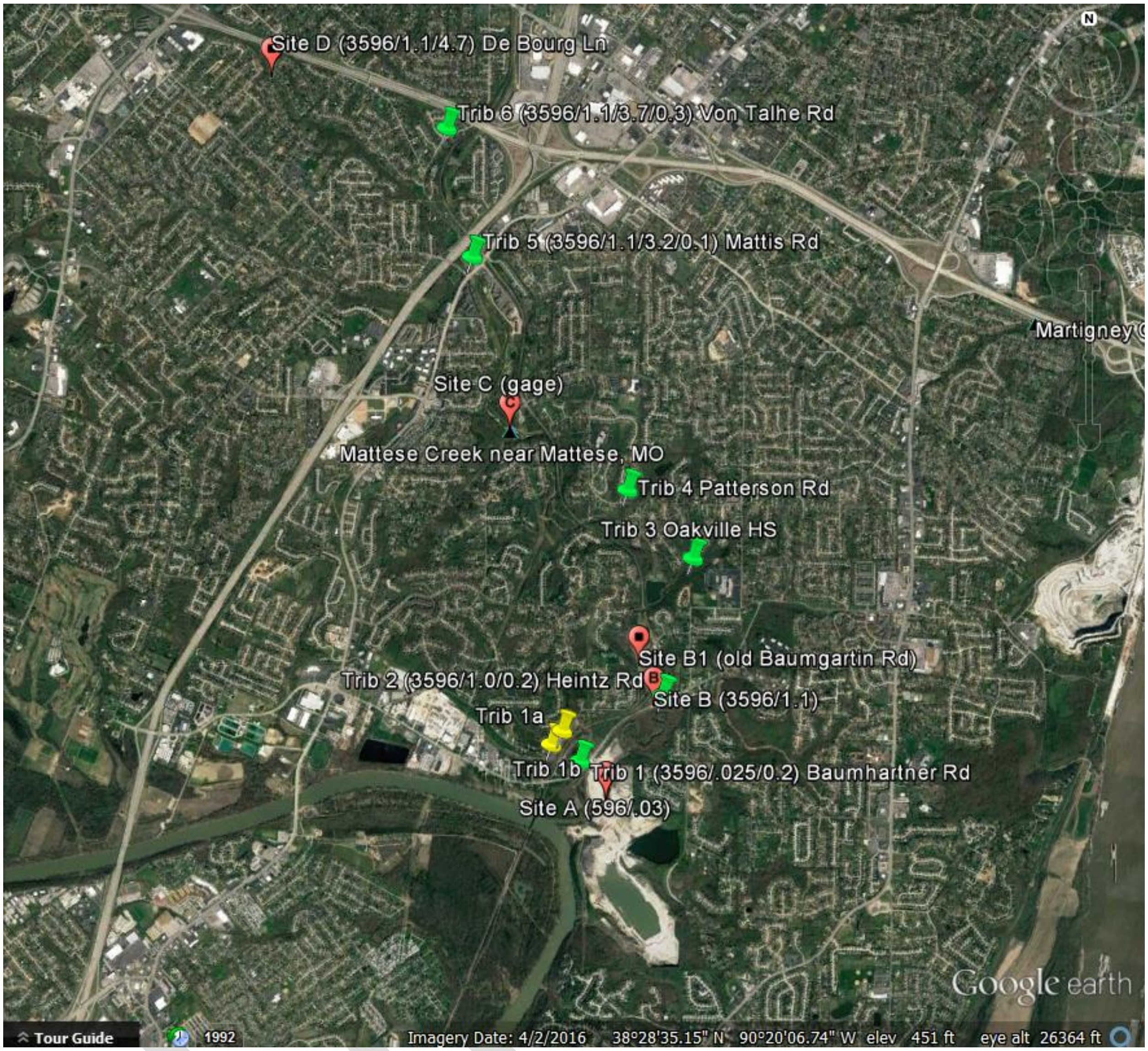

Fig 1. Location of existing and proposed possible monitoring sites in Mattese Creek watershed. Site C is the location of the USGS streamgage (07019317). Continuous water-quality and stage monitoring to be installed at Site B or B1 depending upon suitability of location upon field reconnaissance.

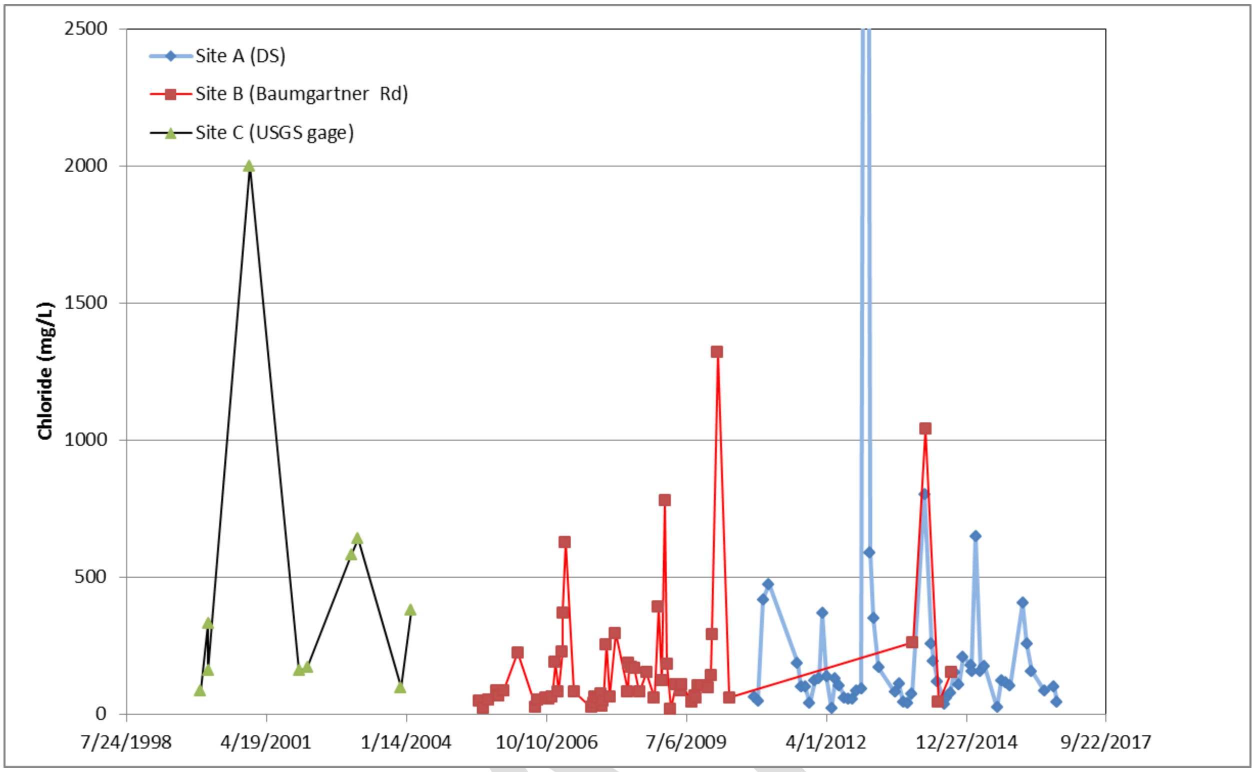

Fig. 2. Concentrations of chloride in samples collected from Mattese Creek at the downstream MSD sampling site (Site A), MSD site on Baumgartner road (Site B), and the USGS streamgage (Site C). Samples collected by MSD (Site A), MSD or Stream Team (Site B), or USGS (Site C).

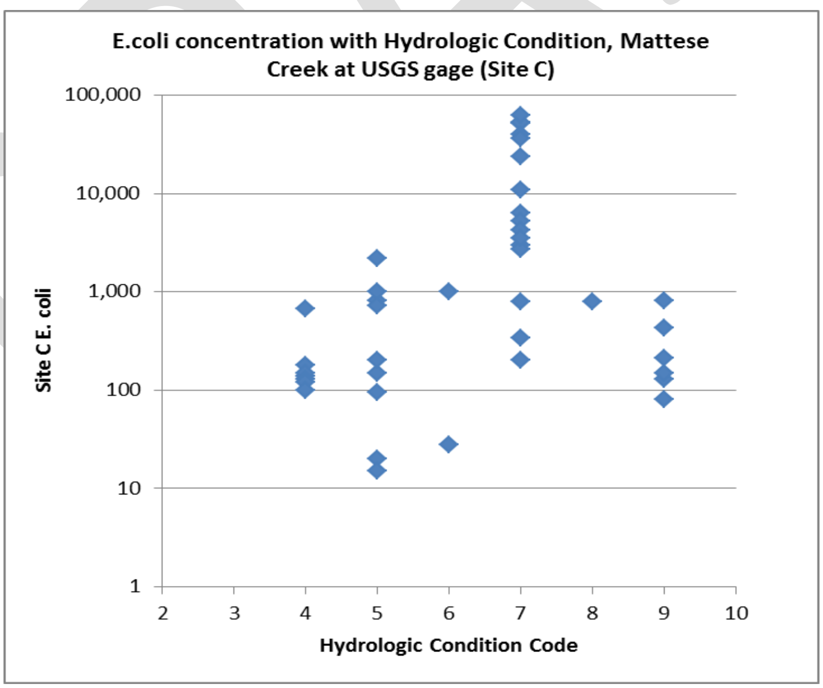

Fig. 3. *E. coli* density in water sampled collected by the USGS at Site C (streamgage 07019317) 1997-2004 at various general hydrologic conditions.

Table 1. Summary of existing Missouri DNR and possible proposed sampling sites in the Mattese Creek Watershed.

MDNR Site Number	MDNR Site Name	Condensed "short name" Site Name (figure 1)	USGS Site Number
3596/0.3	Mattese Cr. at Weber Quarry main rd. bridge	Site A	
3596/1.1	Mattese Cr. nr Weber Quarry	Site B	
		Site B1 (Old Baumgartner Rd)	
3596/0.9/2.5	Mattese Cr. @Ringer Rd. bridge	Site C	07019317
3596/1.1/4.7	Mattese Cr. @ DeBoug Ln.	Site D	
3596/0.25/0.2	Trib to Mattese Cr. @ Baumgartner Rd	Trib 1 Baumgartner Rd	
		Trib 1a (Old Baumgartner Rd)	
		Trib 1b (Old Baumgartner Rd	
3596/1.0/0.2	Trib. to Mattese Cr. @ Heintz Rd.	Trib 2	
		Trib 3 (nr Oakville HS)	
		Trib 4 (Patterson Rd)	
3596/1.1/3.2/0.1	Trib. to Mattese Cr. @ Mattis Rd.	Trib 5 (Mattis Rd)	
3596/1.1/3596/1.1/3.7/0.3	Trib to Mattese Cr. @ VonTalge Rd.	Trib 6	

Monitoring and data deliverables (NWIS or non-interpretive data release)

Option A

Install continuous water-quality monitor (CWQM) on lower reach of Mattese Creek, routine monthly monitoring at two sites, three seepage studies, storm sampling, microbial source tracking. Seepage studies and storm sampling in collaboration with stream team

	Description	Year 1	Year 2	Year 3
Infrastructure (streamgage or Water quality monitor)	Install Continuous water-quality monitor (CWQM) on lower reach of Mattese Creek	$22,522		
	Annual O&M of CWQM monitor	$22,613	$23,065	$23,526
Routine and Event Sampling	Monthly monitoring of Site C and downstream site CWQM location (site B,or B1)	$33,525	$34,195	$34,879
	Runoff event sampling (3 primary sites) 5-7 events. Collaborative with stream team	$8,642	$8,814	$8,991
Bacteria and chloride sources	Seepage studies (total 3 during years 1-2) collaborative with stream team	$50,271		
	Microbial source tracking		$33,851	
Chlroide regression model	Develop chloride/Cond/pH regression model			$25,575
	Water quality monitor	$45,135	$23,065	$23,526
Subtotals	Rountine and event sampling subtotal	$42,167	$43,010	$43,870
	Seepage surveys, microbial source tracking subtotal	$50,271	$33,851	$0
	Chloride/SC/pH regression model development subtotal	0	0	$25,575
	USGS Matching Contribution	-?-	-?-	-?-
	Total Estimated costs	$137,572	$99,926	$92,971

Option B

Similar to option A but cost savings by excluding real-time monitoring and data computations (no CWQM installation and operation or chloride regression model development).

	Description	Year 1	Year 2	Year 3
Infrastructure (streamgage or Water quality monitor)	Install Continuous water-quality monitor (CWQM) on lower reach of Mattese Creek			
	Annual O&M of QW monitor			
Routine and Event Sampling	Monthly monitoring of Site C and site B	$33,525	$34,195	$34,879
	Runoff event sampling (3 primary sites) 5-7 events. Collaborative with stream team	$8,642	$8,814	$8,991
Bacteria and chloride sources	Seepage studies (total 3 during years 1-2) collaborative with stream team	$50,271		
	Microbial source tracking		$33,851	
Chlroide regression model	Develop chloride/Cond/pH regression model			
	Water quality monitor	$0	$0	$0
Subtotals	Rountine and event sampling subtotal	$42,167	$43,010	$43,870
	Seepage surveys, microbial source tracking subtotal	$50,271	$33,851	$0
	Chloride/SC/pH regression model development subtotal	0	0	0
	USGS Matching Contribution	-?-	-?-	-?-
	Total Estimated costs	$92,438	$76,861	$43,870

	Option C Similar to Option B but further cost savings by no microbial source tracking.			
	Description	Year 1	Year 2	Year 3
Infrastructure (streamgage or Water quality monitor)	Install Continuous water-quality monitor (CWQM) on lower reach of Mattese Creek			
	Annual O&M of QW monitor			
Routine and Event Sampling	Monthly monitoring of Site C and site B	$33,525	$34,195	$34,879
	Runoff event sampling (3 primary sites) 5-7 events. Collaborative with stream team	$8,642	$8,814	$8,991
Bacteria and chloride sources	Seepage studies (total 3 during years 1-2) collaborative with stream team	$50,271		
	Microbial source tracking			
Chlroide regression model	Develop chloride/Cond/pH regression model			
	Water quality monitor	$0	$0	$0
Subtotals	Rountine and event sampling subtotal	$42,167	$43,010	$43,870
	Seepage surveys, microbial source tracking subtotal	$50,271	$0	$0
	Chloride/SC/pH regression model development subtotal	0	0	0
	USGS Matching Contribution	-?-	-?-	-?-
	Total Estimated costs	$92,438	$43,010	$43,870

Option D Similar to Option c but further cost savings by no seepage studies.			
Description	Year 1	Year 2	Year 3
Install Continuous water-quality monitor (CWQM) on lower reach of Mattese Creek			
Annual O&M of QW monitor			
Monthly monitoring of Site C and site B	$33,525	$34,195	$34,879
Runoff event sampling (3 primary sites) 5-7 events. Collaborative with stream team	$8,642	$8,814	$8,991
Seepage studies (total 3 during years 1-2) collaborative with stream team			
Microbial source tracking			
Develop chloride/Cond/pH regression model			
Water quality monitor	$0	$0	$0
Rountine and event sampling subtotal	$42,167	$43,010	$43,870
Seepage surveys, microbial source tracking subtotal	$0	$0	$0
Chloride/SC/pH regression model development subtotal	0	0	0
USGS Matching Contribution	-?-	-?-	-?-
Total Estimated costs	$42,167	$43,010	$43,870

APPENDIX J

FISHPOT CREEK EROSION REVIEW –
CITY OF VALLEY PARK

Fishpot Creek Erosion Review

The City of Valley Park has some significant problems along Fishpot Creek at two specific locations and is interested in making some modifications to the channel to minimize some of the erosive effects during high flow conditions. The two major areas of concern are the erosion of the bank adjacent to the Summertree Condominiums and the bank spillover/erosion from a meander neck or a channel cutoff developing in Vance Trails Park. The impacts of erosive effects have increased over recent years, seemingly due to increased development upstream of the City of Valley Park and/or possibly from stream impacts such as rock deposition.

The erosion of the bank adjacent to Summertree Condos has been increasing by getting closer to the actual residential structures. The City would like to prevent further erosion along the bank that may eventually cause the failure/loss of the structure. A previous solution of rock blanket placed on the bank by the Metropolitan St. Louis Sewer District (MSD) has failed and the City would like to install a natural stream restoration design to restore the ecological impacts caused by the erosion. This natural stream restoration design will also include the increase of the water quality of Fishpot Creek.

The bank spillover/erosion from the meander neck has started to form a channel cutoff along Fishpot Creek through Vance Trails Park and has caused the trail through the park to be in jeopardy. The channel cutoff appears to be developing through the park and if allowed to naturally develop, will eliminate a portion of the trail through the park. The City is reviewing possibly installing a cutoff channel that is of a natural stream design that will prevent future erosion. The channel elevation difference (approx. 4’) from the upstream to downstream channel will require stepped solutions to minimize velocities that may lead to bigger erosion problems. The City will also need to install a bridge system to extend over the newly designed channel to provide a continuous trail system within the park. This natural stream restoration design will also include the increase of the water quality of Fishpot Creek.

A preliminary engineering study for this solution would include:

-Topographic survey of 2 sites (Summertree Condo’s area and Vance Trails Park Site)
-Geomorphology Report for possible Vance Trails Park Channel and verification of Summertree Site. (A previous geomorphology report was completed for Fishpot Creek)
-Slope stability analysis (engineering characteristics beyond geomorphology report)
-Preliminary Hydraulic Analysis
-Engineered Preliminary Cost Estimates with Economic Analysis of possible solutions

Preliminary Engineering ~ $100k

Total Project Cost ~ $ 1 million dollars

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APPENDIX K

PUBLIC LANDS BEST MANAGEMENT STRATEGIES AND PROJECT IDEAS – ST. LOUIS COUNTY PARKS AND GREAT RIVERS GREENWAY

Appendix K

Lower Meramec River Watershed Plan Update
Public Land Best Management Strategy and Project Ideas
St. Louis County Parks and Great Rivers Greenway
March 2017

Purpose:

St. Louis County Parks Department and Great Rivers Greenway are both government agencies that own land in the Lower Meramec Watershed for a combined 6,644 acres of land. This large amount of public land provides opportunity to implement sound management practices to improve and protect the overall health of the watershed. Therefore, St. Louis County Parks and GRG are key stakeholders supporting the Lower Meramec Watershed Planning efforts being spearheaded by East West Gateway. In addition, these agencies own public land contiguous to each other from river miles 7 – 10. The combined acreage for these contiguous properties is just over 638 acres and includes over 20,400 feet of river frontage. This provides a unique opportunity to develop collaborative land management strategies and habitat restoration projects that have unified goals to manage the entire landscape rather than piecemeal objectives for each site.

This collaborative approach will achieve common goals while restoring the watershed in a more holistic way and also provide an economy of scale to conduct the work. Efficiencies will be gained by combining efforts to hire a contractor, utilizing in-house equipment and labor, and engaging volunteers.

The following best management practices are recommended on properties owned by St. Louis County Parks and Great Rivers Greenway along river miles 7 -10. The goal of implementing these practices is to reduce sedimentation, improve water quality and the overall environmental health of the Meramec River and its tributaries as they pertain to public lands in the lower watershed.

Public Land Management Practices & Projects for St. Louis County Parks and GRG Properties (where applicable)

- Conduct litter pickup and flood debris removal activities as needed
- Identify locations along the Meramec River and associated tributaries that have unstable banks and evidence of slope failure.
- Stabilize banks of Meramec River with native vegetation such as willow staking in places where bare soil is exposed and/or where erosion is actively occurring
- Remove hard structures or rip rap materials that have previously been used to armor banks and stabilize the channel along the main stem of the Meramec River and the tributaries located on public land (where feasible)
- Increase the riparian corridor with natural vegetation along the main stem of the Meramec River and associated tributaries to achieve a minimum buffer width of 100 feet for the Meramec River and 50 feet for the associated tributaries (where feasible).
- Identify those sites that produce large amounts of runoff.
- Enhance any existing degraded wetlands and construct new wetlands to capture runoff from developed areas.

- Reduce the amount of fertilizer that is used for lawn maintenance. Take soil samples to better ensure that fertilizer is not being over used.
- Reduce the amount of salt or other chemicals for snow removal.
- Reduce impervious surfaces during new or replacement construction.
- Require rain gardens or detention/wetland basins for all new or replacement construction projects.
- Eliminate curbs along parking lots and roadways that prevent the water from sheet flowing off the surface and instead being forced into stormwater drainages (where feasible).
- Construct detention/wetland basins/filter strips to collect runoff from parking lots and buildings
- Utilize native plantings whenever possible.
- Remove invasive plant species and revegetate those areas with native plants.
- Reduce the amount of lawn maintained.
- Areas with minimal recreational value should be converted to natural plantings.
- Ensure that adequate buffers are maintained to better control animal waste at Suson and to keep the highly charged waste out of the creeks and waterways.
- Remove or redesign unnecessary or poorly designed trails that add to soil erosion and runoff.

<u>Site Specific Public Land BMPs & Projects</u>:
Listed below is the public land owned by St. Louis County Parks and GRG along river miles 7 – 10 of the Lower Meramec River watershed and a list of land management practices that can be implemented at each site.

<u>Kennedy Park & Complex (263.05 acres)</u>

- Remove invasive plant species and revegetate those areas with native plants
- Implement stormwater BMPS, where feasible, that may include filter strips, rain gardens, or detention/wetland basins to capture runoff from parking lots and building complex.
- Where feasible eliminate curbs along parking lots and roadways that prevent the water from sheet flowing off the surface and instead being forced into stormwater drainages
- Reduce the amount of fertilizer used to maintain lawns.
- Reduce the amount of salt during snow removal.
- Reduce impervious surfaces during new or replacement construction.
- Conduct litter removal activities as needed.

<u>Lower Meramec Park (303.85 acres) and Adjacent GRG Properties (71.19 acres)***</u>

- Conduct litter pickup and flood debris removal activities as needed.
- Remove invasive plant species and revegetate those areas with native plants
- Plant native vegetation in the old field areas that were once used for agriculture.
- Remove hard structures or rip rap materials that have previously been used to armor banks and stabilize the channel along the main stem of the Meramec River and tributaries (where feasible)
- Increase the riparian corridor with natural vegetation along the main stem of the Meramec River to achieve a minimum buffer width of 100 feet (where feasible).
- Enhance any existing degraded wetlands and construct new wetlands to capture runoff from developed areas.
- Plant the old open field next to the golf course off of Meramec Bottom Road with trees.
- Widen the creek corridor by planting trees in the open field off of Krumm Road.
- Ensure the river bank is stable with natural vegetation.

- Areas with bare ground due to extended flooding should be planted with native material to reduce exposure to soil erosion.
- Reduce impervious surfaces during new or replacement construction.

(*** Includes Holzer, Willow Beach and Butler Lake properties)

<u>Suson Park (97.04 acres)</u>

- Remove invasive plant species and revegetate those areas with native plants
- Implement stormwater BMPS, where feasible, that may include filter strips, rain gardens, or detention/wetland basins to capture and contain runoff from parking lots and building complex.
- Where feasible eliminate curbs along parking lots and roadways that prevent the water from sheeting off the surface and being forced into stormwater drainages.
- Reduce the amount of fertilizer used to maintain lawns.
- Reduce the amount of salt during snow removal.
- Ensure the creek bank is stabilized and naturally vegetated.
- Plant native trees to expand the creek corridor to 100 feet throughout the park.
- Open areas with minimal recreation value should be planted with native vegetation.
- Ensure the pasture areas are not overgrazed.
- Ensure animal waste material from the barns, pastures or storage area does not runoff into the creek.
- Enhance any existing degraded wetlands and construct new wetlands to capture runoff from developed areas.
- Reduce impervious surfaces during new or replacement construction.
- Reduce soil erosion by stabilizing drainages.
- Conduct litter pickup activities as needed.

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APPENDIX L

KIEFER CREEK FIVE STAR AND URBAN WATERS RESTORATION PROJECT PROPOSAL NARRATIVE, EDUCATION COMPONENT – THE NATURE CONSERVANCY

Five Star & Urban Waters Restoration Program
Full Proposal Project Narrative

Instructions: Save this document on your computer and complete the narrative in the format provided. ***Do not change the formatting (Times New Roman 11pt font, ¾ inch margin)***. The final narrative should not exceed six (6) pages. Do not delete the text provided below. Upload completed document as a PDF or MS Word file into the on-line application as instructed. Bulleted lists may be used.

I. PROJECT CONTEXT

1. Specify the total acres the project will restore and identify the target watershed and focal species/habitat. Describe the project's connection to the watershed and explain the need for the project. *Show total magnitude/relative impact of the project (acres restored, etc.); identify the watershed and any targeted species; explain how the project complements or implements existing national, state or regional watershed management plans, state wildlife action plans or species conservation plans; and, identify overall key threats to targeted species and watershed.*

The Nature Conservancy (TNC), with its partners, will develop a targeted outreach and education program for local communities and professionals focused on stream health using natural stream channel design and riparian habitat restoration as part of a larger stream restoration project in Kiefer Creek in the Meramec River Basin. The project location in the St. Louis metropolitan area within a state park with high visitation (796,903 visitors in 2016) from a diverse population of 2.8 million people, combined with the relative health of the watershed, presents a unique opportunity to engage people in protecting and improving water quality and riparian habitat.

This project will complement upcoming stream restoration on the lower 1.5 miles of Kiefer Creek as it flows through Castlewood State Park to its confluence with the Meramec River. The restoration objective is to reduce sedimentation by stabilizing streambanks using bioengineering; increase in-stream aquatic habitat; and improve the riparian corridor by invasive species management, planting native species, and increasing the riparian width of the stream. The Kiefer Creek watershed is a 6.7 square mile subwatershed of the Meramec River, one of the most biologically diverse, free-flowing, and healthy rivers in any urban area in the United States. Historical land use practices have over-widened the stream and caused bank erosion and sedimentation. Although protected as a state park since the 1980's, a recent analysis suggests that the creek is in a state of disequilibrium, resulting in excessive streambank erosion and sedimentation that will continue unless actively stabilized and restored.

Kiefer Creek has been identified as a priority project area within multiple plans and studies, including the Kiefer Creek Watershed Restoration Draft Plan (Missouri Department of Natural Resources, Missouri Coalition for the Environment 2014), Meramec River Conservation Action Plan (TNC 2014), Kiefer Creek Stream Restoration Master Plan (TNC 2016), Meramec River Ecosystem Restoration Feasibility Study (ongoing Army Corp of Engineers), and Lower Meramec River Watershed Plan (2012) and update (ongoing, East West Gateway Council of Governments). TNC is currently contracting for the stream restoration design and construction, expected to be completed in Spring 2018. Funding for the project is partly in hand and the remainder is to be procured in 2017.

Due to the high-profile location in proximity to St. Louis Metro area, this natural stream channel design project is being advocated as a centerpiece for education and community engagement on water quality and stream health both for the Kiefer Creek watershed, and as a demonstration and model for on-the-ground work and education efforts in the entire Meramec River Basin. The outreach and education elements proposed here will help fulfill outreach needs identified in the aforementioned plans and studies, as well as the Corps of Engineers' Ecosystem Restoration Feasibility Study in the Meramec River Basin; the Department of Natural Resource led Interagency Communications Plan reaching communities impacted by lead contamination and other non-point source pollutants; the USEPA's Urban Waters Federal Partnership, Meramec and Big River initiative; and the Kiefer Creek Stream Restoration Master Plan. This watershed is threatened by sedimentation from streambank erosion and is listed as impaired under Missouri's 303(d) for bacterial contamination and chloride. Citizen awareness, interest, and support are needed to be successful in clean up and avoiding further degradation here and throughout the Meramec River Watershed.

2. Who will be involved in the planning and implementation phases of the project? State the number of community members directly engaged or impacted. Describe community characteristics of the project

area and identify any underserved or high-need communities. *Explain the role each partner will play in planning and implementing the project and include the total magnitude/relative impact of the project (# people engaged, etc.). Use poverty statistics, school lunch data or demographic records to articulate high-need or underserved communities and identify how the project increases community members' access to nature and decreases their potential risk of harm from potential environmental hazards.*

The Nature Conservancy, EPA Region 7, U.S. Army Corps of Engineers, Missouri State Parks, Missouri Department of Natural Resources (DNR), East-West Gateway Council of Governments, St. Louis University Center for Sustainability, and the local non-profit Wildlife Rescue Center are project partners and will be involved in planning and implementing different phases of the project. Castlewood State Park attracts close to 800,000 visitors annually from the greater Saint Louis Metropolitan area; these community members will be directly or indirectly affected by the project. The park is a popular place for swimming and spending time in the creek, but there are times when the water quality presents hazards to human health. Under this proposal, TNC and partners will complete outreach and education actions with park visitors and local homeowners to explore how they can be involved in reducing pollutants and benefit the ecology of Kiefer Creek. The watershed has approximately 3,220 suburban single-family households which constitutes 53% of its land-use, thus the small size of this watershed means residential decision making about property management could have a significant impact on the quality of water within the stream. The following are requests for funding under this proposal, as well as matching and non-matching complementary actions related to this proposal:

- **Stream and riparian restoration** (funding not requested under this proposal; to be used as project match): The Nature Conservancy, in partnership with Missouri State Parks and the Wildlife Rescue Center, will implement the streambank stabilization and riparian corridor enhancement project.
- **Outreach: Research** (requested under this proposal): St. Louis University Center for Sustainability will conduct homeowner outreach and research reaching approximately 3,220 households and interview up to 40 residents. The research will examine the interactions between social and ecological systems and provide direction on what actions could best engage local stakeholders for watershed conservation.
- **Education: Stakeholders** (requested under this proposal): TNC and DNR will train and support up to 23 Castlewood State Park Stream Team citizen science volunteers on how to rapidly assess and prioritize streambank erosion for nonpoint source pollution reduction.
- **Education: Technical** (requested under this proposal): TNC and East West Gateway Council of Governments will work with the engineering firm contracted to complete the restoration to provide professional onsite training on science and application of natural stream restoration using bioengineering to protect roads, bridges and other infrastructure for at least 25 participants from local governments and consultants who serve local governments in the region.
- **Education: Stakeholders** (requested under this proposal): TNC and State Parks will develop onsite signage for a visitor trail along the restored creek, information handouts, before- and after- construction photos, and print, television, and social media for park visitors, local stakeholders, and residents of the St. Louis metropolitan area.
- **Outreach and Education: Teachers** (requested under this proposal): A TNC and STEM teacher program on streambank assessments and stream health will be continued in 2017 and 2018. In 2016-2017 the program trained 159 teachers, who further influence an estimated 6,975 students, grades K-8, and their families. The teachers represent 16 school districts from the greater St. Louis Region (including East St. Louis, Jefferson Counts, St. Louis City and County, and St. Charles County). Similar results are expected for the 2017-2018 teacher program. According to participant district demographics, the students in STEM TQ classrooms are 51% white, 43% black, 4% Hispanic, 1% Asian. Also, according to participant district data, 53% of student in STEM TQ classrooms are free/reduced lunch eligible.
- **Outreach and Education: Children** (not requested under this proposal or as match but affected by this project): MO State Parks educators will use the restoration project for summer camp programing for the "Show Me Parks" and Greater City YMCA programs for approximately 150 children from underserved communities in the St. Louis region. In past years, roughly 95% of the participants were African American and the camps were from low-income areas. Participants from Jamison Memorial, the

Overland/Vanita Park area, as well as, the YMCA of O'Fallon, IL visited the park. Additional participants came from Ferguson, City of St. Louis, and other nearby areas.

3. **Will your project involve a USFWS-designated National Wildlife Refuge or Migratory Bird Treaty Area?** *See Funding Availability in RFP and answer only if applicable.* N/A
4. **If your project is located in one of the corporate-sponsored urban areas requesting a community service opportunity, describe the type of day-long community service event you propose to host for up to 50 employees of our corporate sponsor and your partnership's capacity to carry out this event**. *Include event location, specific activities and approximate date. See Funding Availability in RFP and answer only if applicable.* N/A

II. CONSERVATION AND OUTREACH ACTIVITIES

5. **For each conservation metric, identify and briefly describe the major restoration activity that your partnership will undertake.** *For each metric, list major restoration activities and describe how each will meaningfully advance the project's conservation goals and improve the health of the watershed and focal species/habitat.*

The partnership will implement on-the-ground construction of the natural stream restoration design recommended in the Kiefer Creek Stream Restoration Master Plan (TNC 2016, see attached plan; funding for this work is not being requested under this proposal.) Riparian restoration will consist of stabilizing the stream using bioengineering techniques. Woody material toe protection and/or boulder toe structures will be installed to stabilize bends. Live gravel bar plantings will help promote building of banks and narrowing/deepening of the channel. All proposed woody and herbaceous vegetation will be native to the area and locally sourced if practical. This will help provide the necessary conditions to resist shear stresses, and encourage the stream to naturally narrow and deepen to allow for adequate transport of supplied sediment and significantly reduce sedimentation from the eroding streambank. These techniques will also improve habitat for aquatic species by providing shading and places to hide in the woody material toe protection, and improve riparian habitat along the creek by providing native vegetation and increasing the riparian buffer. Riparian buffers are high-value habitat for wildlife movement, access to water, and aquatic food sources.

6. **For each outreach/educational and conservation metric, briefly describe each corresponding, major educational/outreach activity that your partnership will undertake.** *For each metric, list major outreach/educational activities and describe how each will meaningfully advance the educational and conservation goals of the project and benefit the targeted communities.*

This project will leverage the ecological outcomes and public engagement opportunities provided by the Kiefer Creek restoration to create an outreach and education program that informs behaviors and provides benefits throughout the greater Meramec River Basin. Our approach is divided into strategies targeting audiences essential for the future of water and stream health, including local homeowners, students (our future generation), community citizen activists, professional practitioners, and park visitors. Each strategy is outlined below.

- **Outreach: Research** (requested under this proposal): **Learn from homeowners in the local watershed**. Saint Louis University Center for Sustainability will examine homeowner motivations and interests regarding the protection of water resources and associated habitats to inform outreach activities here and in other parts of the Meramec River Basin. To generate their interest and participation, homeowners will be informed via mailing about the streambank stabilization project and why it is being done. To engage homeowners in ongoing water quality improvements, we will gather information about how they value the stream and related amenities; their understanding of urban stream characteristics; knowledge of water quality improvement efforts via stream bank restoration; ideas they have for improving water quality on their properties; and desire to become involved in the restoration of Kiefer Creek. Homeowners will also have the opportunity to voice their concerns, interests, and ideas for protection of the Kiefer Creek watershed through up to 40 one-on-one interviews and possible formation of a citizen advisory committee. Results will be vital in developing future community outreach work in other areas in the Meramec River Watershed. Homeowner outreach is anticipated to set the stage for receptivity for future efforts to encourage homeowners to replace and maintain home septic systems to address this primary source of bacterial contamination in Kiefer Creek. This has been identified in the Kiefer Creek Watershed Restoration Draft Plan (DNR, Missouri Coalition for the Environment 2014) and is an activity identified in the East West Gateway Council of Governments led Lower Meramec Watershed Plan Update.

- **Outreach and Education: Teachers** (requested under this proposal): **Engage STEM teachers within underserved St. Louis communities.** We will continue to teach science skills and share connection with nature and water resources on the Meramec with teachers as hands-on STEM curriculum through the Washington University in St. Louis STEMpact program. Each summer, we bring approximately 100 K-8 teachers in the St. Louis area to Kiefer Creek to discuss river function, how scientists assess streambank health and erosion risk, and how this science can be translated into STEM curriculum for their classrooms. STEMpact considers our field trip a premier experience for teachers in their Summer Teacher Quality (TQ) program, and we now provide this hands-on STEM curriculum development opportunity to every teacher participating in the TQ program. Our objective is for schools in the region is to have STEMpact-trained teachers who can share with students how securing river health and clean water is an urgent STEM challenge and inspire communities to understand and value the rivers they depend on.
- **Education: Stakeholders** (requested under this proposal): **Pilot new module for Missouri Stream Team citizen science program.** We will develop a new module on streambank erosion assessment for Missouri's Stream Team citizen science program (see www.mostreamteam.org/index.asp). The goal is to develop community awareness about the importance of riparian buffers and other land use conditions' impacts on streambank erosion and stream health that can be adopted by other Stream Teams in the Meramec River watershed. The Kiefer Creek Stream Team will monitor and assess streambank erosion before and after stream stabilization construction.
- **Education: Technical** (requested under this proposal): **Train professionals on best practices for natural stream design and restoration.** The Kiefer Creek riparian restoration construction site will be used to train engineers, practitioners, and decision makers working throughout the Meramec River Basin. Current practices throughout the region use traditional hard armoring (e.g., riprap) to reduce streambank erosion; unfortunately, those techniques are commonly expensive, prone to failure, are aesthetically unattractive, and often have minimal ecological benefits to stream habitat and water quality. This site is well located to engage municipal public works officials, engineers, consultants, construction contractors, and state and federal agency staff to learn from stream restoration experts (contracted by TNC for this project) on innovative bioengineering techniques that provide natural habitat while providing stabilization and reduction of erosion and related nonpoint source pollutant loadings to the stream. Such natural stream restoration practices are effective in protecting infrastructure, including sewers, roads and bridges, as well as reducing erosion that damages private property. In addition to the training, products will include a handout on the 'why' and the 'how' of best practices to share with professionals and stakeholders throughout the region.
- **Education: Stakeholders** (requested under this proposal): **Spreading the message.** In an effort to reach a broader audience, TNC will use onsite park interpretive trail signs and flyers about the stream restoration project, video of the construction process, website stories on TNC and partner websites, Facebook stories, and "Water Matters" (see www.ninenet.org/water-matters/) TV stories. "Water Matters," is a television-based outreach partnership TNC is leading with Nine Network of Public Media, a St. Louis PBS affiliate. In collaboration with regional conservation organizations, this initiative is producing original multi-media content to raise public awareness and understanding about the connections between our rivers and our land, people, and economies. We fully anticipate that our work on Kiefer Creek will be among the stories covered by producers per the actions completed under this grant.
- **Outreach and Education: Children:** (not requested under this proposal or as match but affected by this project): **Engage Castlewood State Park summer campers from underserved St. Louis communities**. Park camp educators are intending to incorporate the Kiefer Creek stream and riparian restoration project

and interpretive trail into their Water Theme program for approximately 150 students to teach about water quality and stream bank erosion.

7. **What are your long-term educational and conservation outcomes for this project and how will you measure progress?** *Include your conservation target species, habitats and/or any threats to these species and habitats you will address. Explain how this project will contribute to these long-term outcomes and how you will disseminate results and apply lessons learned to future efforts.*

St. Louis, a large urban area with a diverse population and over one million people living within half an hour drive of the park, benefits directly from the relatively clean and healthy Meramec River watershed with clean drinking water and recreational opportunities. Efforts to protect and restore habitat and water quality depend on a citizenry who value the resource and understand and are willing to take and support actions, both in their backyards such as septic maintenance, and in the watershed such as storm water best practices. The overarching long-term educational outcome is to raise the awareness of stream health and restoration in order to catalyze long-term engagement and stewardship of water resources throughout the region and of community members within the Meramec River Basin understanding that restoring stream health for wildlife, habitat and people is doable and that multiple activities, both in stream and in the watershed, are needed. Educational outcomes expected include:

- Development of a community driven Kiefer Creek stakeholder group and interest in promoting individual actions for water protection on private land. Results from the St. Louis University study will inform updates to the Meramec River Watershed Plan and the DNR/EPA Communications Plan for development of outreach in other regions of the Meramec River Basin.
- STEM teachers will continue to participate in streambank assessment teacher training. The STEMpact program will track numbers of teachers participating and numbers of students reached.
- New module for the Missouri Stream Team citizen science program on streambank erosion. Number of Stream Teams that adopt this new citizen science activity will be tracked.
- Web page highlighting the values and best practices of natural stream restoration and general watershed conservation for clean water. Numbers of views and webpage visits will be tracked.
- Professional stream restoration community will develop expertise of natural stream design techniques using bioengineering and will apply these practices to future projects. TNC will continue to work with partners and assess ongoing education needs of practitioners.

The conservation outcome will be stream stabilization on 1.5 miles of Kiefer Creek and significant sediment reduction. The Kiefer Creek Stream Restoration Master Plan (TNC 2016) provided science-based estimates of current streambank erosion rates and loadings under current channel instability. TNC, the restoration contractor, and the Stream Team will monitor the site for future erosion after construction and compare future erosion rates and total loadings to before-construction data to determine project success and/or need for further action.

III. Matching Contributions & Capacity Building

8. **Complete the table to describe how all partners are involved in the project.** *The project must have at least* ***5 diverse partners*** *contributing a variety of expertise to the project. All partner contributions should include a dollar value equivalent and* *<u>each should correspond exactly to the "matching contributions" section</u>* *of your Easygrants proposal while expanding on partner roles. Add rows as needed.*

	Partner (organization / individual)	**Qualifications** (project-related skills/expertise)	**Contribution(s)** (goods or service being provided)	**Value of Contribution(s)** (dollar equivalent)
Example:	*John Smith*	*Naturalist*	*Provide details on appropriate native species to be planted in project area*	*$500*
Example:	*Girl Scout Troop #242*	*Manual labor*	*Volunteer hours to construct trail bridge and educational signs on nature trail*	*$1000*
1	STEMpact Program	Teacher education	Coordinate and assist teaching teachers and classroom implementation	$3750

2	Stream Team 168	Team leader	Volunteer coordination and volunteer labor	$1615
3	East/West Gateway	Planner	Coordinate logistics, administer, and promote and advertise professional training	$1800 federal funds
4	TNC	Freshwater Director & Watershed Coordinator	Project management, workshop teaching, communications, streambank restoration project construction	$35,460
5	MO State Park	Park Superintendent	Lead sign development & production, restoration project assistance	$6500
6	DNR	Outreach	Meramec Watershed outreach/coordination	$2675
Total:				**$51,800**

9. Describe how the project partnership will build capacity for expanding community stewardship in the area. *Discuss the relationships (new and existing) that you and your partners have with each other and the target audiences, and how this will influence future community stewardship efforts.*

Project partners have been working together for the last four years to focus conservation efforts for the Meramec River Basin. The need for outreach has been consistently identified as an important strategy in the basin. This project will build capacity for expanding community stewardship in several ways:

1. Providing funding to engage in outreach activities identified as a need by project partners.
2. Using Kiefer Creek restoration to showcase and promote water quality, and innovative restoration actions throughout the Meramec River Watershed.
3. Developing materials that can be used by project partners to engage community stakeholders beyond Kiefer Creek, such as a handout on the values and best management practices of streambank stabilizations, Stream Team citizen science streambank erosion volunteer module, professional training workshop design, and broad media outreach.
4. Researching how homeowners within the Kiefer Creek watershed value the stream and related amenities; residents' understanding of urban stream characteristics; knowledge of water quality improvement efforts via streambank restoration; ideas watershed residents have for improving water quality on their properties; and desire to become involved in the restoration of Kiefer Creek and applying findings locally and to additional watersheds.
5. Helping spur the development of a citizen-led watershed stakeholder group in the Kiefer Creek and Castlewood State Park.

10. Explain your plan for monitoring project achievements beyond the project period (3 years or more). *Include brief details as to how your partnership will ensure the sustainability of the project's results.*

The organizations partnering on this grant have long-term commitments to the project area. TNC and partners are currently collaborating to update the 2014 Meramec River Conservation Action Plan with targeted implementation activities. This Plan update will incorporate the activities and findings of this NFWF project, specifically:

- TNC and Missouri State Park will monitor the success of the riparian restoration streambank stabilization project.
- TNC will work with DNR to add the Missouri Stream Team citizen science streambank assessment module to the menu of volunteer projects that local Stream Teams can adopt.
- All project partners will have access to outreach materials, including handouts, training information, and videos to use for other outreach efforts in the Meramec River basin, including the Army Corp of Engineers Meramec River Ecosystem Restoration Feasibility Study and Lower Meramec River Watershed Plan update that are currently in progress.