Chapter III. Kiefer Creek Nine Element Plan for Bacteria

Element A – Identification of the Causes and Sources, or Groups of Similar Sources that will need to be controlled to achieve the Load Reductions and Water Quality Goal.

1. Causes and Sources of Bacteria Impairment in Kiefer Creek

The draft Kiefer Creek watershed Restoration Plan developed by the Missouri Coalition for the Environment in 2014[26] (referred to as MCE draft Kiefer Creek plan) researched literature, analyzed data and conducted field studies to determine the likely causes and sources of the bacteria impairment in Kiefer Creek. The draft Kiefer Creek Plan noted that "the high bacteria levels in Kiefer Creek could come from a variety of sources in the watershed, the most likely being faulty on-site wastewater treatment systems contaminating the groundwater and pet and wildlife waste washed into the creek."[27] Historical data shows Kiefer Creek having a steadily elevated level of *E. coli* bacteria, although not nearly as high as has been recorded by the USGS, MSD and MoDNR in recent years.

In September 1972, East West Gateway published the St. Louis County Water Pollution Control Study - Phase I -Areas Tributary to the Meramec River.[28] In this study, EWG looked specifically at the potential to expand sewer services to tributary areas of the Lower Meramec River, with specific emphasis on Fishpot and Grand Glaize Creek, but also including the Kiefer Creek watershed. (See Map 10) As a regional planning agency, EWG saw that the population would inevitably expand into these areas and the existing wastewater infrastructure, or lack thereof, would be inadequate to handle this influx. This study included testing of three locations in the Kiefer Creek watershed for a variety of parameters. The data indicates high bacteria levels in Kiefer Creek, showing that Kiefer Creek has had a bacteria problem for a long time, although the scale may have fluctuated over time. Recent data shows that Kiefer Creek can have very low levels of bacteria during low water and very high levels during high water.[29]

Table 9. 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
Kiefer (3592)	St. Louis	1.2	*E. coli* (2012)	WBC-A	Rural non-point source

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

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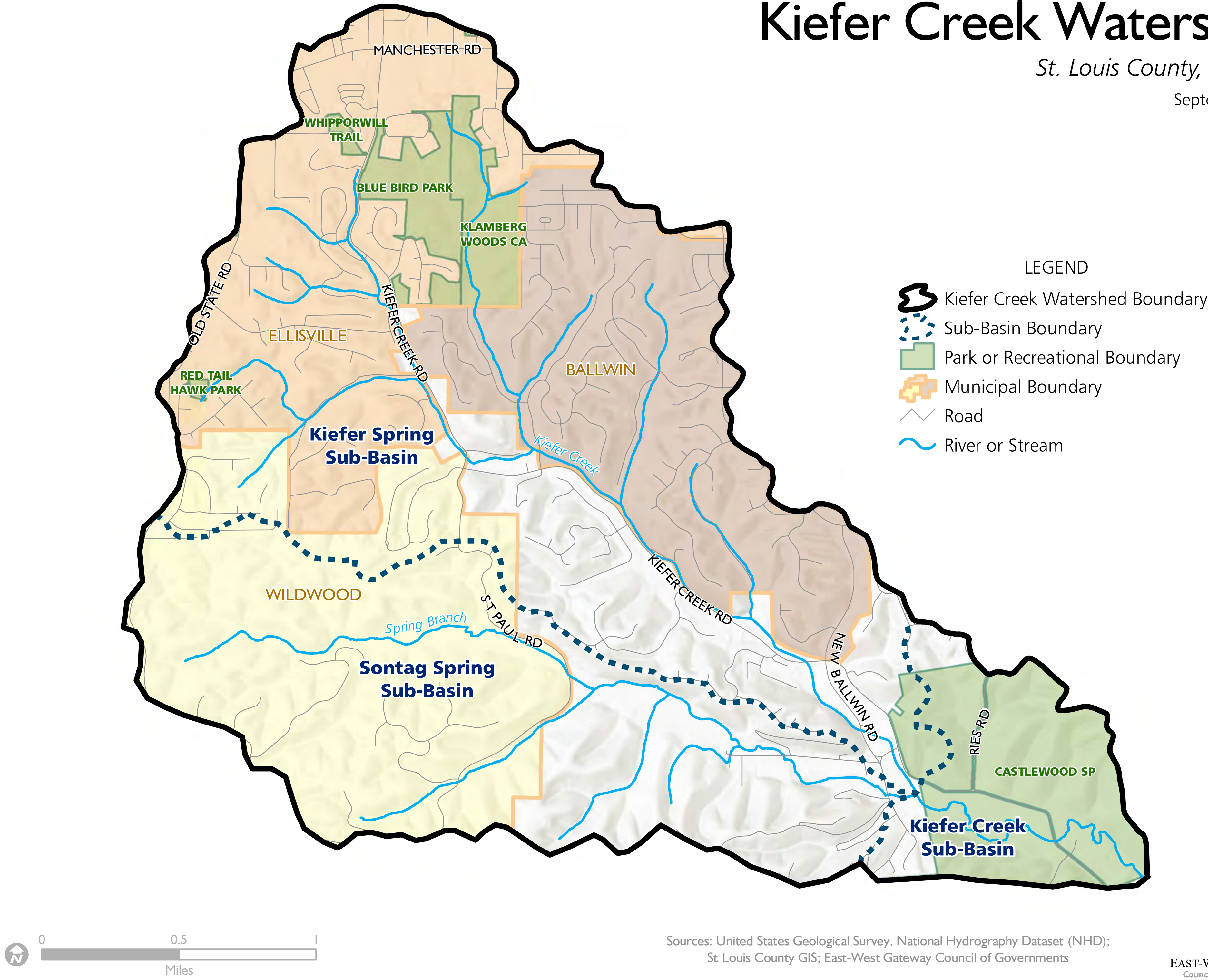
[26] Missouri Coalition for the Environment. Kiefer Creek Watershed Restoration Plan Draft Development Copy, October 20, 2014. http://www.ewgateway.org/wp-content/uploads/2017/09/KieferCreekDraftPlan-October2014.pdf
[27] Ibid., page 10
[28] Hard copy available from the reference library at East-West Gateway Council of Governments.
[29] Missouri Department of Natural Resources Keifer Creek *E. coli* Load Duration Curve and Estimates of Needed Load Reductions, March 16, 2017 contained in Appendix B and also refer to pages 18-21 of the MCE draft Kiefer Creek plan for a review of bacteria data collected from MoDNR, USGS and MSD.

Map 10
Kiefer Creek Watershed

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

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1.1 Domestic pets as a source

In the urban watersheds in the St. Louis region, domestic pet waste has been identified as common nonpoint source of bacteria.[30] To gauge the potential for bacteria from pets to cause the impairment of Kiefer Creek, the MCE draft Kiefer Creek plan applied the American Veterinary Medicine Association's 'Pet Ownership Calculator' to the estimate number of pets in the watershed. The calculator returned an estimated pet population of 2,472 dogs and 2,700 cats based on the human population.[31] When this waste isn't properly managed it can contribute significantly to high bacteria levels in our waterways. The MCE draft Kiefer Creek plan assumed the bacterial output from dogs was entirely outdoors with a 50% likelihood of cleanup before a rain event could wash the waste into the stream. Outdoor cats are likely to defecate outdoors 100% of the time, but only about 55% of cats in the US have outdoor access. Dogs have been found to contribute up to 15% of the bacteria in local watersheds that have a higher population density, and subsequently more pets, than the Kiefer Creek Watershed. These highly pet-populated watersheds display lower concentrations of bacteria than Kiefer Creek, and so it is unlikely that waste from domestic pets is the primary bacteria source in Kiefer Creek.[32]

1.2 Wildlife as a source

The MCE draft Kiefer Creek plan ruled out wildlife waste as a major source because the relatively small impact of wildlife waste is apparent in healthy watersheds which typically support a panoply of wildlife without violating water quality criteria. In the Kiefer Creek watershed, there are many pets and horses as well as an array of wildlife, all of which contribute to the bacteria that is present in the watershed. As a watershed changes from natural to developed, and its natural land cover is reduced, its capacity to process the waste from animals diminishes, whether they are native wild animals, or domesticated animals brought in with development. In the MCE draft Kiefer Creek plan's efforts to develop a watershed model, wildlife waste and urban runoff were accounted for in pathogen loading analyses.[33] It has also been found that desiccation of animal and wildlife waste typically results in 90% die off of bacteria.

1.3 Horse farms as a source

The MCE draft Kiefer Creek plan evaluated the potential for bacterial nonpoint sources typical to both urban and rural regions of the Meramec Basin that are represented within the watershed. In the rural Ozarks, common nonpoint bacteria sources include livestock, horses and broken or poorly designed on-site wastewater treatment systems. Many parts of Kiefer Creek are still quite rural in terms of the land use and land cover, allowing for many watershed residents to keep horses at their home. The Kiefer Creek watershed does not contain any livestock operations, however there are many horses in the watershed at two commercial stables and on over a dozen residential parcels (see Map 11).

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[30] Donald H. Wilkison and Jerri V. Davis, U.S. Department of the interior, U.S. Geological Survey, *Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007,* Scientific Investigations Report 2010-5150 (Reston, VA: U.S. Geological Survey, 2010), 28, Figure 12. https://pubs.usgs.gov/sir/2010/5150/pdf/sir2010-5150.pdf

[31] MCE draft Kiefer Creek Plan, page 23.

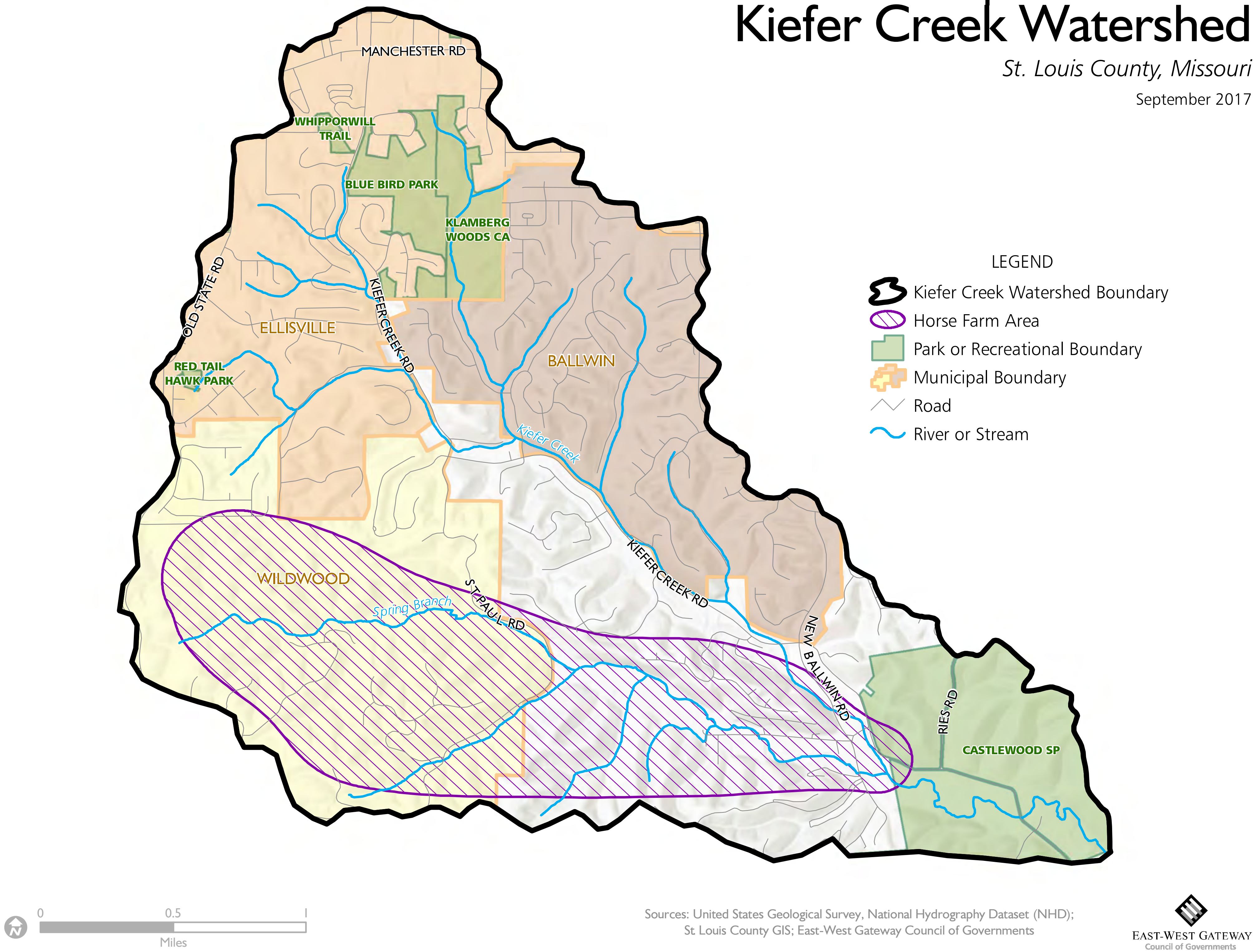
[32] Ibid., page 30

[33] Ibid., page 23

Map 11
Kiefer Creek Watershed

St. Louis County, Missouri

September 2017



Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

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Horse manure is a common nonpoint source of bacteria in watersheds across the United States. The MCE draft Kiefer Creek plan used field observations and aerial imagery to identify all of the pastures and visible horses, and spoke with residents about manure management practices. The imagery review and interviews led to an informed estimate of 116 horses in the watershed mostly housed at the commercial stables with some form of manure management, but many issues were identified relating to exhausted pastures and erosion. Residential owners employed less effective manure management practices, however their horses tended to have access to more area of pasture per horse resulting in healthier pastures.[34] The MCE draft Kiefer Creek plan estimated that each individual horse produces an average of 9 tons of manure and 3.5 tons of urine per year.

Horse waste has been known to cause issues in other Ozark waterways, such as the Jack's Fork, which was listed as impaired in 1998 for recreational use due to bacteria in 1998 and 2002. The TMDL written to address the impairment of the Jack's Fork River included a specific assessment of potential waste loading from horses and proposed management measures to reduce this source of bacteria. Through interviews with horse owners in the watershed, the MCE draft Kiefer Creek plan estimated on average local horses are outside 70% of the time, where manure is not typically cleaned up and about 10% of the manure in the watershed is stored outdoors in uncovered piles. Horses produce a high volume of waste that has a low density of bacteria so the small population of horses in the watershed should not pose a significant threat to water quality, especially with improved storage and composting of horse manure and effective pasture management. Even if the horse manure is uncovered and located close to a tributary channel, it could contribute only a relatively small amount of bacteria compared to other likely sources such as on-site wastewater treatment systems.[35]

1.4 On-site wastewater treatment systems as a source

Failing on-site wastewater treatment systems can produce a very high concentration of bacteria that is highly mobile, especially in a karst area such as the Kiefer Creek watershed. Untreated wastewater from leach fields can also build up in shallow soils to be washed into a nearby stream by rainfall. According to EPA, the estimated failure rate of on-site wastewater treatment systems in Missouri is 30% to 50%, with old age and poor design being major factors responsible for system failure.[36] The primary source of bacteria in Kiefer Creek watershed is highly likely to be on-site wastewater treatment systems because of hydrological a soil conditions and because of the significant number, and poor functioning of, on-site wastewater treatment systems in the watershed.

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[34] Ibid. page 24.
[35] Ibid. page 30.
[36] U.S. EPA, Office of Water, Office of Research and Development, On-site Wastewater Treatment Systems Manual (EPA/625/R-00/008, Washington, DC: GPO, 2002), 1-7, Table 1-3.

Kiefer Creek is fed by at least six significant springs throughout the watershed, and major portions of the creek may be categorized as losing streams (the portion of Kiefer Creek upstream of Spring Branch is classified as a losing stream, while downstream of Spring Branch it is classified as a gaining stream). These two conditions mean that the water quality of Kiefer Creek is dependent on the quality of the groundwater in addition to the quality of the runoff and drainage that reaches the stream bed. This makes Kiefer Creek highly susceptible to bacteria leaked from faulty on-site wastewater treatment systems in the area. In addition, groundwater does not follow the topographical boundaries that delineate watersheds, and it is likely that the spring water feeding Kiefer Creek originated from an area much wider than the watershed, carrying with it accumulated contamination. According to hydrologic analysis of the East West Gateway's 1978 St. Louis Water Pollution Control Study on areas that are tributaries to the Lower Meramec River, the groundwater in the Kiefer Creek area flows in a northeast direction.[37] This suggests that some of the water entering Kiefer Creek through the various springs likely contains contamination from other areas.

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 Resources Conservation Service, or 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 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 on-site 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.

Table 10, based on information from the 2012 Lower Meramec Watershed Plan, shows that 30.9 percent of the Hamilton Creek watershed (which contains Kiefer Creek) has Group D poorly drained soils not suitable for on-site wastewater treatment systems.[38]

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[37] East-West Gateway Council of Governments, St. Louis, MO Water Quality Management Plan, Area-wide waste treatment management study (208), May, 1978. http://www.ewgateway.org/pdffiles/library/wrc/208Rpt-1978/208Rpt-Part1.pdf

[38] East-West Gateway Council of Governments, Lower Meramec Watershed Plan 2012, page 114. http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

Table 10. 2012 Lower Meramec Plan Hamilton Creek Watershed Hydrologic Soil Groups

Hydrologic Soil Group	Acres	Percent Share
A	385.8	1.1
B	12,730.2	36.4
B/D	18.4	0.1
C	9,702.6	27.8
C/D	41.8	0.1
D	10,802.2	30.9
No Data	1,275.0	3.6
Total	34,956.0	100

The MCE draft Kiefer Creek plan estimated the number and age of on-site wastewater treatment systems in the watershed using datasets and assistance from MSD and St. Louis County, which rendered a highly refined on-site wastewater treatment system dataset for the watershed.
The St. Louis County Parcel Database contains a wide range of useful attribute data including a column called 'YEARBLT,' which refers to the year in which a structure was first built according to county records. The MSD pump station in Castlewood State Park came online in 1986, and serves the majority of the parcels within the Kiefer Creek catchment. All non-vacant watershed parcels developed prior to the operational date of the pump station were extracted to a new dataset representing potentially un-sewered parcels based on the infrastructure timeline.

Table 11. On-site Wastewater Treatment System Dataset

Year Built Range	Non-Vacant Parcels	Single Family	Duplex Townhome	Multi-Family	Institutional & Parks	Commercial & Industrial
1900 >	**3**	3	0	0	0	0
1901 - 1910	**2**	2	0	0	0	0
1911 - 1920	**20**	19	1	0	0	0
1921 - 1930	**62**	58	1	1	1	1
1931 - 1940	**12**	8	1	2	1	0
1941 - 1950	**33**	32	0	0	0	1
1951 - 1960	**64**	58	1	0	2	3
1961 - 1970	**62**	55	1	1	1	4
1971 - 1980	**310**	247	0	53	2	8
1981 - 1985	**180**	140	0	33	1	6
Total	**748**	**622**	**5**	**90**	**8**	**23**

Table 12. Kiefer Creek Age of Structure Dataset

Kiefer Spring Branch					Sontag Spring Branch			Kiefer Main Branch		
Year Range	**Count**	**Single Family**	**Dplx/ TwnH**	**Commercial**	**Single Family**	**Dplx/ TwnH**	**Commercial**	**Single Family**	**Dplx/ TwnH**	**Multi-Family**
1850 - 1920	**6**	0	0	0	5	0	0	1	0	0
1921 - 1940	**19**	3	1	0	10	0	1	1	1	2
1941 - 1960	**9**	3	1	1	3	0	0	1	0	0
1961 - 1980	**37**	23	0	0	12	1	1	0	0	0
1981 - 2000	**23**	8	0	0	15	0	0	0	0	0
2001 - 2012	**6**	4	0	0	2	0	0	0	0	0
Total	**100**	41	2	1	47	1	2	3	1	2

With this approach, the MCE draft Kiefer Creek plan identified properties unlikely to be connected to sanitary sewers and are therefore likely using an on-site wastewater treatment system - 159 residences that do not pay for sanitary sewers and another 100 non-vacant residential and commercial properties that were not detected as unbilled, but are outside of the feasible reach of the existing infrastructure (See Map 12 which presents extent of sanitary facilities in the watershed). The MCE draft Kiefer Creek plan then evaluated the functioning of the on-site wastewater treatment systems based on a number of factors related to age of the system and drainfield effectiveness. Each factor was broken down into a ranking representative of the relative significance of each factor attribute, the higher the category and overall ranking, the higher the potential for system failure and bacterial loading.

Parcel Area: Without sufficient area for an on-site wastewater treatment system it is unlikely that the system is effectively eliminating the bacteria in the effluent. St. Louis County requires a minimum lot size of 20,000 square feet if the premises are served by a public water main or 30,000 square feet otherwise.[39] The MCE draft Kiefer Creek Plan found there are 80 likely on-site wastewater treatment systems, or about 31 percent of the likely systems in the watershed, on parcels that are less than 20,000 square feet, with 33 which are less than 10,000 square feet.[40] These systems are likely to be failing due to a lack of sufficient area for processing of effluent to effectively eliminate bacteria. All of these systems are located within 1.25 miles of the swimming area in Castlewood State Park and all but one are on parcels developed before 1980 with an overall average estimated system age of 82 years (See Map 12.)

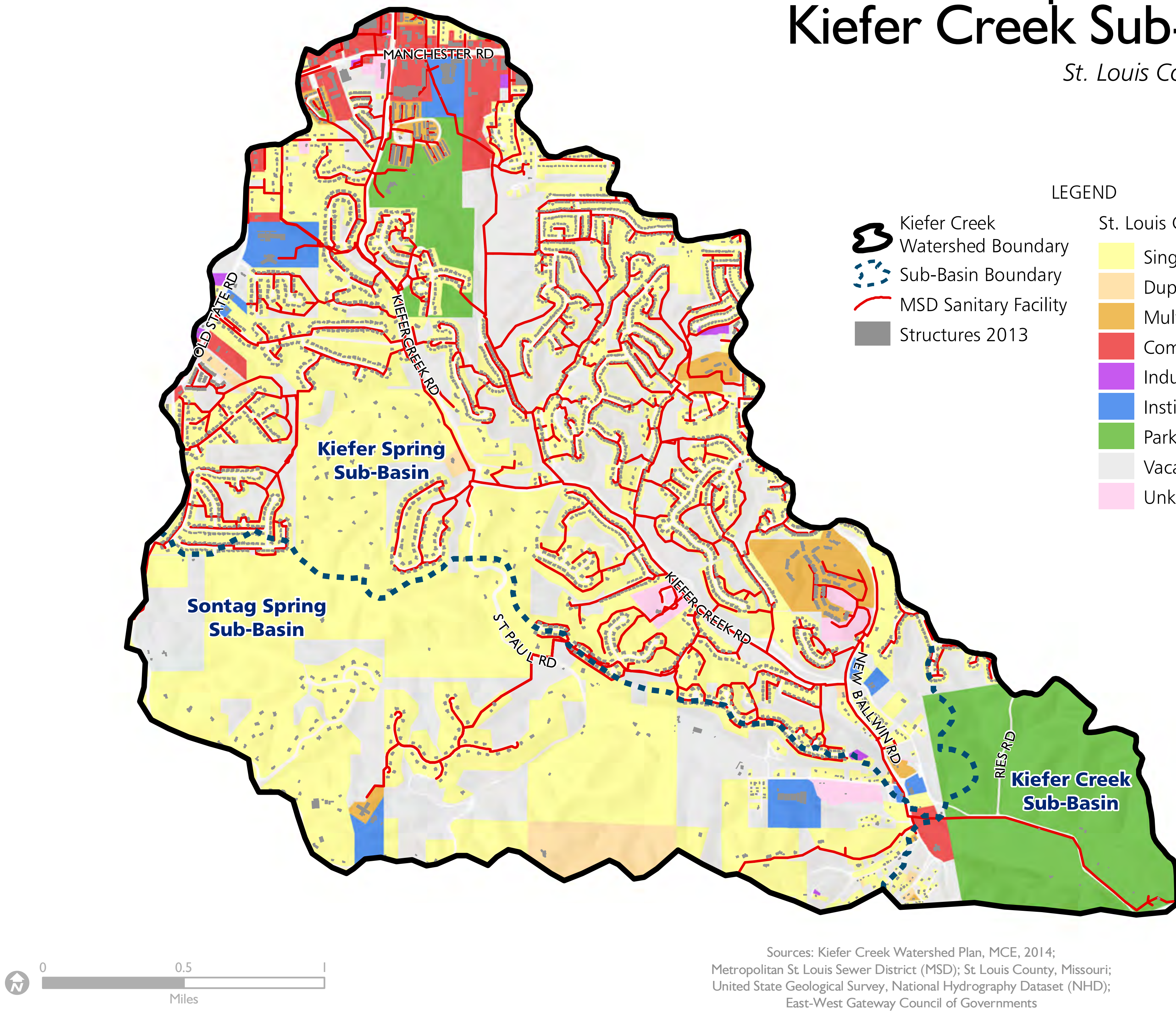
[39] http://www.stlouisco.com/Portals/8/docs/Document%20Library/Public%20Works/code%20enforcement/ordinances/09-UPC-Plumb-Ord.pdf.
[40] MCE draft Kiefer Creek plan, page 27.

Map 12

Kiefer Creek Sub-Basins

St. Louis County, Missouri

September 2017



Sources: Kiefer Creek Watershed Plan, MCE, 2014; Metropolitan St Louis Sewer District (MSD); St Louis County, Missouri; United State Geological Survey, National Hydrography Dataset (NHD); East-West Gateway Council of Governments

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Table 13. Parcel Area- On-site Wastewater Treatment System

Parcel Area (Square Feet)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
< 10000	**10**	5	17	11	**33**
10000 –20000	**9**	13	23	11	**47**
> 20000	**1**	80	95	4	**179**

On-site wastewater treatment system estimated age: As on-site wastewater treatment systems age, the likelihood of failure increases. Older systems also lack the advantage of modern system design and any system built prior to 1996 were not subject to state design standards. The MCE draft Kiefer Creek plan used parcel data to rank from 1 to 10 on-site wastewater treatment systems based on age.[41]

Table 14. Estimated Age- On-site Wastewater Treatment System

System Age (Years)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
> 50	**10**	38	68	25	**131**
41 -50	**9**	6	9	0	**15**
31 -40	**7**	34	12	1	**47**
21 -30	**5**	12	26	0	**38**
11 -20	**3**	5	19	0	**24**
1 -10	**1**	3	1	0	**4**

The plan found there are only 28 systems that were likely to be built in accordance with state design standards. At the same time, 146 systems are likely to be more than 40 years old. With excellent design and maintenance, including replacement of broken and rusted components, an on-site wastewater treatment system can function indefinitely. Without information on specific system designs it is difficult to assume a certain rate of failure based on age, for example concrete on-site wastewater treatment tanks can last indefinitely while metal tanks usually fail due to rust in 15 to 20 years. Drip fields tend to have a lifespan of around 20 years, however this can vary depending on the soils, slope and encroachment of plant root systems. Considering these factors it is also very likely that many older systems in the watershed have had failing components replaced at some point, however for this to happen a failure would have to have been detected. In some cases a failing system may not be apparent if the effluent flows directly into the sub-surface flows where it will not be easily detected.

Land Cover: Overall trees are great for the watershed and perform irreplaceable environmental services while providing habitat, however they can also wreak havoc on an on-site wastewater treatment system. Some newer on-site wastewater treatment systems do not require a drip field, however most do, and drip fields work best when the effluent is exposed to the ultra violet rays from sunlight. Tree root systems can also damage the drip field, lateral connection and on-site wastewater treatment tank. The MCE draft Kiefer Creek plan ranked from 1-10 drip field areas with low amounts of un-forested areas because they are more likely to malfunction.[42]

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[41] Ibid.
[42] Ibid. page 28.

Table 15. Land Cover- On-site Wastewater Treatment System

Grass Area	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
10m2>	**10**	0	2	0
11m2 - 25m2	**9**	0	2	2
26m2 - 50m2	**8**	0	6	3
51m2 - 75m2	**7**	1	6	4
76m2 - 125m2	**6**	4	12	5
126m2 - 175m2	**5**	3	5	3
176m2 - 250m2	**4**	5	9	5
251m2 - 500m2	**3**	19	16	3
500m2 - 1000m2	**2**	14	11	1
1001m2<	**1**	52	66	0

Soils: The typical Ozark soils and karst topography in the watershed are not well suited for on-site wastewater treatment systems. That said, the MCE draft Kiefer Creek plan considered the hydrologic soil groups in terms of their potential to process on-site wastewater treatment system effluent or transmit it untreated into the stream flow. When an on-site wastewater treatment system is installed or inspected according to current design guidelines and local ordinance, a percolation test is conducted to calibrate the system design, especially the drip field, to the soil conditions on site.[43]

Table 16. Soils- On-site Wastewater Treatment System

Hydrologic Soil Group	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
D	**10**	6	11	0
C	**7**	57	84	16
B	**3**	35	40	10

Slope: The steeper the slope of an on-site wastewater treatment system drip field the less likely that effluent will be fully treated before it runs off the site and into the nearest stream channel. The average slope of each potential drip field zone was calculated to assign a ranking from 1 to 10.

[43] Ibid.

Table 17. Slope- On-site Wastewater Treatment System

Average Slope (%)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
9.01 -10	**10**	0	1	0
8.01 -9	**9**	0	0	0
7.01 -8	**8**	0	1	0
6.01 -7	**7**	0	6	0
5.01 -6	**6**	2	17	1
4.01 -5	**5**	25	22	12
3.01 -4	**4**	24	30	10
2.01 -3	**3**	9	24	2
1.01 -2	**2**	9	19	0
0.0 -1	**1**	29	15	1

The MCE draft Kiefer Creek plan added up each attribute ranking for each parcel with an on-site wastewater treatment system to create an overall ranking the system in the watershed with a maximum possible raw score of 50 and a minimum raw score of 5.

Table 18. Overall Ranking- On-site Wastewater Treatment System

Raw Score	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
46 to 50	0	1	0	1
41 to 45	0	4	1	5
36 to 40	0	14	11	25
31 to 35	1	16	6	23
26 to 30	19	16	7	42
21 to 25	36	26	1	63
16 to 20	36	42	0	78
11 to 15	4	15	0	19
5 to 10	2	1	0	3

The raw score provides a good overview of the conditions that affect each system in the watershed, however certain conditions are more consequential to the function of a system than others. Parcel area, age and grass area are all critical aspects of on-site wastewater treatment system function, while slope and soil group are less pertinent in this analysis. Estimating the failure rate of on-site wastewater treatment systems is imprecise; only through a professional inspection can a system be conclusively evaluated. However, inspection reports are not necessarily submitted to or collected by any regulatory agency, making it necessary to use estimates such as these to evaluate the potential impacts from failing systems when developing a watershed plan. Using this analysis, the MCE draft Kiefer Creek plan assumed that all systems with an age, parcel area or grass area rank of 9 or 10 are likely to be failing.

The data gathering and analysis done as part of the MCE draft Kiefer Creek plan demonstrates that on-site wastewater treatment systems are the source of the majority of the excess bacteria in Kiefer Creek. These systems also happen to be a very complex and expensive source of bacteria to control.

Element B: An Estimate of the Load Reductions Expected for the Management Measures Described in Element C

1. Estimating Pollutant Loadings

In the 2012 Lower Meramec Watershed 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 Kiefer Creek sub-watershed. 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)[44] were utilized. Model default values represent best professional judgement and give additional weight to studies conducted at a national level. These default values do not incorporate studies on arid climates. Bacteria concentrations came from the Minnesota Pollution Control Agency Estimator tool to calculate TMDL benefits.[45] A description of the Simple Method technique can be found in Appendix D of the 2012 Plan.[46] Table 19 below contains the baseline estimates developed for the four pollutants and bacteria in the Kiefer Creek sub-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.

Table 19. Kiefer Creek Sub-watershed Baseline Annual Loads

Pollutant	Pounds per year	Billion colonies
Phosphorous	1,529.6	
Nitrogen	9,499.5	
Total Suspended Solids	417,528.9	
Biological Oxygen Demand	28,894.1	
Fecal Coliform		82,220.5
E. coli		73,315.0

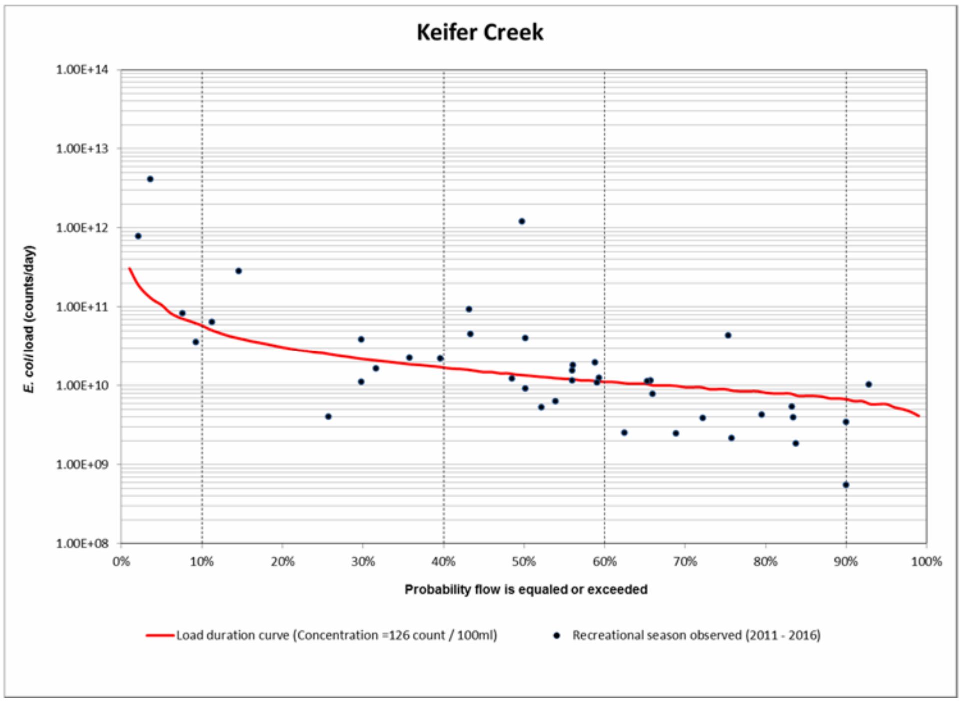
2. Kiefer Creek Load Duration Curves and Pollutant Reduction Estimates

Load duration curves and pollutant reduction estimates for *E. coli* bacteria for impaired streams in the lower Meramec watershed, including Kiefer Creek, have been prepared by MoDNR. These load duration curves and reduction estimates were developed to support this plan, and are for informational purposes only as they are not part of a TMDL. Percent reductions were calculated using the load duration curve and available water quality data collected from the water body. Load

[44] http://it.tetratech-ffx.com/steplweb/default.htm
[45] https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
[46] http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf

duration curves are a visual tool used to characterize water quality concentrations at different flow levels and the relationship between stream flow and loading capacity. The preliminary load reduction curve for Kiefer Creek is presented below in Figure 4. Table 20 presents the reduction estimate for the 50 percent flow range and can be used to aid in the selection and placement of BMPs. This load reduction was selected as these are flows associated with runoff when nonpoint source contributions are likely to occur. Appendix B contains a complete discussion of load duration curves and pollutant reduction estimates for those streams impaired by bacteria (load duration curves prepared by MoDNR). See Appendix B for additional explanation on how to interpret load duration curves.

Figure 4. Kiefer Creek Load Duration Curve



Source: MoDNR

Table 20. Estimate of Bacteria (*E. coli*) Load Reduction Needed to Attain Water Quality Standards

Impaired Stream	Flow (cfs)	Loading Capacity (counts/day)	Existing Loading (counts/day)	Reduction Needed (counts/day)	Percent Reduction Needed
Kiefer Creek	4.39	1.35E+09	2.21E+10	8.58E+09	38.8

cfs – cubic feet per second
Loading Capacity – The greatest amount of pollutant loading that a water body can receive without violating water quality standards.
Existing Loading – Estimated as the geometric mean of all observed *E. coli* loads within a specific flow range
Reduction Needed – Amount of reduction in bacteria loading needed to achieve Loading Capacity
Source: MoDNR

The percent share of bacteria loading from on-site wastewater systems, farm animals, urban areas and wildlife (including pets) was estimated by the MCE as part of the modeling they calculated for the MCE draft Kiefer Creek Plan. EWG used these percentages to allocate the estimated existing *E. coli* loading among these sources (see Table 21).

Table 21. Kiefer Creek Estimated Bacteria Contribution by Activity

Bacteria Source Groups	Percent Share	Existing *E. coli* Loading (counts/day)
On-Site Wastewater Treatment Systems	83.6	1.85E+10
Farm Animals	6.4	1.41E+09
Urban Areas	4	8.84E+08
Wildlife (and Pets)	6	1.33E+09
Total	100	2.21E+10

3. Load reductions from management measures in Element C

3.1 Load reduction estimates from on-site wastewater treatment system management measures

Element A provides information about on-site wastewater treatment systems as a primary source of bacteria in the Kiefer Creek watershed. Of the 259 properties identified in Element A likely to contain an on-site wastewater treatment system, 95 percent are single family residential units. The remaining parcels are multi-family residential (7), commercial (3), institutional (2) and recreational (1). The parcel area (in square feet) of these 259 properties was calculated and is presented in Table 22. It was assumed that on-site wastewater systems on parcels which are 20,000 square feet (0.46 acres) or less could potentially be failing because of the lack of square footage for the operation of an effective drainfield. Assumption for total acreage was that all parcels in: Category A were 10,000 square feet in size; Category B, 20,000 square feet; and Category C, 30,000 square feet.

Table 22. Kiefer Creek Sub-watershed Size of Parcels with On-site Wastewater Systems

Parcel Category	Parcel Area In Square Feet	Sub-watershed	Acreage
A	< 10,000	33	7.6
B	10,000 – 20,000	47	21.6
C	> 20,000	179	123.5
Total		259	152.7

To reduce bacteria levels, management measures target connecting half of the parcels from each category to the MSD collection system where physically feasible, or making repairs to, or replacement of, the on-site wastewater system so that it functions properly (see Element C). For this subset of properties with individual on-site wastewater systems in the Kiefer Creek watershed, baseline and future year pollutant and bacteria loadings were calculated using the Simple Method to determine annual urban stormwater loads[47]. Since 95 percent of the parcels are single family residential, the mean concentrations of the single family residential pollutant concentrations and bacteria event were utilized. The focus of this management practice is to reduce the pollution contribution from on-site wastewater treatment systems. Instead of only using the residential impervious acreage in the calculation, all of the acreage associated with this subset were used as a failing on-site wastewater treatment system can impact an entire parcel.

[47] Since the Simple Method uses annual load, and the TMDLs identify daily count, for this plan an approximate correlation of percent load must be assumed for all watersheds. Monitoring will be necessary to obtain actual load reduction counts.

For future years, it was assumed that half of the acreage in Categories A, B and C would receive improvements and, therefore would no longer contribute to the bacteria impairment in Kiefer Creek. Table 23 presents the baseline and future year loadings from the on-site wastewater system subset.

Table 23. Kiefer Creek On-site Wastewater System Subset

Kiefer Creek Sub-watershed (Hamilton watershed)			
Pollutant	**Baseline Loading Pounds per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Pounds per Year**	**Reduction Pounds per Year**
Phosphorus	139.4	69.5	69.9
Nitrogen	766.8	382.2	384.6
Total Suspended Solids	34,855.3	17,370.6	17,484.7
Bacteria	**Baseline Loading Billion Colonies per Year**	**Future Loading with MSD Connection and On-site Waste Water System Improvements Billion Colonies per Year**	**Reduction Billion Colonies per Year**
Fecal Coliform	12,311.2	6,135.4	6,175.8
E. coli	11,188.1	5,575.7	5,612.4

Simple Method to Calculate Urban Stormwater Loads

Referencing the load duration curve prepared by MoDNR for the 50 percent of time creek flow is equaled or exceeded, management measures are planned for improvements to be made to 130 parcels over the next twenty years[48], either by connecting to the MSD collection system or by replacing or repairing on-site wastewater treatment systems, resulting in a 50 percent reduction in bacteria loading from on-site wastewater systems (see Table 24). It is assumed that this effort would begin in year 3 after the adoption of this plan.

Table 24. Kiefer Creek- Estimated Improvements to Residential Properties with On-site Wastewater Treatment Systems

Time Period	Residential Properties	Estimated Loading Reduction
End of Year 4	10	7.11E+08
End of Year 5	10	7.11E+08
End of Year 10	30	2.13E+09
End of Year 15	40	2.84E+09
End of Year 20	40	2.84E+09
Total	130	9.24E+09

3.2 Load reductions from manure management measures

In addition, outreach and education on manure management techniques for the commercial stables and residential parcels with horses in the sub-watershed are planned. It is assumed that efforts will be focused on those owners of parcels adjacent to Kiefer Creek and its branches. It is estimated that by 2038, there will be a 30 percent reduction in bacteria load associated with farm animals (primarily horses). Table 25 presents the bacteria load reduction estimates.

[48] This assumes that half of the systems may be failing, need servicing, or replacement.

Table 25. Kiefer Creek- Implementation of Manure Management Education and Outreach

Time Period	Parcel Owners Participating	Estimated Loading Reduction
Year 1 – Year 3	2	4.04E+07
Year 4 - Year 5	4	8.08E+07
Year 6 – Year 10	6	1.21E+08
Year 10 –Year 20	9	1.82E+08
Total	21	4.24E+08

3.3 Load reductions from riparian buffer and stream channel stabilization management measures

Protecting and improving the riparian buffer along Kiefer Creek will result in a passive bio-filter for remaining urban overland runoff and further reduce NPS bacteria loads from wildlife and pet waste. Data on pollutant and bacteria removal efficiencies for naturalized stream buffers come from the Lower DuPage River Watershed Study (see Table 26). The Lower DuPage watershed study recommends using the middle value when a range of pollutant removal efficiencies are provided.

Table 26. Examples of Riparian Buffers Pollutant Removal Efficiencies

Reference Source*	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids	Percent Fecal Coliform
Lower DuPage River watershed Plan, 2011 – Naturalized Stream Buffer	40 - 65	40 - 50	55- 85	45 - 55
Chesapeake Bay Program – Urban Riparian Forest Buffer	50	25	50	N/A
Eightmile River, 2005 – Forested Buffer	36 – 70	48 – 74	70 – 90	N/A
Eightmile River, 2005 – Vegetated Filter Strips	24 – 85	4 – 70	53 – 97	Not Calculated
Eightmile River, 2005 – Forested and Vegetated Filter Strips	73 - 79	75 - 95	92 - 96	Not Calculated

The Conservation Foundation, Lower DuPage River Watershed Plan, 2011(http://www.dupagerivers.org/LDRWatershedPlan.htm)
Yale School of Forestry and Environmental Studies, Riparian Buffer Zones: Functions and Recommended Widths for the Eightmile River Wild and Scenic Study Committee, 2005 (http://eightmileriver.org/resources/digital_library/appendicies/09c3_Riparian%20Buffer%20Science_YALE.pdf)
Chesapeake Bay Program, Best Management Practices for Sediment Control and Water Clarity Enhancement, 2006 http://www.chesapeakebay.net/content/publications/cbp_13369.pdf)

Table 27. Naturalized Stream Buffer Pollutant/Bacteria Removal Efficiencies

Best Management Practice	Percent Removed
Total Phosphorous	53
Total Nitrogen	45
Total Suspended Solids	70
E. coli	Not Calculated
Fecal Coliform	50

In the Lower DuPage River Watershed Study, the cost to construct a naturalized stream buffer was between $5,000 and $10,000 per acre.

Based on results from the DuPage River Watershed Plan, it is estimated that bacteria load from the continuation and expansion of buffers in the Kiefer Creek sub-watershed would be reduced by 50 percent. The Nature Conservancy has proposed performing stream channel stabilization and buffer improvement on a 3,565 foot long portion of Kiefer Creek within Castlewood State Park. This bacteria reduction has been assigned to both the Urban Areas and Wildlife groups. Table 28 presents the overall load reduction allocated by source groups for Kiefer Creek.

Table 28. Kiefer Creek Estimate Load Reductions Allocated by Source Group

Kiefer Creek Watershed Groups with Bacteria Contribution	Bacteria Percent Share	Existing *E. coli* Loading (counts/day)	Percent Loading Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	Estimated Reduction with Implementation of BMPs and Naturalized Stream Buffer by Group	20 Years *E. coli* Loading (counts/day)
On site Wastewater Systems	83.6	1.85E+10	50	9.26E+09	9.24E+09
Farm Animals	6.4	1.41E+09	30	4.28E+08	9.90E+08
Urban Areas	4	8.84E+08	50	4.42E+08	4.42E+08
Wildlife (& Pets)	6	1.33E+09	50	6.67E+08	6.63E+08
Total	100	2.21E+10	48.7	1.08E+10	1.13E+10

MoDNR has estimated the Kiefer Creek loading capacity for the 50 percent of time creek flow is equaled or exceeded at 1.35E+10. At the end of the 20 year period, by improving on-site wastewater treatment systems, connecting to sewer lines, improving horse manure management practices and improving the riparian buffer of Kiefer Creek, it is estimated the *E. coli* loading could be 1.13E+10, a 48.7 percent reduction. This target may exceed the 38 percent reduction required to achieve water quality standards as identified in Table 19.

4. Stormwater BMP Removal Efficiencies

Four stormwater BMPs (e.g. rainscaping) were selected based on their ability to reduce bacteria and other pollutants in the impaired streams:

- Bioretention
    - Swales
    - Native Soil Rain Gardens
- Pervious Pavements

Tables 29 and 30 contain information on pollutant and bacteria removal efficiencies for these BMPs.

Table 29. BMP Pollutant Removal Efficiencies

Best Management Practice	Percent Total Phosphorus	Percent Total Nitrogen	Percent Total Suspended Solids
Bioretention	50	60	80
Pervious Pavement	45	10	90
Vegetated Swale	25	20	65
Rain Garden	65	60	75

Sources for bioretention, pervious pavement (permeable pavement with underdrain), vegetated swale and rain garden removal efficiencies can be found in Table 20 of the 2012 Plan at
http://www.ewgateway.org/lowermeramec/lowermeramecwatershedplan-final.pdf –

Table 30. BMP Bacteria Removal Efficiency

Best Management Practice	Removal Fraction	
	E. coli	Fecal Coliform
Biofiltration*	0.75**	0.75
Permeable pavement	0.70	0.70
Swale	0.00	0.00

Minnesota Pollution Control Agency Estimator for TMDL Annual Reporting -
https://stormwater.pca.state.mn.us/index.php/Guidance_and_examples_for_using_the_MPCA_Estimator
*Biofiltration assumed to be same as bioretention (large properties and individual raingardens).
**A value of 0.50 means that the BMP 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.

4.1 Bioretention

Bioretention is a depressed landscape feature which stores, filters, and infiltrates stormwater runoff. Bioretention is an effective BMP in areas already developed because it can be tucked into greenspace such as curb and cul-de-sac islands, streetscapes, and even planter boxes, and in parks it can be strategically located to capture stormwater from impervious surfaces.
Basic components important to most St. Louis area bioretention "cells" are native (or deep rooted) vegetation and organic soil that will drain well and provide growing media for plants. An ample supply of mulch to a bioretention cell along with native deep rooted plants will open heavy clay soil to improve drainage over time. Any bioretention feature should include an overflow structure to compensate for stormwater volumes exceeding the capacity of the bioretention cell.

Bioretention can include swales or rain gardens. Swales are shallow, grass or vegetated-covered channels designed to convey and slow down stormwater runoff and facilitate infiltration. A native soil rain garden is a small depression planted with native vegetation. It is designed to temporarily hold and soak in runoff from impervious surfaces (roads, roofs, and parking lots) and yards. A rain garden can be installed for an individual residence or government or commercial structures. For existing construction, the native soil garden offers a low-cost opportunity to capture and hold stormwater. Like stream buffers, the advantage of the native soil rain garden is that it improves efficiency over time, as plant roots continue to improve soil porosity. The proposed voluntary bioretention projects refer to native soil and native or deep rooted plants.

These projects can be sited in, or adjacent to, parking lots, near roads or buildings, or in residential yards and common ground areas, which would otherwise be conventionally landscaped.

4.2 Pervious Pavement

Pervious pavement is designed to allow water to drain through the surface and into the underlying soil or a stone reservoir. Pervious pavement includes porous asphalt and porous concrete as well as materials with void spaces for drainage such as porous pavers or interlocking grid materials. Pervious pavement is effective in parking lots, but not in areas that may experience erosion or flooding that deposits sediment in the pores of the pavement.

5. Load Reductions from Short-term Stormwater BMP Management Measures

5.1 Estimated Load Reductions from Rainscaping in Castlewood State Park

Demonstration rain garden projects are proposed for Castlewood State Park. Approximately 6,800 square feet of rain gardens would be installed at sites adjacent to the State Park office, one trailhead parking lot and the parking lots for the shelter/picnic areas. Table 31 below shows the estimated reduction associated with these raingardens.

Table 31. Castlewood State Park Demonstration Rain Gardens Estimated Reductions

Demonstration Rain Gardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	1.4	0.7	0.7
Nitrogen	7.4	4.4	3.0
Total Suspended Solids	337.8	270.2	67.6
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	119.3	89.5	29.8
E. coli	108.4	81.3	27.1

5.2 Estimated Load Reduction from Rainscaping on Private Property

A rainscaping cost-share program for privately owned lands has been proposed for the Kiefer Creek sub-watershed. The program would be focused on the installation of rainscaping on residential properties. A subdivision was identified as a critical area for rainscaping (see Element C) so the baseline load and estimated reduction of pollutant and bacteria was calculated for the 160 acre single family residential development. This subdivision contains 252 parcels with 34 impervious acres. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels (30,200 square feet). Table 32 presents the estimated reductions associated with the raingardens.

Table 32. Kiefer Creek Estimated Pollutant Load Reduction with Rain Gardens in One Subdivision

Example Subdivision Rain Gardens Estimated Reductions			
Pollutant	**Baseline Loading (Pounds per Year)**	**Future Reduction (Pounds per Year)**	**Future Loading with BMPs (Pounds per Year)**
Phosphorus	33.2	13	20.2
Nitrogen	182.8	65.7	117.1
Total Suspended Solids	8,308.7	3,732.1	4,576.6
Bacteria	**Baseline Loading (Billion Colonies per Year)**	**Future Reduction (Billion Colonies per Year)**	**Future Loading with BMPs (Billion Colonies per Year)**
Fecal Coliform	2,934.7	1,315	1,619
E. coli	2,667	1,198	1,469

6. Load Reductions from Long-term Implementation of Stormwater BMPs

Table 33. BMP Package

Land Use	BMP
Commercial	Bioretention (for 90 percent of impervious acreage) Pervious Pavement (for 10 percent of impervious acreage)
Industrial	Bioretention
Institutional	Bioretention
Multi-Family Residential	Vegetated Swales
Single-Family Residential	Rain Gardens
All land uses	Naturalized Stream Buffer
Roads	Vegetated Swales

In years 5-10, the widespread installation of stormwater BMPs in this sub-watershed will be encouraged by the cost share program to reduce the volume of runoff, reduce potential for streambank erosion and reduce pollutant and bacteria loading. Depending on the type of land use, BMPs will be implemented by individual homeowners, homeowner associations, private businesses, local governments or school districts. The BMP selection will require an analysis and evaluation of cost, funding sources, operation and management requirements, environmental evaluation and BMP siting and construction requirements. The full extent of BMP implementation in years 5-10 will be dependent upon the success of the demonstration BMP projects planned in years 1-5.

The full suite of BMPs will enable a reduction in average volume of stormwater runoff to local streams, and these practices will help to reduce general nonpoint pollutant load.
The design goals for the selected BMP demonstration projects are as follows:

1. Implement the selected BMP's in the locations identified in Element C. The BMPs installed on public lands will maximize speed of installation, and expand opportunities for educational and public outreach opportunities.
2. The performance goal of the various BMP installations will be capturing and treating stormwater runoff from 90 percent of the recorded daily rainfall events, which is based on a rainfall amount of 1.14 inches of rain during a typical storm event.
3. Monitor the reduction in peak flow rates in relation to rainfall events, overall volume reduction due to plant uptake and infiltration. Also, document the effectiveness of filtering at least one organic pollutant.

4. Use the BMP demonstration results to build public awareness of the cost-effectiveness of bio-retentive BMPs and their applicability to local building and sanitation codes.

In years 10-20, the BMP package will eventually be implemented on 60 percent of the existing and planned commercial, industrial, institutional, multi-family residential and single-family residential impervious acreage in the sub-watershed. For roads, the assumption will be 20 percent of the impervious surface acreage. Element C outlines the initial projects that have been identified as ways to encourage land managers to meet the goal of having BMPs installed on 5 percent of impervious acreage. This will increase to 10 percent by year 10, 30 percent by year 15 and 60 percent by year 20. Such an aggressive implementation percentage will be dependent upon significant "buy-in" by local governments and developers as well as private land owners. New development and redevelopment is already being addressed by permitting, so the focus of this plan is centered on the voluntary efforts that must also take place. Table 34 presents the estimated BMP load reductions in five-year increments for the Kiefer Creek sub-watershed. Based on the calculated load reductions by land use impacting the impaired streams, if BMPs are implemented across 60 percent of impervious acreage within each sub-watershed, then water quality standards will be met after 20 years. The Simple Method was used to calculate the estimated load reduction.

Table 34. Kiefer Creek Sub-watershed Estimated BMP Load Reduction over Time

Kiefer Creek Sub-watershed	**Annual Pollutant Loading (lbs/year)**				
Pollutant	**Baseline Loading**	**End of Year 5 5% Impervious Acreage Affected By BMP Suite**	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Phosphorus	1,529.6	1,499.5	1,448.5	1,355.6	1,241.8
Nitrogen	9,499.5	9,325.5	9,023.1	8,462.0	7,771.1
Total Suspended Solids	417,528.9	424,944.2	401,394.6	361,530.1	313,410.0
Bacteria	**Baseline Loading**	**Annual Billion Colonies**			
		End of Year 5 5% Impervious Acreage Affected By BMP Suite	**End of Year 10 15% Impervious Acreage Affected By BMP Suite**	**End of Year 15 35% Impervious Acreage Affected By BMP Suite**	**End of Year 20 60% Impervious Acreage Affected By BMP Suite**
Fecal Coliform	82,229.1	78,810.2	72,545.6	60,586.5	45,778.9
E. coli	73,322.4	70,279.7	64,669.2	53,920.5	40,602.0
E. coli % Reduction		4.1%	11.8%	26.5%	44.6%

Element C: Descriptions of the NPS Management Measures that will need to be implemented to Reach Load Reductions and Identification of the Critical Areas in which to implement those Measures

1. Water Quality Goal

Based on pollutant loading modelling and load reduction curves contained in Element B (see Table 20), the water quality goal for Kiefer Creek watershed is to:

Reduce Bacteria loading in Kiefer Creek by 38.8 percent to meet water quality standards by 2038

2. Management Measures and Project Descriptions to Achieve Water Quality Goal

Four non-point source management measures are proposed in key critical areas to address the sources of impairment in Kiefer Creek and result in the attainment of water quality standards

Management Measure 1: Restore the Riparian Corridor of Kiefer Creek to Enhance its Ecological Functions Associated with Reducing Sediment Loads and Filtering Pollutants.

Kiefer Creek flows through Castlewood State Park, which experienced 750,000 visitors in 2015. The creek is an attractive area for families to wade and play in the water during the summer. Although protected as a state park since the 1980s, the creek has experienced excessive streambank erosion and sedimentation that will continue unless actively stabilized and restored. Pet and wildlife waste can be filtered through a healthy riparian buffer. The buffer can reduce the amount of nonpoint source pollution entering waterbodies, enhance stream bank stability, reduce erosion, and provide aquatic and wildlife habitat. A buffer can also help slow runoff velocity from impervious surfaces and trap and filter out sediments and bacteria. The impaired section of Kiefer Creek also coincides with an eroded and degraded riparian buffer and stream channel in Castlewood State Park. A section of Kiefer Creek in Castlewood State Park has been identified as a critical area to stabilize the stream channel in order to improve buffer conditions and the ability to filter pollutants (see Map 13). Stream channel stabilization and riparian buffer restoration at this location will filter out bacteria and slow polluted water containing pet or wildlife waste from entering the stream where people swim and recreate as trees, shrubs and grasses grow and extend roots more deeply into the soil.

Solution 1.1: Stabilize Kiefer Creek streambank to facilitate riparian corridor filtration of pollutants

Project description - Kiefer Creek Stream Channel Stabilization & Buffer Improvement
The Nature Conservancy (TNC) has proposed to stabilize Kiefer Creek streambank and undertake riparian restoration in the lower section of Kiefer Creek in Castlewood State Park.[49]

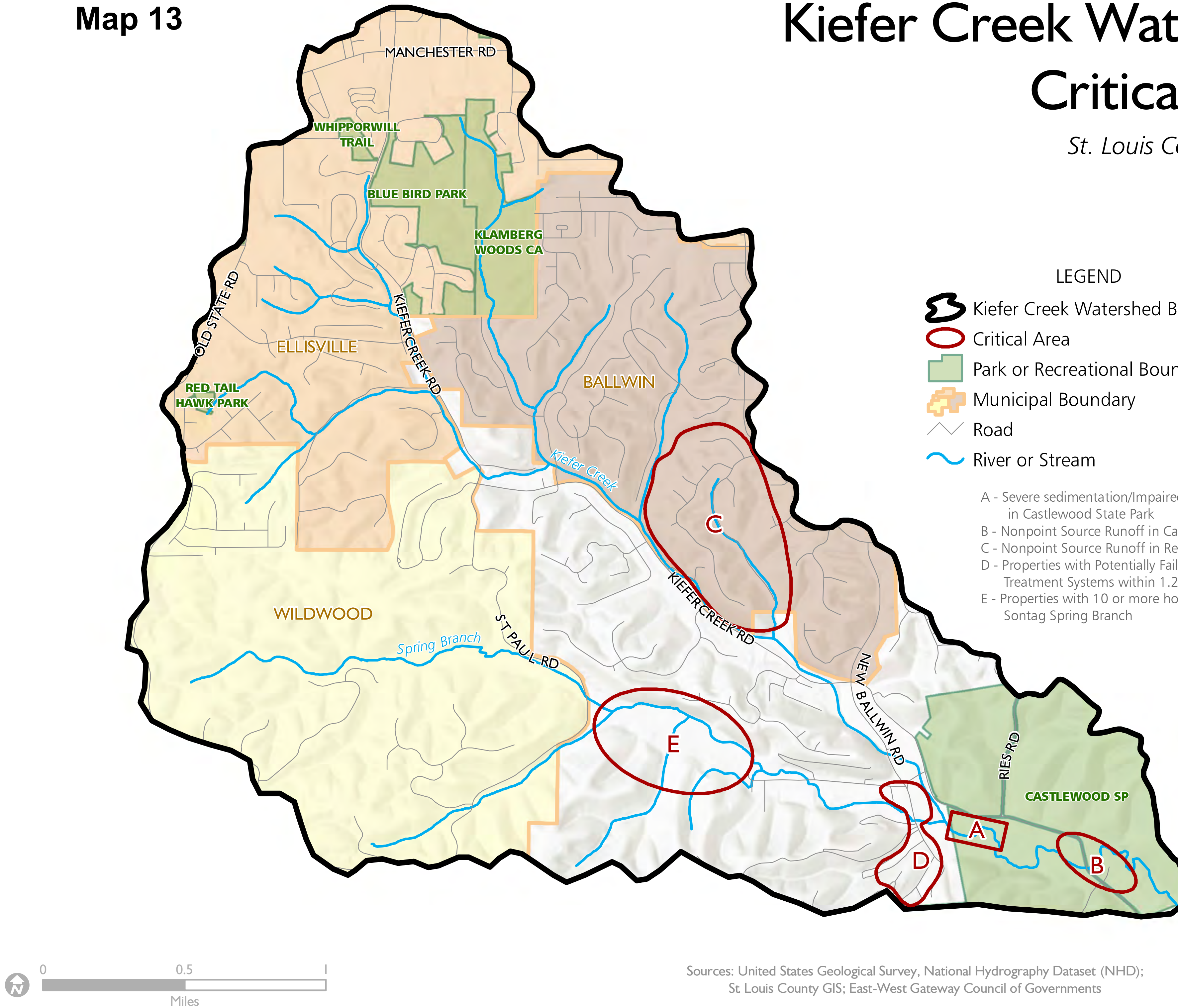
[49] A full project design plan can be found at https://tnc.app.box.com/s/e26gbr8fldzcbb1n01t0wqhctv0q7mcf

Map 13

Kiefer Creek Watershed Critical Areas

St. Louis County, Missouri

September 2017



LEGEND

- Kiefer Creek Watershed Boundary
- Critical Area
- Park or Recreational Boundary
- Municipal Boundary
- Road
- River or Stream

A - Severe sedimentation/Impaired Section of Stream in Castlewood State Park
B - Nonpoint Source Runoff in Castlewood State Park
C - Nonpoint Source Runoff in Residential Area
D - Properties with Potentially Failing On-site Wastewater Treatment Systems within 1.25 miles of Kiefer Creek
E - Properties with 10 or more horses within 400 feet of Sontag Spring Branch

Sources: United States Geological Survey, National Hydrography Dataset (NHD); St Louis County GIS; East-West Gateway Council of Governments

EAST-WEST GATEWAY
Council of Governments

This section is classified as impaired and identified as a critical area to improve riparian filtration of bacteria. The restoration objectives are: 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 stabilization of the channel will enable restoration of a healthy forested buffer zone along the creek, and the shaded buffer will help reduce bacteria, because stream temperatures will be lower. The buffer will also help to capture and filter pollutants, especially in high water conditions, which is when bacteria counts increase. The channel restoration will also improve aquatic habitat. This natural stream channel design project is 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 Lower Meramec River Basin.

Management Measure 2: Expand the use of Rainscaping BMPs throughout the Kiefer Creek Watershed to Treat Stormwater at its Source.

Projects on public and private property that are beyond MS4 permit requirements can serve to reduce stormwater runoff and demonstrate the practices for the many visitors to the parks and residents of subdivisions.

Solution 2.1: Implement Demonstration Rainscaping Projects on Public Property

Project Description: Rainscaping Projects to Capture Stormwater from Parking Lots and Roads in Castlewood State Park

Based on the location of the impaired section of Kiefer Creek, high resolution land cover data, aerial photography and MSD stormwater drainage data identified impervious surfaces that may be contributing sources of polluted runoff from pet and wildlife waste to Kiefer Creek. Through this analysis, critical areas for rainscaping on public property near the impaired section of Kiefer Creek in Castlewood State Park were identified (see Map 13). Approximately 6,800 square feet of rain gardens are to be installed at sites adjacent to the State Park office, one trailhead parking lot and the parking lots for the shelter/picnic areas. Rain garden projects will be implemented by the partnership, and will also include expanding the riparian buffer zone in the center of the park.

Solution 2.2: Implement a Private Lands Rainscaping Cost-Share Program.

Project description: Kiefer Creek Watershed Rainscaping Cost-Share Program

Lower Meramec watershed plan partners will develop a rainscaping cost-share program to support homeowners in the Kiefer Creek watershed. Native soil raingardens can reduce runoff, capture rainwater, and improve water quality Based on the location of the impaired section of Kiefer Creek, high resolution land cover data, aerial photography and MSD stormwater drainage data, impervious surfaces were identified that may be contributing sources of polluted runoff from wildlife and pet waste to Kiefer Creek. Through this analysis, a stormwater outfall from a piped stream that conveys stormwater from a large subdivision was identified as a critical area for rainscaping to achieve significant reduction in contaminated runoff (see Map 13). The subdivision is a160 acre single family residential development. It contains 252 parcels with 34 impervious acres. It was assumed that 200 square foot raingardens would be installed on 60 percent of the parcels for a total of 30,200 square feet. Sign-up for the cost-share program will be conducted via the Clear Choices Clean Water platform for Kiefer Creek. Parcels that have applied for the program and that have been approved for the program can be placed on an interactive map.[50]

Management Measure 3: Mitigate On-site Wastewater Treatment System Discharges
Parcel area, age and grass area are key factors in a failing on-site wastewater treatment system. Those parcels with a ranking of 9 or 10 in Element A are targeted as critical areas to do further on-site wastewater treatment system investigation, remediation or replacement. The MCE draft Kiefer Creek Plan identified 80 likely on-site wastewater treatment systems on parcels that are less than 20,000 square feet, with 33 which are less than 10,000 square feet within 1.25 miles of the swimming area in Castlewood State Park. Those 33 parcels are the critical areas to focus on in a sewer connection feasibility study and educating homeowners about repair or replacement (see Map 13).

Solution 3.1: Upgrade, Repair, Replace or Connect On-site Wastewater Treatment Systems Though Resident Education and Cost-Share Assistance

Project description: Develop and Implement Individual On-site Wastewater treatment system, Connection, Maintenance or Replacement Cost-Share Program
Encouraging homeowners to take action to repair, replace or connect their systems to the public sewer lines can be facilitated by a cost-share program, or if necessary by stronger enforcement of St. Louis County Department of Public Health regulations. An outreach strategy and informational materials on maintenance considerations for on-site wastewater treatment systems will be developed and a database created of owners of parcels which are not currently connected to MSD. To specifically engage homeowners in the cost-share program, *Clear Choices Clear Water* will be used to encourage people to take a pledge related to their septic system. After taking a *Clear Choices, Clean Water* pledge, they receive feedback about how much pollution they have prevented from entering Kiefer Creek. They get to see their location on an interactive map – providing further confirmation that they are doing their part. They also get an easy, low-pressure way to encourage their friends, family, and neighbors to do their part by way of email invitations or Facebook and Twitter feeds.

The goal is to achieve a minimum of 20 properties either connected to sewer or with an improved on-site wastewater treatment system by Year 5 and a total of 130 homes with failing on-site wastewater treatment systems in full compliance by Year 20.[51] The ability to determine which properties could be feasibly connected to public sewer lines will be determined through a sewer connection feasibility study undertaken by EWG in cooperation with MSD through funding under section 604(b) of the Clean Water Act. Property owners interested in connecting to MSD where economically and physically feasible, technical assistance will be made available as well as information on sources of financial assistance. It would be the responsibility of property owner(s) to construct sewer laterals and connect to MSD or construct a collection system and turn it over to MSD.

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[50] See Solution 2.1 in Element E for more information on Clear Choices Clean Water project description.
[51] See Element F for full implementation schedule.

Management Measure 4: Reduce Runoff from Agricultural Property

Critical areas to focus project implementation for manure management practices are the parcels with the largest number of horses identified in the MCE draft Kiefer Creek Plan and are closest to the Sontag Spring Branch of Kiefer Creek, (see Map 13). These parcels are likely to be producing more pounds of manure and have less healthy pastures as identified through interviews in the MCE draft Kiefer Creek plan. Furthermore, these parcels are located in the Sontag Spring Branch sub-watershed which enters the portion of Kiefer Creek that has been classified as impaired. Smaller parcels can be eligible for cost-share assistance. The land upon which the cooperator intends to install an eligible practice through program assistance must be located within a Missouri soil and water conservation district. In order to be eligible for cost-share, the land must have an FSA farm number. A cooperator must either have agricultural activity on three acres or more, or may own land of any size if $1,000 or more of agriculture products are normally produced and sold in a year. Funding for agricultural cost-share programs will be sought for those practices over and above, or not supported by the Natural Resource Conservation Service (NRCS) or State cost-share programs.

Solution 4.1: Encourage Agricultural Best Management Practices (BMPs) to Manage Animal Waste in Kiefer Creek Watershed.

Project description: Work with Local Horse Stables on Manure Management Education

Through a cooperative effort with the St. Louis County SWCD, partners will engage with parcels where horses are stabled about manure management education through implementation of Comprehensive Nutrient Management Plans (CNMP), Nutrient Management Plans (NMPs) and the use of BMPs to reduce animal waste entering the stream. The NMP is a farm-specific document designed to help farmers minimize nutrient runoff into local streams and rivers within a watershed. NMP's keep track of the amount, time, and application of manure on a farm. NMP's can also work to balance farm profits by implementing cost-effective alternatives to fertilizer management. A CNMP provides storage and destination ideas for managing manure produced within a farm. To accommodate specific needs of a NMP or CNMP a horse owner should consult with the Natural Resources Conservation Service (NRCS) or SWCD. In order to utilize the services of the NRCS in composing a NMP or CNMP, a horse owner must first register with the USDA Farm Service Agency as a farm. Keeping, raising and stabling horses is considered an agricultural practice. Many of the horse owners in the Kiefer Creek watershed are probably unaware of the benefits of a NMP or CNMP and the support offered through the NRCS and the SWCD.

BMPs include improved manure storage, composting horse manure, and installing grazing systems. Often times it may be the case that the location of manure piles and the design of storage area have not been considered in terms of reducing runoff to the stream. Ideally a manure pile will be located as far from the nearest stream channel or flow path as is possible on a given lot. In addition it is recommended that the location of the pile be graded to drain inwards and that the pile be covered by a roof or a weighted tarp to prevent any runoff.
When properly treated, horse manure is a valuable commodity for replenishing and fertilizing depleted soil, and it is wasteful and harmful to let it wash into Kiefer Creek. If properly composted, the manure from the horses in the Kiefer Creek watershed could be put to good use rebuilding the watershed soils that were depleted in the course of development and deforestation.

Grazing management is another practice that distributes manure throughout pastures for best uptake by vegetation. The potential for bacteria from manure to enter the stream channel can be further reduced by cleaning up manure in areas with high slopes, riparian buffer zones, and in areas where there isn't a healthy vegetative land cover. Targeted area cleanup could be expedited by placing manure composters in multiple locations.

Clear Choices Clean Water[52] contains a Soil Health Program that can be customized for horse property owners and manure management practices. All horse operations who pledge to develop nutrient management plans or other BMPs identified in CCCW will receive fence signage, tack medallions and other materials as well as information on the impacts their practices are making. An interactive map displays who is pledging to encourage uptake by other horse property owners.

[52] Refer to Element E for full project description of *Clear Choices Clean Water*

Element D: Estimate of the Amounts of Financial Assistance and the Sources and Authorities that will be relied upon for Each Project.

Table 35 lists the estimated costs associated with each project described in Elements C and E, the agencies, organizations and/or groups involved, and the amount of funding sought. Cost estimates were derived from a variety of sources. The Nature Conservancy provided information regarding streambank stabilization costs as well as costs associated with conducting technical workshops on channel stabilization and buffer improvements for local governments. Resources for cost-estimates for the on-site wastewater treatment system programs include the Missouri on-site wastewater improvement grant/loan program administered by the Missouri Association of Council of Governments, which provides loads up to $25,000 per homeowners to repair or replace septic systems (see http://www.macogonline.org/onsite/docs/Fact%20Sheet%20-%20Revised%203-15-16.pdf). Resources also include meeting with state licensed septic tank inspectors during a series of watershed stakeholder meetings. Information regarding working with local horse farmers came from the 2003 NRCS report: "Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plans." The Open Space Council provided cost estimates on the expansion of Operation Clean Stream from the main stem of the Meramec River to Kiefer Creek. America's Confluence provided cost estimates on the Clear Choices Clean Water pilot in Kiefer Creek Watershed. Costs associated with the Long Term Water Quality Monitoring Strategy were provided by the U.S. Geological Survey.   Sources for the costs estimates for rainscaping practices can be found in Table 21 in the 2012 Lower Meramec Watershed Plan. Other sources of available funding through grants or loans are found in Table 36.

Table 1. Estimated Project Costs for Kiefer Creek

Project Description	Project Costs	Partner Contribution	Funding Sought
Kiefer Creek streambank stabilization and buffer improvement	Phase 1: 375 feet of stream construction Observation: $22,497.00 Construction Total: $85,391.00 Contingency: $21,347.75 Total:$129,235.75	TNC $150,000 Other match is still TBD	42% or $300,000 in Year 1
	Phase 2: 3190 feet of stream construction Observation: $51,289.00 Construction Total: $420,588.17 Contingency: $$105,147.04 Total: $577,024.21		

Project Description	Project Costs	Partner Contribution	Funding Sought
	Total: $706,259.96		
Demonstration rainscaping projects in Castlewood State Park	Average cost for raingarden is $10 per square foot for design and installation 1,600 sq. ft. of rain gardens in Year 2-3 5,200 sq. ft. of rain gardens in Year 4-6 Total cost $68,000	MO State Parks – providing equipment Open Space Council – providing labor for installation 40% of total cost or $27,200	60% $9,600 in Years 2-3 $31,200 in Years 4- 6 Total amount sought $40,800
Kiefer Creek Watershed Rainscaping Cost Share Program	Average cost of raingarden is $10 per sq. ft. for design and installation 6,000 sq. ft. in Years 4 -6 $60,000 24,200 sq. ft. in Years 6- 20 $242,000 Total cost of $302,000	40% contributed by residents cost share and MDC cost share towards design and plants[53] $120,800	60% $36,000 in Years 4-6 $145,200 in Years 6-20 Total amount sought $181,200
Develop and Implement Individual On-site Wastewater Treatment System Connection, Maintenance or Replacement Cost Share Program	Costs range from $300 for a simple pump-out to $25,000 per property for a new system Costs to connect homes to sewer lines range from $10,000-$30,000 per property. The number of homes to be connected is dependent on recommendations in the study. 33 systems have been identified as critical areas nearest Kiefer Creek to address either by repair, replacement or connection to sewer lines. Costs could range from $9,900 to repair 33 systems to $825,000 to replace or connect.	40% contributed by Property owner cost share	60% For 33 systems costs range from $5,940 to $495,000 depending on whether repairing, replacing or connecting to sewer line For all 130 systems costs range from $23,400 to $1,950,000

[53] Refer to Table 35 for more information about MDC private land cost-share assistance as well as Appendix D

Project Description	Project Costs	Partner Contribution	Funding Sought
	Costs range from $39,000 to repair all 130 systems to $3,250,000 to replace or connect all systems.		
Work with Local Horse property owners on Manure Management Education	Average cost of $1500 per farm for comprehensive nutrient management plans[54] 4 horse property owners by end of Year 5 for a cost of $6,000 17 additional horse property owners by Year 20 for a cost of $25,500 Total cost = $31,500	40% provided by: SWCD NRCS Horse property owners cost share $12,600	60% Year 1- 3 $1800 Year 4-5 $1800 Year 6-20 $15,300 Total: $18,900
Expand Operation Clean Stream from main stem of Meramec River to Kiefer Creek.	$10,000 is required for volunteer coordination, event liability insurance, signage and supplies	40% or $4,000 provided by Open Space Council Missouri Stream Team	60% or $6,000
Clear Choices Clean Water Pilot in Kiefer Creek Watershed	Software License: 4 years. $16,300 Municipal Mapping GIS: $500 Private Septic Mapping GIS: $500 Private Septic Pledge Collateral: $1,000 Pet Waste Pledge Collateral: $1,000 Lawn Fertilizer Pledge Collateral: $500 Volunteer Service Pledge Collateral $500 Native Plants and Gardens Pledge Collateral $500 Marketing and Signage: $25,000 MS&T Biological Sciences: $3,000 America's Confluence overhead: $10,000 Total cost for 4 years: $58,000	40% $23,200 provided by America's Confluence	60% or $34,800
Technical Workshop on Channel	$7000 for contractor to present at workshop $300 for room rental $375 for refreshments	45% TNC Personnel Match: $2927 TNC 15% overhead Match: $1590	55% or $7675

[54] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012131.pdf

Project Description	Project Costs	Partner Contribution	Funding Sought
Stabilization and Buffer Improvement for Local Governments	$2,927 for personnel $1,590 for overhead $1800 for advertisement and registration Total Cost: $13,992	East West Gateway Council of Governments Match: $1800	
Install Signage along Walking Trail in Kiefer Creek Watershed about Stabilization Project for Park Visitors	Personnel: $2796 Overhead: $1169 Design and production: $5000 Installation: $6500 Total Cost: $15,465	68% TNC Personnel Match: $2796 TNC 15% overhead Match: $1169 Castlewood State Park Match: $6500	32% or $5000
Homeowner education through interviews with residents in Kiefer Creek	$14,500 for SLU to conduct residential surveys and outreach $2320 for the handout design and printing for homeowners and park visitors Personnel: $9735 Overhead: $3983 Project Cost with overhead: $30,538	40% or $12,218 TNC Personnel Match: $5560 TNC 15% overhead Match: $3983 DNR Watershed Coordinator Match: $2675	60% or $18,230 To cover residential surveys, design and printing and partial personnel costs
Citizen science volunteer training	$170 for supplies above and beyond what is supplied by Missouri Volunteer Water Quality Monitoring Program $1840 TNC Personnel Overhead: $544 Total Cost: $4169	15% TNC 15% overhead match: $544	85% or $3,625

Project Description	Project Costs	Partner Contribution	Funding Sought
Long-term water quality monitoring strategy	**Year 1** $116,674 **Year 2** $148,183 **Year 3** $125,066 **Year 4** $88,861 **Year 5** $139,307 Refer to Appendix E for costs for Years 6-20	**MSD match** **Year 1** $19,600 **Year 2** $19,992 **Year 3** $20,392 **Year 4** $20,800 **Year 5** $21,216 **Stream team in-kind** **Year 1** $6,886 **Year 2** $7,024 **Year 3** $16,509 **Year 4** $11,951 **Year 5** $11,981 **USGS Match** **Year 1** $20,200 **Year 2** $32,300 **Year 3** $13,126 **Total match** **Year 1** $46,686 **Year 2** $59,316 **Year 3** $50,026 **Year 4** $32,750 **Year 5** $33,196	Year 1 $69,998 Year 2 $88,867 Year 3 $75,040 Year 4 $56,111 Year 5 $106,111

Table 36. Grants and Funding Opportunities

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
North American Wetland Conservation Act – U.S. Standard Grants Program U.S. Fish and Wildlife Service	Program that supports public-private partnerships carrying out projects in U.S. Projects must Involve long-term protection, Restoration and/or enhancements of wetlands and associated uplands habitats.		50% matching funds required. Grants start at $100,000	www.fws.gov/birdhabitat/grants
Planning Assistance to States U.S. Army Corps of Engineers	Provides assistance with the development of comprehensive plans for the development and conservation of land and water resources. Cover planning level of detail.	States, local governments and other non-federal entities. Non-profits are not eligible but could partner with state or local governments.	Limit for each state is $500,000 Annually. Cost Share is 50-50. Generally studies range from $25,000-$75,000.	www2.mvn.usace.army.mil/pd/pppmd_assistance_states.asp
Environmental Education Grants U.S. Environmental Protection Agency	EPA's Office of Environmental Education, Office of External Affairs and Environmental Education supports environmental education projects that enhance the public's awareness, knowledge and skills to help people make informed decisions that affect environmental quality. Grants are awarded based on funding appropriated by Congress.	Applicant must represent one of the following types of organization to be eligible: local education agency; state education or environmental agency; college or university; non-profit organization 501(c) (3), noncommercial educational broadcasting entity; or tribal education agency	Annual funding for this program ranges between $2 and $3 million range. Non-federal matching funds of at least 25% are required.	www2.epa.gov/education/environmental-education-ee-grants
Watershed Management Plan Development Grant - U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	Provides funding for development of watershed-based management plans to restore watersheds impaired by non-point source pollution. Due to funding limitations and a new approach, the general solicitation schedule for watershed Planning has been discontinued.	Eligible organizations include state and local agencies, educational institutions and Non-profits organizations with demonstrated 501 (c) (3) status.		www.dnr.mo.gov/env/wpp/nps

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
Section 319 Nonpoint Source Grant Program U.S. Environmental Protection Agency administered through Missouri Department of Natural Resources	NPS source grant funds are provided from EPA through Section 319(h) of Clean Water Act. Funds can be used to implementing Best Management Practices and associated activities as detailed in their watershed management plan. Annual announcement on availability of funds. Amount of funding is dependent upon number of applications received.	Eligible organizations include state and local agencies, educational institutions and non-profits organizations with demonstrated 501 (c) (3) status.	Variable award amounts will be based on number of applicants, amount of funding available at time of request. Matching support: 60% federal and 40% non-federal (cash or eligible in-kind contribution)	www.dnr.mo.gov/env/swcp/nps
Targeted Watershed Grants Program U.S. Environmental Protection Agency	Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waterways. It is a competitive program. Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. Implementation grants support on-the-ground watershed projects and Capacity Building grants are awarded to leading organizations with a national or regional focus that are able to provide training, technical assistance and education to local watershed groups. Check with EPA for next proposal cycle.	Eligible organizations include State and local governments, public and private non-profit institutions/organizations, federally recognized Indian tribal governments, U.S. territories or possessions and interstate agencies. For profit commercial entities and all federal agencies are ineligible.	Applicants are required to demonstrate a minimum non-federal match of at least 25% of total project cost. Funding could range from $400,000 to $900.000.	Http://water.epa.gov/grants_funding/twg/initiative_index.cfm
Private Services Landowner Assistance Program Missouri Department of Conservation	Financial assistance is offered to communities interested in habitat and natural recourse management every year	Nonprofits, city/county units of government and non-government entities are eligible to apply	Assistance is available on July 1 each year. All applicable projects are subject to reimbursement caps per cooperator year. Most projects will be reimbursed at a rate of 50 percent of total costs up to a	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

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
			maximum limit, some restrictions apply.	
Clean Water Act Section 604(b) federal grant funds administered by the U.S. Environmental Protection Agency through the Department of Natural Resources	The Water Protection Program components under the Clean Water Act Section 604(b) federal grant, are intended to assist with the revision of Water Quality Standards, risk-based groundwater standards, the anti-degradation policy and implementation method, toxicity testing, area-wide wastewater management prioritization, including planning studies and, wastewater feasibility studies. A portion of the 604(b) federal grant is awarded to Missouri communities for water quality planning.	Communities are invited to submit their competitive project proposals through their Regional Planning Commissions and the Missouri Councils of Governments for funding. The water quality management funds could be used for activities such as: watershed management plans, urban stormwater management plans, and stormwater planning. Applicants were especially encouraged to give priority to watershed management planning in urban watersheds or sensitive watershed threatened by development, along with green infrastructure, water or energy improvements related to water quality, or other environmentally innovative planning activities.	Missouri's share of the 604(b) Recovery Act Funding is $1,097,400 million. The Clean Water Act Amendments required states to pass through 40 percent of the 604(b) funds to regional public comprehensive planning organizations.	https://energy.mo.gov/division-of-energy/transform/water-quality-planning-and-management---604(b)
State Revolving Fund (SRF) Loan Program Missouri Department of Natural Resources	The State Revolving Loan Program provides low-interest loans to Missouri communities for projects that improve wastewater and drinking water infrastructure. The Missouri Department of Natural Resources and the Environmental Improvement and Energy Resource Authority work together to administer this program and to protect public health and the environment. The SRF has implemented an agriculture loan program, in cooperation with the Missouri Agriculture and Small Business Development Authority, to fund certain nonpoint source projects, and has recently set aside funding for new initiatives to	Cities, towns, counties, regional sewer/water districts, water authorities and instrumentalities of the state are eligible for wastewater, drinking water and nonpoint source SRF loans. Private and nonprofit facilities are eligible for drinking water and nonpoint source loans. Individuals and citizen groups are also eligible for nonpoint source loans.	Missouri applies to the U.S. Environmental Protection Agency (EPA) annually for capitalization grants to fund its SRF Programs. To increase available funds, the state leverages its EPA capitalization grants in the municipal bond market. These funds are combined with the EPA required state match and then	https://dnr.mo.gov/env/wpp

Grant Program Sponsoring Agency	General Information	Eligibility	Level of Assistance	Website
	fund on-site wastewater treatment projects.		made available to Missouri communities in the form of low interest loans. As the loans are repaid, the money is reused (revolved) by the SRF to provide for future projects. The SRF is a fixed rate, 20-year loan. Interest rates are generally 30 percent of the market rate.	

Element E: Education Component used to Enhance Public Understanding and Encourage Continued Participation

1. Importance of Education

The Kiefer Creek watershed has approximately 3,220 suburban single-family households which constitutes 53 percent 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. Educating residents and visitors to the watershed will help to increase public awareness of water quality issues and ways individuals can act to improve and protect water quality in the Kiefer Creek watershed.

2. Management Measures to Enhance Public Understanding and Encourage Continued Participation in Water Quality Projects

Three management measures have been proposed as an education component to enhance public understanding of the projects proposed in Element C and to encourage continued participation in those projects. This section describes the projects associated with each management measure.

Management Measure 1: Engage Public in Positive Action to Improve Stream Buffers

Solution 1.1: Engage Citizens in Volunteer River Clean up and Riparian Buffer Improvements

Project description - Expand Operation Clean Stream from main stem of Meramec River into Kiefer Creek

Open Space Council plans several river trash removal projects under their program called Operation Clean Stream to improve water quality and access to the river, while also motivating more people to become involved in watershed protection. Each year Operation Stream Clean involves over 2,000 volunteers in river and stream clean-ups in the Lower Meramec watershed. In 2016, over 1,632 citizen volunteers cleaned up nearly 500 miles of waterway in the Meramec River watershed. Volunteers donated 4,900 hours and pulled 1,904 tires, 12,518 pounds of metal and 355.35 cubic yards of trash from the river. This effort has become a popular tradition and much of the outreach is done through word of mouth, Facebook and reaching out to existing stream teams. The EPA has recognized the role trash plays in contributing to water quality problems.[55] Open Space Council seeks to expand their clean-up activities to include Kiefer Creek to recruit volunteers in the watershed and provide education about water quality for residents in the watershed. The Open Space Council will start outreach efforts in order to engage Kiefer Creek residents in stream clean-up activities. This process will involve new volunteers signing up for monthly newsletters containing opportunities to get involved and encourage registration. *Clear Choices Clean Water*[56] also contains a volunteer services module to help people take a pledge do volunteer work and can connect pledgers to Operation Stream Clean activities.

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[55] https://www.epa.gov/trash-free-waters/clean-water-act-and-trash-free-waters

[56] See Solution 2.1 below

Management Measure 2: Provide Education Resources to Citizens in the Kiefer Creek Watershed to Affect Behavior Change on Private Property

Solution 2.1: Use social media and web-based platforms to affect behavior change in the Kiefer Creek Watershed

Project description - Clear Choices Clean Water Pilot in Kiefer Creek Watershed
Clear Choices Clean Water (CCCW) 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 such as agricultural BMPs and horse manure management. This flexibility provides for a dynamic outreach program that can grow over time or be changed seasonally or regionally to focus on 'hot topics'. This project proposes America's Confluence to become an affiliate and administer and choose which pledge campaigns to include in the program based on the management measures in this plan.

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.

This project proposes Kiefer Creek watershed to have its own site, complete with localized resources and mapping features and administered by America's Confluence. Refer to Appendix C for more detailed information about CCCW and how to license the program.

Solution 2.2: Provide Technical Assistance to Local Governments and Educational Opportunities to the Public

Project description - Technical workshop on channel stabilization and buffer improvement for local governments based on Kiefer Creek experience
As the Kiefer Creek Stream Channel Restoration is completed, TNC and EWG will work with the engineering firm contracted to complete the restoration to provide professional on-site training on science and application of natural stream restoration using bioengineering to protect roads, bridges and other infrastructure. A workshop for at least 25 participants from local governments and consultants who serve local governments in the region, will address best practices and solutions. 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 NPS 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.

Project description - Install signage along walking trail in Kiefer Creek watershed about stabilization project for park visitors
To explain the streambank stabilization project and why it is important for water quality and habitat, TNC and MoDNR State Parks will develop on-site signage for a visitor trail along the restored creek, create video of the construction process, provide website stories on TNC and partner websites, Facebook and public television stories, and prepare information handouts for park visitors, local stakeholders, and residents of the St. Louis metropolitan area.

Project description - Homeowner education through interviews with residents in Kiefer Creek
St. Louis University Center for Sustainability (SLU) will conduct homeowner outreach and residential surveys reaching approximately 3,220 households and interview up to 40 residents. They will examine homeowner motivations and interests regarding the protection of water resources and associated habitats. This effort will inform outreach activities here and in other parts of the Meramec River Basin. To generate 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, SLU 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, including the possible formation of a citizen advisory committee. Homeowner outreach is anticipated to set the stage for receptivity for future efforts to encourage homeowners to replace and maintain on-site wastewater treatment systems to address this primary source of bacterial contamination in Kiefer Creek.

Project description – Citizen Science volunteer training
TNC and MO Stream Team will train and support up to 25 Castlewood State Park Stream Team citizen science volunteers on how to rapidly assess and prioritize streambank erosion for NPS pollution reduction. Citizen scientists will monitor streambank erosion before and after the Kiefer Creek streambank stabilization project. For more information about the efforts described in Solution 2.2, see Appendix L, the TNC Five Star Urban Waters Restoration Project, Education Component.

Element F: Schedule for Implementing the NPS Management Measures

Element G: Description of Interim, Measurable Milestones

Element H: Criteria to Determine Whether Loading Reductions are being achieved over Time and Substantial Progress is being made toward Attaining Water Quality Standards

Table 37 contains the schedule for implementing the NPS management measures identified in Elements C and E; the interim, measurable milestones for determining that the projects listed in Elements C and E are being implemented; and a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards. By tracking indicators/criteria and milestones, both qualitative and quantitative, adaptive management can take place. The most recent information can be used to make a course correction to a specific project or update the plan. Overtime, as practices and/or cost-share programs are implemented, the proposed USGS water quality monitoring plan (See Element I) will help to determine if progress is being made to meet the estimated load reductions in Column 5 of Table 37 as well as the overall water quality goal for bacteria for Kiefer Creek (see Table 20). The core partners will meet on an ongoing basis (at minimum twice a year) to evaluate the progress of implementation activities and achieving load reductions, and to identify any implementation problems. When any course corrections are to occur, the associated schedule and project focus will be revised to address issues noted.

Table 37. Schedule of Implementation for Kiefer Creek Projects

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction	Critical Area
Years 1-3	Kiefer Creek Streambank Stabilization construction	# of linear feet of streambank constructed and stabilized	375 ft.	*E. coli* 1.51E+08 (counts/day) 0.7 percent reduction Phosphorous 0.14 (pounds/year) 0.4 percent reduction Nitrogen 0.9 (pounds/year 0.5 percent reduction Total Suspended Solids 54 (pounds/year) 0.6 percent reduction	A
	Design and installation of Rainscaping at Castlewood State park	# of square feet of rainscaping installed	1600 square feet		B
	Develop residential application process and recruitment strategy for private property rainscaping cost-share program		Application instructions and form completed		C
	Secure funding, develop residential application process for cost-share program, and conduct outreach to confirm interested homeowners who need connection, repair or replacement of on-site wastewater treatment systems	# of confirmed property owners with failing on-site wastewater treatment systems recruited to address system issues	10 property owners		D
	Starting in year two, manure management information materials will be distributed. Commitments to implement manure management efforts will begin	# of horse property owners involved in developing a plan	2 horse property owners		E
	Beginning in year one, Open Space Council will begin outreach efforts and register volunteers for Operation Stream Clean expansion into Kiefer Creek.	# of volunteers recruited for Kiefer Creek cleanup and riparian restoration event	30 Volunteers		A-E
	Beginning in year two, Clear Choices Clean Water pledge-based NPS watershed social marketing program will begin, a combination of education with commitments/pledges to take action elements	% of pledges made by on-site wastewater treatment system owners % of pledges by pet owners % of pledges by horse property owners	30% of system owners 10% of horse property owners 20% of pet owners		A-E
	Technical Workshop on Kiefer Creek Channel Stabilization and Buffer	# of participants in workshop and	Expected number of participants is		A

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction	Critical Area
Years 1-3	Improvement for Local Governments	percentage who find it useful	up to 25. Of participants, 50-85% finding it useful and requesting additional information		
	Install Signage along Walking Trail in Kiefer Creek Sub-watershed about Stabilization	# of signs installed	3-5 signs		A
	Homeowner Education through surveys and Interviews with Residents in Kiefer Creek Sub-watershed	Survey response rate and # of interviews conducted	3,220 surveys distributed. Response rate 35 – 65 percent. Up to 40 one-on-one interviews conducted		C
	In Year 1, training of citizen science volunteers would take place and rapid streambank assessment would take place before the streambank stabilization project begins.	# of volunteers trained and # of assessments undertaken	25 citizen science trained 1 Rapid stream assessment completed		A
	Water quality monitoring strategy	# of gages installed # of monitoring sites established and frequency of monitoring frequency of monitoring results reports	1 new gage installed 3 primary monitoring sites established At least 36 monitoring results recorded from routine monthly monitoring 1 monitoring report after Year 3		A-E
	Kiefer Creek Streambank Stabilization construction	# of linear feet of streambank constructed and stabilized	3,190 additional ft. Total of 3,565 feet by end of Year 5		A

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction	Critical Area
Years 4-5	Installation of rainscaping projects in Castlewood State Park	# of square feet of rainscaping installed	2,600 ft2	*E. coli* 1.72E+09 (counts/day) 7.8 percent reduction Phosphorous 2.86 (pounds/year) 8.3 percent reduction Nitrogen 14.7 (pounds/year) 7.7 percent reduction Total Suspended Solids 842.7 (pounds/year) 9.7 percent reduction	B
	In year four, continued outreach, education and recruitment of homeowners to rainscaping cost-share program	# of square feet of rainscaping installed	6,000 ft^2		C
	Beginning in year four, owners, interested in connecting to sewer lines, repairing or replacing on-site wastewater treatment systems, can participate in cost-share program	# of homeowners participating in cost-share program that have either connected to a sewer line, repaired or replaced on-site wastewater treatment system	20 homeowners		D
	Continuation of working with horse property owners to develop comprehensive nutrient management plans	# of horse property owners who have developed and are implementing a plan	4 Property Owners Involved		E
	Open Space Council will conduct a cleanup and riparian restoration event in Kiefer Creek	# of cleanup and restoration events in Kiefer Creek	2 events		A,B
	In Year 5, citizen science volunteers will do rapid streambank assessment after the streambank stabilization project is completed.	# of assessments completed	1 assessment completed		A
	Pledge-based NPS Clear Choices Clean Water watershed social marketing program will continue, a combination of education with commitments/pledges to take action and feedback measurement elements	% of residents who have made pledges	Additional 70% of system owners Additional 40% of horse property owners Additional 40% of pet owners		
Years 6-20	Year six complete rainscaping in Castlewood State Park.	# of square feet of rainscaping installed	2,600 square feet of 6,800 square feet by Year 20	*E. coli* 8.90E+09 (counts/day) 40.3 percent reduction Phosphorous 10.7 (pounds/year)	B
	Rain gardens will continue to be installed in the subdivision	# of square feet of rainscaping installed	24,200 square feet with a Total of 30,200 square feet by Year 20		C

Timeframe	Project description	Indicator/criteria to determine progress	Measurable Milestone	Estimated load reduction	Critical Area
Years 6-20	Continue outreach, education and recruitment to on-site wastewater treatment system cost-share program	# of homeowners participating in cost-share program who have connected to sewer line, repaired or replaced on-site wastewater treatment systems	110 homeowners with a total of 130 by Year 20	30.9 percent reduction Nitrogen 54.5 (pounds/year) 28.7 percent reduction Total Suspended Solids 3,105.6 (pounds/year) 35.9 percent reduction	D
	Continuation of working with horse property owners to develop comprehensive nutrient management plans	# of horse property owners who have developed and implemented a plan	15 Property Owners Involved Total of 21 Property Owners (100%) by Year 20		E
	Open Space Council will continue to recruit volunteers and conduct clean- up and riparian restoration events in Kiefer Creek	# of volunteers recruited and # of cleanup and restoration events	60 Additional Volunteers and 14 events		

Element I – Monitoring Component to Evaluate the Effectiveness of the Implementation Efforts Over-Time, Measured Against the Criteria Established Under Element H Immediately Above

1. Current Water Quality Monitoring in Kiefer Creek

Water quality monitoring provides an analytical framework to support project implementation and assess effectiveness. It also serves as a tool to inform and educate residents and stakeholders. Continuous water quality monitoring has been undertaken in Kiefer Creek watershed by USGS and MSD through the Kiefer Creek Monitoring Station. Surface water samples are taken from this site and Table 38 lists the items that are analyzed. In addition, a variety of data collected by various entities is available through the MoDNR web site at http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch. This data can be screened to determine where additional monitoring is needed and/or to track water quality changes.

Table 38. Items Analyzed for Water Quality Monitoring

USGS Station Number – 0719072	
Location – at Kiefer Creek Road (WBID 3592/0.5)	
Items Analyzed MSD	USGS Parameters
Ammonia-Nitrogen	Discharge
Chemical Oxygen Demand	Gage Height
Chloride	
Dissolved Oxygen	
E. coli	
Fecal Streptococcus Group Bacteria	
Hardness caused by Divalent Cations (Calcium, Magnesium)	
pH	
Sulfate	
Temperature of Water	
Total Suspended Solids	

2. Proposed Project Effectiveness Monitoring

Using this monitoring station, it will be possible to obtain long term analysis of changes over time in the watershed. To monitor the effectiveness of project implementation in the identified critical areas in the Kiefer Creek watershed, USGS has proposed a stream flow and water quality monitoring strategy for which builds off the existing monitoring infrastructure (see Appendix E for full strategy description). This monitoring effort will provide a foundation of routine and event-focused sampling which could be adjusted over time as the projects are implemented and local group(s) become engaged in monitoring.

2.1 Summary of long-term monitoring strategy

This 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).

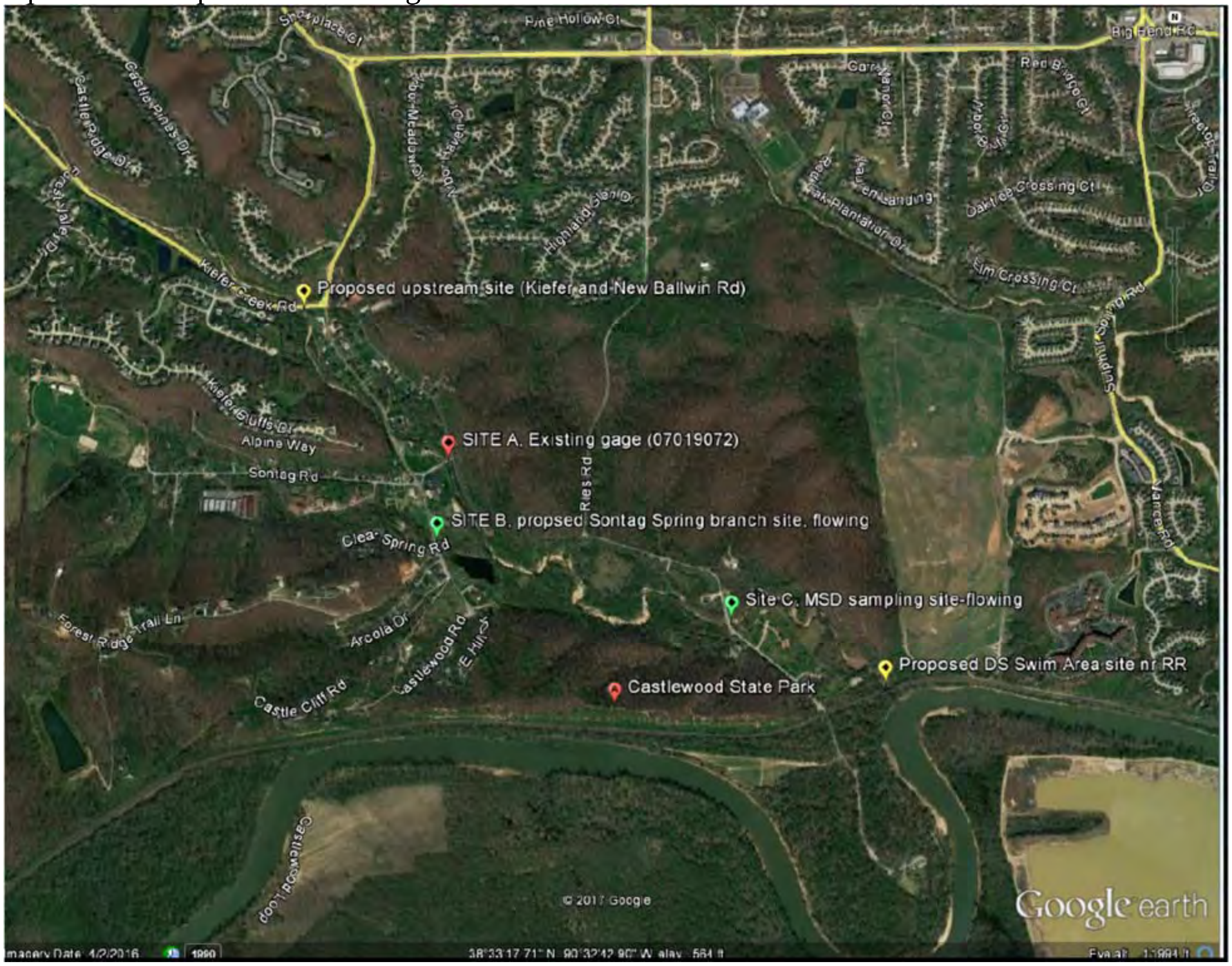
The proposed monitoring plan focuses on a two-year baseline intensive sampling effort that establishes fixed and consistent sampling at six sites combined with distributed sampling across the watershed under various hydrologic conditions via sanitary/seepage surveys. A continuous stage-only gage will 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 (see Map 14). 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 (see Appendix E) 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.

Map 14. USGS Option A – Proposed Monitoring Sites

Option A – Proposed Monitoring Sites



Map Key (North to South)
Yellow point – Proposed upstream site (Kiefer Creek and New Ballwin Road
Red point – Site A, existing USGS gage
Green point – Site B, proposed Sontag Spring branch site, flowing
Green point – Site C, MSD sampling site, flowing
Yellow point – Proposed downstream swim area site near railroad

2.2 Streambank Stabilization Monitoring

The Nature Conservancy will monitor success of streambank stabilization from a geomorphological perspective as well as rate of change. TNC will compare bank profiles:

- Before construction (current condition). TNC set up permanent monitoring stations at three streambanks proposed for stabilization as part of the Master Plan (set in April 2016), and also estimated erosion over time, as described in Appendix E (BANCS MODEL).
- Immediately after construction (i.e., as-built)
- At least once yearly after construction for 3-5 years.

Through these measurements the following will be able to be determined:

(1) How much erosion was predicted to occur in the Kiefer Creek project area using the Bank Assessment for the Nonpoint source Consequences of Sediment (BANCS methods), as measured in the Master Plan (Predicted rate in terms of tons/foot/year or cubic yards/foot/year at each streambank)

(2) How much erosion has occurred along the proposed restoration reaches since April 2016, per the existing permanent monitoring stations (Validated rate in terms of tons/foot/year or cubic yards/foot/year at each streambank)

(3) How much erosion has occurred following restoration of the proposed reaches by again setting up new permanent monitoring stations (Validated rate in terms of tons/foot/year or cubic yards/foot/year at each streambank).

Because these are rates, the total amount of erosion per reach over time (in tons and cubic yards) will also be determined. This will provide a good comparison of how much erosion was happening before and after restoration. Results typically show drastic reduction in rates of erosion following restoration, sometimes over 97%. Small adjustments in the bank shape following restoration after Kiefer Creek experiences high flows are to be expected, but those should be very minor versus the current condition.