Banklick Creek Watershed Plan Supplement and TMDL Alternative Plan: Primary Contact Recreation (PCR) Impairments

November 2024

Contents

1.0 Summary

The Banklick Creek Watershed Plan Supplement and Total Maximum Daily Load (TMDL) Alternative Plan addresses three impaired waterbodies on Kentucky's 2024 303(d) list. These waterbodies, Banklick Creek 0.0 to 3.5, 3.5 to 8.2 and 8.2 to 19.5, are impaired for pathogens for the Primary Contact Recreation (PCR) designated use (Table 2.1). This Plan includes an update on information reported in the approved 319(h)-funded Banklick Creek Watershed Plan (BCWP), and an updated implementation schedule (Appendix A) for addressing the PCR impairment. The implementation schedule includes projects outlined in the amended Northern Kentucky Consent Decree and SD1's Updated Watershed Plan for Northern Kentucky (UWSP).

The Banklick Creek watershed is a little over 58 square miles in size and is located predominantly in Kenton County, KY with a portion of the western headwaters in Boone County, KY. The mainstem of Banklick Creek originates on the border of unincorporated Kenton and Boone County just north of Walton and flows northward to the Licking River. This watershed is diverse in land use with higher density development in the lower portion and lower density residential, some farms and commercial properties in the upper portion. Figure 1.1 shows the watershed and the subwatersheds.

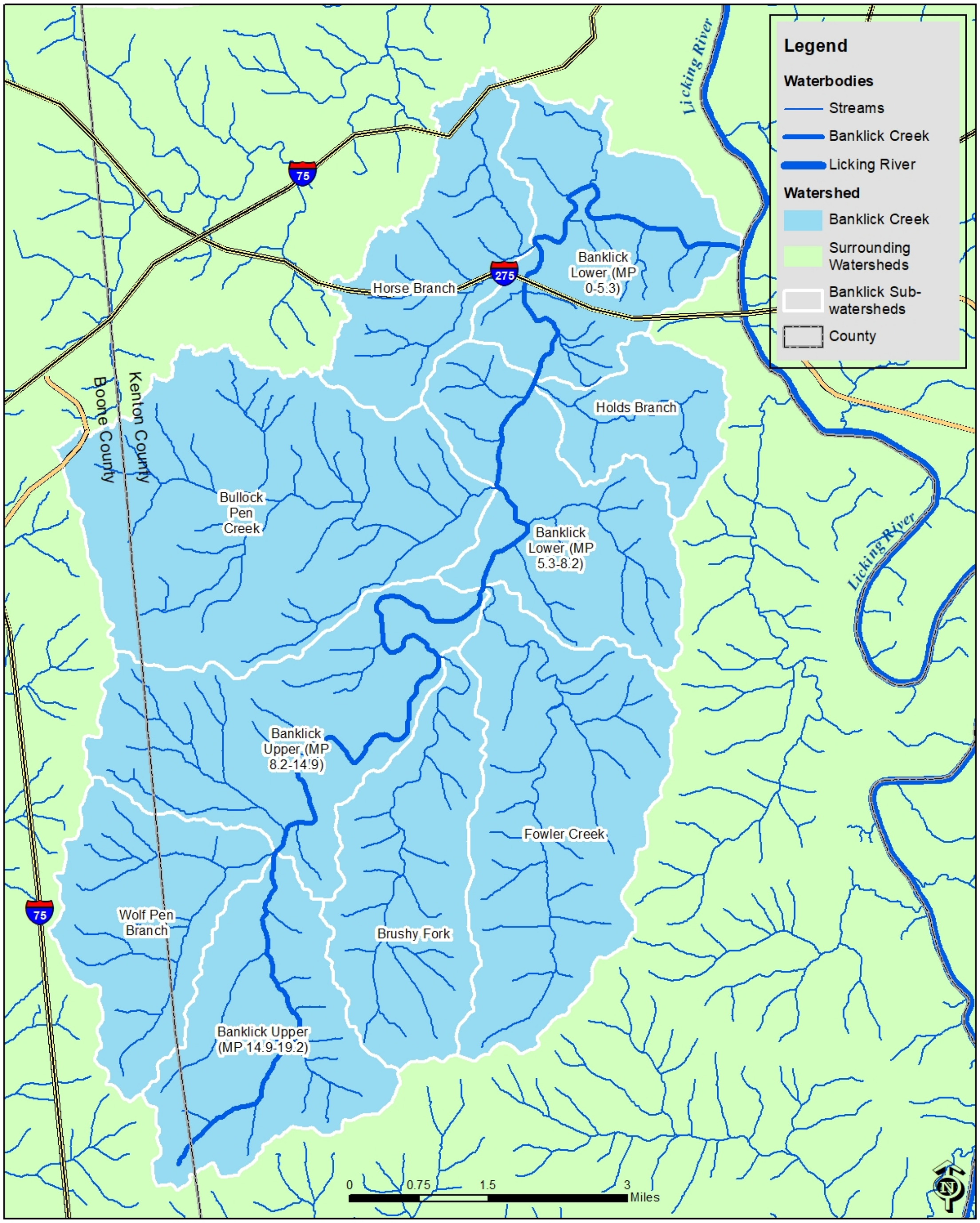


Figure 1.1 Banklick Creek Watershed and Subwatersheds

The Banklick Creek Watershed Plan (BCWP) was developed by the Banklick Creek Watershed Council (BWC) in 2009 through a 319(h)-funded watershed planning effort. The plan used the 2008 Banklick Creek Watershed Characterization Report as the basis for the data analysis, source assessments and loading allocations. This Characterization Report was part of a larger effort to produce reports for watersheds throughout SD1's service area. The purpose of these reports was to describe the physical and natural features, land cover, infrastructure, waterbody conditions, potential pollutant sources and other features within the watersheds. The Banklick Creek Watershed Characterization Report provided an overview of local conditions and historical bacteria data from 1985-2005 and an analysis of bacteria data collected from 2006-2008. Overall, elevated densities of fecal coliform and *E. coli* were found at several locations. The Watershed Assessment Tool (WAT) model within the report identified combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), septic systems, KPDES outfalls, storm water runoff, and livestock as the main sources of bacteria.

The BCWP summarized the data from the WAT model by subwatershed to better categorize the contributing sources and associated pollutant loads (BCWP, Chapter 5 and 6). This analysis of the bacteria data pointed to more point source contribution (CSOs, SSOs) in the lower watershed and more non-point source contribution (septic, agriculture) in the upper watershed. Chapter 7 of the BCWP outlined a plan to address these sources, with the efforts of SD1 (through the consent decree) focused in the lower watershed and the BWC leading efforts for nonpoint source controls in the upper watershed.

Since the development of the BCWP, there has been ongoing implementation and continued monitoring efforts in the watershed. However, the data used for the BCWP is over 14 years old and land use has continued to change throughout the watershed. This document serves as an update to the existing watershed plan by focusing on PCR impairments, identifying potential pollutant sources contributing to the impairments, targeting implementation activities to address these sources, and serve as a TMDL alternative plan.

A TMDL alternative plan outlines a set of actions and milestones that comprise a detailed roadmap to restore water quality in advance of efforts to develop a TMDL. The following chapters present a summary of the new bacteria data collected within the Banklick Creek watershed (Section 3.0), an update and supplemental information on sources (Section 4.0), a summary of implementation thus far and a refined plan for future implementation (Section 5.0) and a success monitoring program focused on the PCR impairments (Section 6.0). SD1 will work with the BWC to analyze and regularly report the results of continued monitoring and implementation activities to KDOW to evaluate whether the plan is on track for achieving water quality standards.

2.0 303(d) Listed Segments for Primary Contact Recreation (PCR)

The entire mainstem of Banklick Creek was listed on the 303(d) List of Impaired Waters for PCR when the watershed plan was developed and these segments remain on the current 2024 303(d) list. However, the listings were revised to pathogens as the parameter in place of fecal coliform, which was used in the previous listings. These segments are included in Table 2.1 and Figure 2.1 below.

Table 2.1 DOW 2024 303(d) Listed Segments for PCR

Waterbody & Segment	Total Size (miles)	AU ID	PCR Use Status*	Pollutant	Suspected Source(s)
Banklick Creek 0.0 to 3.5	3.5	KY-163	Non Support	Pathogens	Unspecified Urban Stormwater, Municipal Point Source Discharges
Banklick Creek 3.5 to 8.2	4.7	KY-164	Non Support	Pathogens	Agriculture, On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)
Banklick Creek 8.2 to 19.5	11.3	KY-165	Partial Support	Pathogens	Agriculture, On-site Treatment Systems (Septic Systems and Similar Decentralized Systems)

*401 KAR 10:031 Section 7 includes the surface water standards for PCR. In summary, *E. coli* shall not exceed 130 colonies per 100 ml as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 240 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for Escherichia coli.

Kentucky's methods for evaluating data for assessments and listing are outlined in the "Consolidated Assessment and Listing Methodology" which is maintained on the Division of Water's Quality Assurance webpage. The data evaluation methods for Primary Contact Recreation Use are summarized below, as they pertain to the types of sampling approaches used by SD1 and the datasets produced:

A segment is listed as non-support if any of the following occur during the PCR season (May -Oct):
(1) Two or more sets of 5 samples in 30 days have a geomean that exceeds 130 colonies/100 mL
(2) 3 of 5 samples exceed 240 colonies/100 mL
(3) 34-100% of 6 or more samples exceed 240 colonies/100 mL

A segment is listed as partial support if any of the following occur during the PCR season (May -Oct):
(1) One set of 5 samples in 30 days have a geomean that exceeds 130 colonies/100 mL
(2) 20-33% of 6 or more samples exceed 240 colonies/100 mL

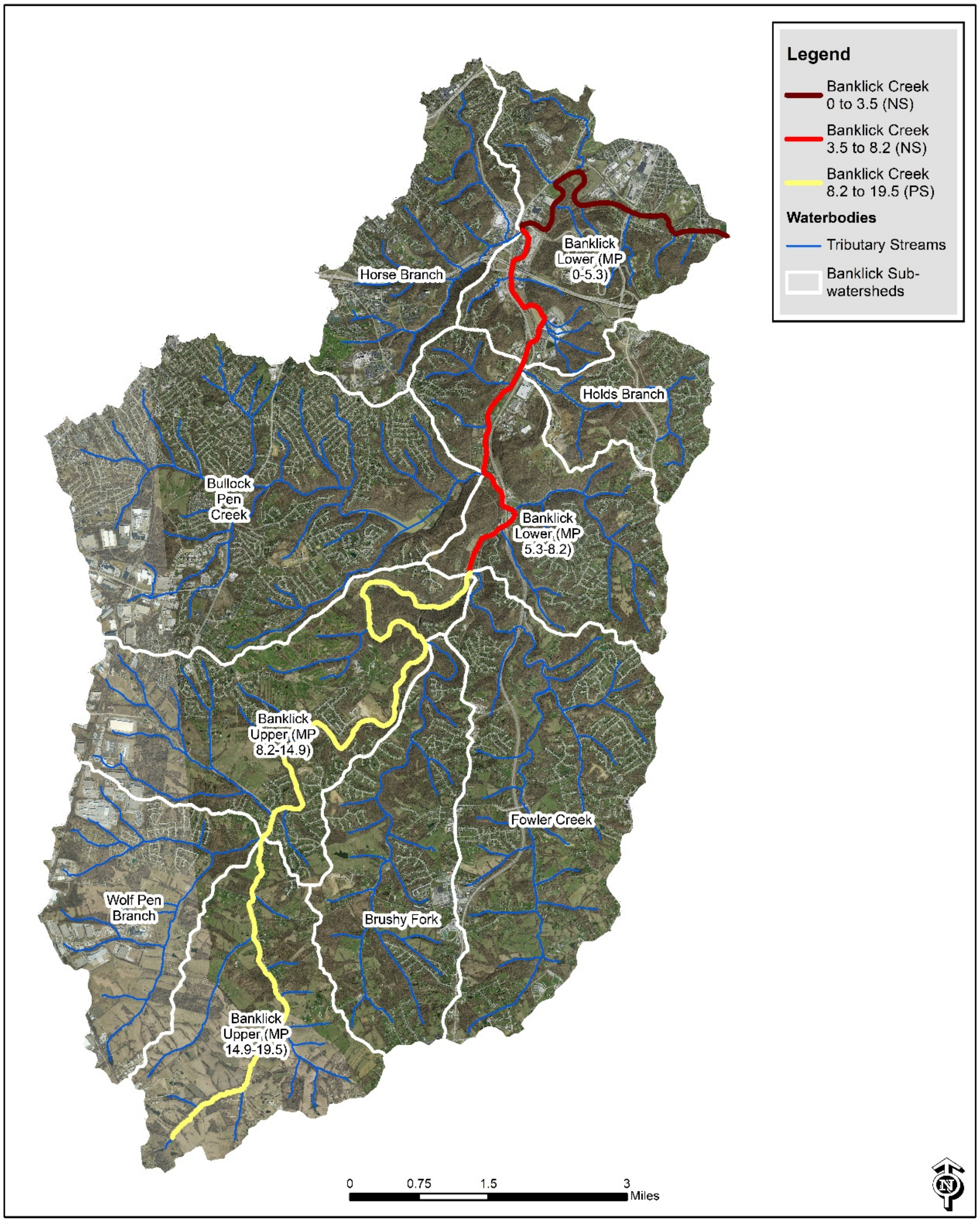


Figure 2.1 2024 303(d) Listed Segments for PCR (Non-support (NS), Partial Support (PS))

3.0 Data Collection and Updated Analysis

Since the development of the BCWP, Sanitation District No. 1 of Northern Kentucky (SD1) has conducted additional *E. coli* monitoring within the watershed. This monitoring is conducted following SD1's Field Monitoring and Sampling Plans (see Appendices B, C and D), which aligns with quality and quantity requirements used by KDOW. This includes specific grab sampling procedures, proper temperature regulation and holding times, and the use of blanks and duplicates for quality control. Samples are processed at SD1's Dry Creek lab, which is certified under the Kentucky Laboratory Certification Program (KLCP).

3.1 Monitoring Sites and Events

SD1 has established eight long-term monitoring sites within the Banklick Creek Watershed (Figure 3.1). All eight sites are part of SD1's base flow characterization program and are located within the SD1 Central Basin (Appendix B). Sampling events for the base flow program were conducted once during dry weather conditions (i.e., no precipitation in watershed 72 hours prior to event and prevailing dry weather conditions throughout event) during the PCR monitoring period in 2008, 2013 and 2017. The use of the term "base flow" throughout this document refers to sampling events that are part of the base flow characterization program.

SD1 also sampled sites BLC 1.2 and BLC 8.1 as part of the bi-weekly monitoring program (Appendix C) during the months of July – November 2015, April – November 2016 and April – June 2017. Samples were collected every fourteen days over the course of these months. These samples were collected under various weather and flow conditions.

One site (BLC 8.1) is part of SD1's ambient monitoring network (Appendix D). This site was sampled multiple times between March through November on an annual basis. Sampling dates are established at the beginning of the season and may include samples collected under various weather and flow conditions. A USGS stream gage is located at this site, which provides stream flow data (gage height and discharge) in 15 minutes intervals.

SD1 conducted additional sampling events for seven of these sites in 2021. *E. coli* samples were collected during five events within a thirty-day period (5 in 30) from July 6 to August 3, 2021. Site BLC 0.3 was not included due to the backwater influence from the Licking River.

Although some samples were collected outside of the PCR season, only results of samples collected during the PCR season (May 1 – October 31) are summarized in this report. Table 3.1 includes the number of samples collected each year during the PCR season. Refer to Appendix E for the results of all events, including those collected outside of the PCR season.

Table 3.1 Number of Samples Collected During the PCR Season by Year and Event Type

SITE	2008	2013	2015	2016	2017			2018	2019	2020	2021
	Base Flow	Base Flow	Bi-Weekly	Bi-Weekly	Base Flow	Bi-Weekly	Ambient	Ambient	Ambient	Ambient	5 in 30
BLC 0.3	1	1	-	-	1	-	-	-	-	-	-
BLC 1.2	1	1	9	13	1	4	-	-	-	-	5
BLC 3.9	1	1	-	-	1	-	-	-	-	-	5
BLC 8.1	1	1	9	13	1	4	6	9	9	9	5
BLC11.6	1	1	-	-	1	-	-	-	-	-	5
BLC15.6	1	1	-	-	1	-	-	-	-	-	5
BPC 0.1	1	1	-	-	1	-	-	-	-	-	5
FWC0.1	1	1	-	-	1	-	-	-	-	-	5

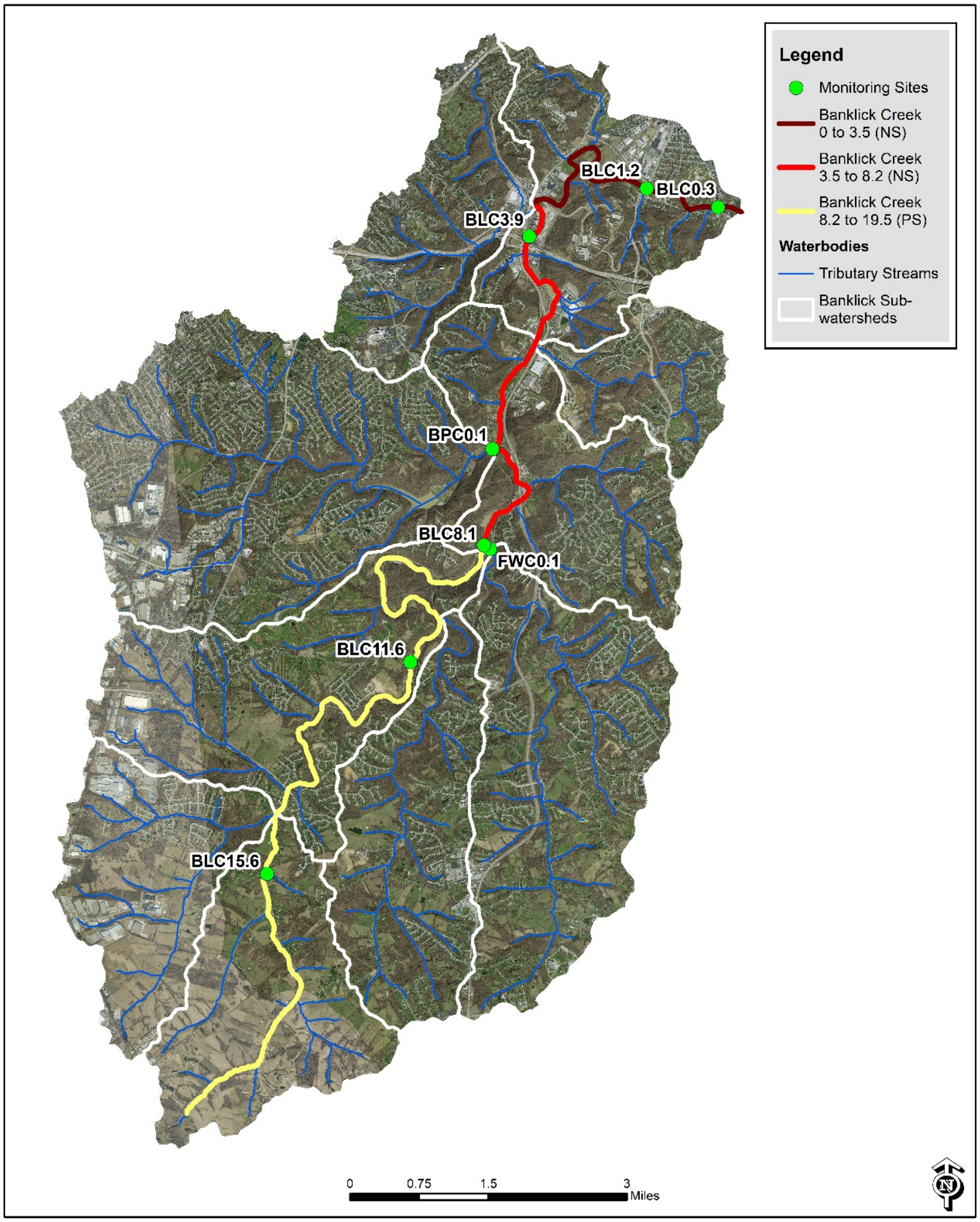


Figure 3.1 Monitoring Locations in the Banklick Creek Watershed

3.2 Monitoring Results and Analysis

Central Basin Monitoring Cycle and 2021 Event Results

The *E. coli* results collected within the PCR season of the 2008, 2013 and 2017 sample cycles for the eight Banklick Creek sites are included in Table 3.2 and the results of the five events in

2021 are included in Table 3.3. All results exceeding the 240 colonies/100 mL standard are displayed in red font.

Table 3.2 SD1 Base Flow Monitoring *E. coli* Results from 2008, 2013 and 2017 (excludes samples collected outside of the PCR Season)

Site	Description	Results (cfu/100mL)		
		June 2008	August 2013	June 2017
BLC 0.3	Banklick Creek at RM 0.3 (Rt. 177)	160	48	252
BLC 1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	160	49	444
BLC 3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	359	74	1460
BLC 8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	189	1462	244
BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	134	395	268
BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	282	118	580
BPC 0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	132	325	316
FWC 0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	75	105	116

Table 3.3 *E. coli* Results from Five Events Collected within Thirty Days (5 in 30) in 2021

Site	Event Date and Condition					Geomean of 5 Samples
	7/6/2021	7/13/2021	7/20/2021	7/27/2021	8/3/2021	
	DRY	WET	DRY	DRY	DRY	
BLC 1.2	256	5656	264	68	60	275
BLC 3.9	328	1104	296	204	240	350
BLC 8.1	212	1164	352	36	44	169
BLC 11.6	116	3684	452	124	1164	489
BLC 15.6	192	1140	640	136	68	265
BPC 0.1	88	1460	200	164	92	208
FWC 0.1	116	2452	180	108	168	248

The base flow monitoring from 2008, 2013 and 2017 show exceedances of the *E. coli* water quality standard. One sample for each site per year does not provide sufficient quantity of data to evaluate support of the PCR use; however, these results are consistent with the listings since exceedances were widespread and were observed during dry weather when *E. coli* loading can be expected to be lowest.

Additional monitoring was conducted in 2021 to provide a data set consistent with the DOW assessment and listing methodology used for 303(d) listings. The notes in Table 2.1 outline the indicators used to determine if a segment is non-support or partial support for PCR. One of the indicators for non-support (3 of 5 samples exceed 240 colonies/100 mL) and one of the indicators for partial support (one set of 5 samples in 30 days have a geomean that exceeds 130 colonies/100 mL) apply to this data set. As displayed in Table 3.3 and Figure 3.2, sites BLC 1.2, BLC 3.9 and BLC 11.6 have three of five samples exceeding the 240 colonies/100 mL, which indicates non-support. The other sites do not meet the non-support indicator but do meet the partial support indicator with geomeans that exceed 130 colonies/100 mL These preliminary conclusions are consistent with the current 303(d) listings displayed in Figure 3.1. However, site BLC 11.6 should continue to be evaluated since this data set suggests a possible attainment change from partial support to non-support. All of the sites from the one wet weather event on July 13 show increased levels of *E. coli* especially compared to the dry events.

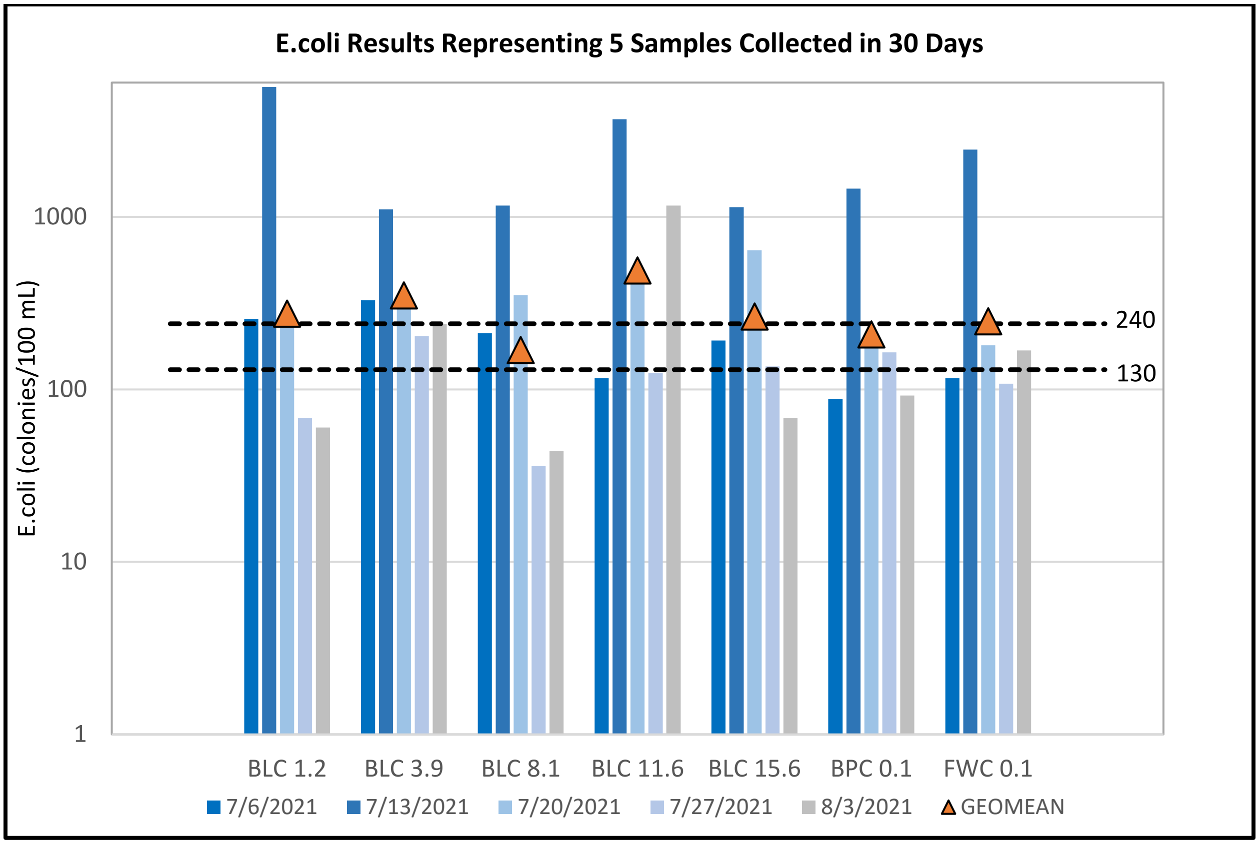


Figure 3.2 *E. coli* Results Representing 5 Samples Collected in 30 Days (5 in 30)

Bi-weekly and Ambient Monitoring Results

The *E. coli* results of the bi-weekly monitoring for site BLC 1.2 are compiled in Table 3.4. The results of both the bi-weekly and ambient monitoring for site BLC 8.1 are compiled in Table 3.5. The tables include the number of samples analyzed for each weather condition (#), the average of those sample results (AVG) and the percent of the samples that exceeded the water quality standard (%EX). The data are compiled according to weather conditions. Samples with no precipitation 72 hours prior to event and prevailing dry weather conditions throughout event are classified as dry and all others are classified as wet. Refer to Appendix E for the results of all events.

Table 3.4 Bi-weekly *E. coli* Results for Site BLC 1.2 - Number of Samples, Average and Percent of Samples Exceeding the Standard (excludes samples collected outside of the PCR Season)

SITE	CONDITION	2015			2016			2017		
		#	AVG	%EX	#	AVG	%EX	#	AVG	%EX
BLC 1.2	ALL	9	2882	56%	13	2229	69%	4	4051	100%
	WET	5	4848	80%	7	3809	71%	1	504	100%
	DRY	4	426	25%	6	385	67%	3	5233	100%

Table 3.5 Bi-weekly and Ambient *E. coli* Results for Site BLC 8.1 - Number of Samples, Average and Percent of Samples Exceeding the Standard (excludes samples collected outside of the PCR Season)

SITE	CONDITION	2015			2016			2017		
		#	AVG	%EX	#	AVG	%EX	#	AVG	%EX
BLC 8.1	ALL	9	4291	78%	13	3087	92%	10	2882	50%
	WET	5	7501	100%	7	5291	86%	3	4992	100%
	DRY	4	278	50%	6	517	100%	7	1977	29%
	CONDITION	2018			2019			2020		
		#	AVG	%EX	#	AVG	%EX	#	AVG	%EX
	ALL	9	275	56%	9	130	11%	9	320	22%
	WET	3	480	100%	3	231	33%	1	1844	100%
	DRY	6	173	33%	6	79	0%	8	130	13%

The bi-weekly and ambient monitoring events include more than six samples collected within the PCR season for the year. Due to this, the percent of samples exceeding the PCR water quality standard can be used to evaluate possible impairments based on the indicators for non-support (34-100% of 6 or more samples exceed 240 colonies/100 mL) and partial support (20-33% of 6 or more samples exceed 240 colonies/100 mL).

The results for site BLC 1.2 in Table 3.4 meet the non-support indicator, which also are consistent with the current 303(d) listing. The bi-weekly events concluded in 2017 for this site. The 2021 monitoring events still align with the non-support status although the average and percent of samples exceeding the standard has decreased.

The results for site BLC 8.1 in Table 3.5 include the bi-weekly as well as the ambient events, which provides a larger data set for this site. Figure 3.3 shows a decrease in the percent exceedance for 2019 and 2020. The 2020 results show a 22% exceedance, which still aligns with the partial support status, however the data for this site show a trend towards improvement.

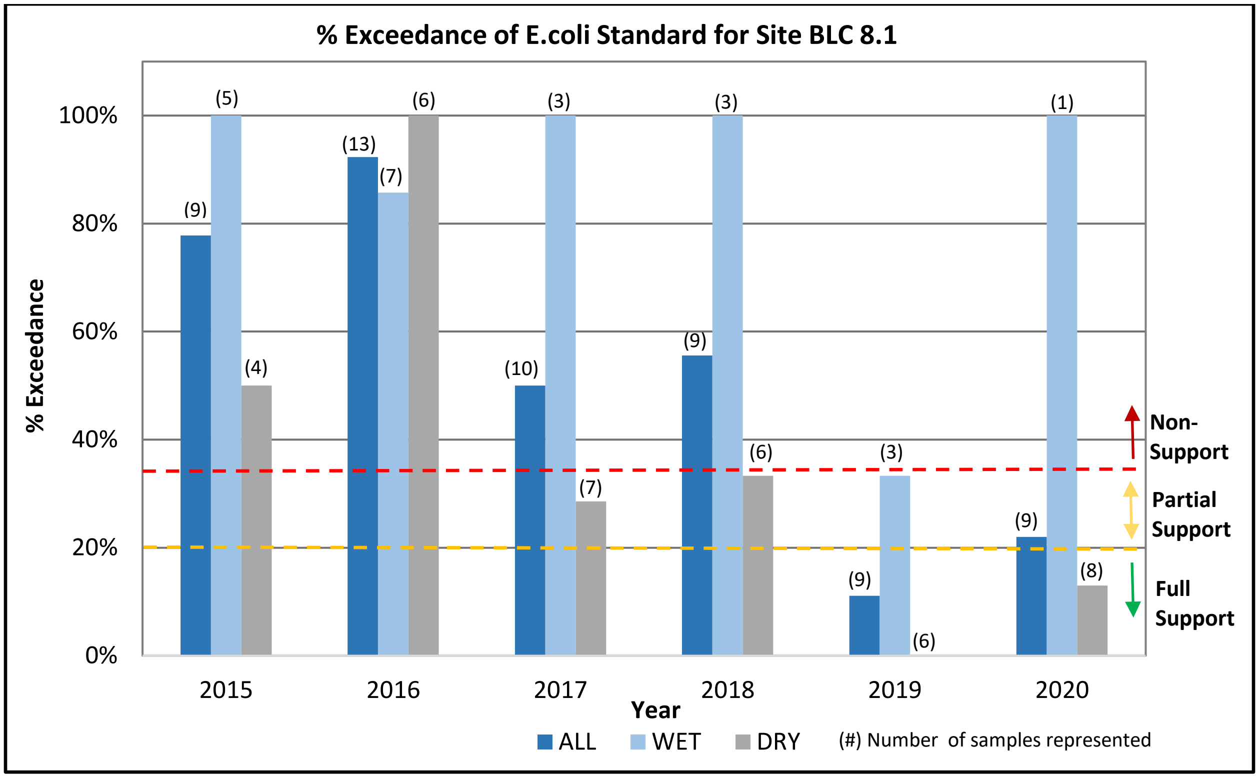


Figure 3.3 Percent Exceedance of the Standard for Site BLC 8.1

Pollutant Load Calculations

The Banklick Creek Watershed Plan includes pollutant loads and reductions needed to achieve water quality standards. These loads are based on modeled annual fecal coliform loadings from a 2004 Hydrologic Simulation Program in Fortran (HSPF) model. Details of the model and results are included in Section 6.02 of the BCWP. Although current criteria for the designated use as well as the updated analysis presented above are based on *E. coli*, comparisons can be made with the fecal coliform load reductions..

The 5 in 30 event from 2021 provides the most recent and widest coverage of data and was used to estimate load reductions to compare to the load reductions in Banklick Creek Watershed Plan. Discharge was not collected at each of the sites, so the USGS gage data located at site BLC 8.1 was used to estimate discharge for each event. Additional information on the method to estimate discharge is included in Appendix F.

The results of the pollutant load reductions needed from the 2021 events and the 2004 HSPF model are presented in Table 3.6. The 2021 reductions are categorized as all samples, dry weather samples and wet weather samples. Since the number of samples and the timeframe is limited for the 2021 events, the highest value (i.e. wet-weather event) can be used for a comparison to the 2004 HSPF to ensure a conservative estimate of current pollutant loads. Based on this, all sites show a high percent reduction needed to meet water quality standards.

Table 3.6 Comparison of Pollutant Load Percent Reductions Needed to Achieve Water Quality Standards (WQS) - Samples from the 5 in 30 Event and Banklick Creek Watershed Plan HSPF Mode

Site	E.coli Average % Reduction Needed - All Samples from 5 in 30 event (2021)	E.coli Average % Reduction Needed - Dry Weather Samples from 5 in 30 event (2021)	E.coli Average % Reduction Needed - Wet Weather Sample from 5 in 30 event (2021)	Fecal Coliform % Reduction Needed - HSPF Model from 319(h) Watershed-based Plan (2004)*
BLC 1.2	22.2	3.8	95.8	99.4
BLC 3.9	24.8	11.4	78.3	99.5
BLC 8.1	22.2	8.0	79.4	97.2
BLC 11.6	44.0	31.6	93.5	98.6
BLC 15.6	28.3	15.6	78.9	97.6
BPC 0.1	16.7	0.0	83.6	98.7
FWC 0.1	18.0	0.0	90.2	96.2

* The HSPF Model was performed for subwatersheds. This table includes the loads for the subwatershed that contain the monitoring location listed under site. See Table 6.02-2 in the Banklick Creek Watershed Plan for all results.

Summary of Results

Overall, the data collected by SD1 confirm the existing impairments in the 2024 303(d) list. The bi-weekly, ambient and the 5 in 30 events typically show elevated *E. coli* levels and greater percent exceedances during wet weather events. This is demonstrated with the comparisons of the pollutant load reductions needed in Table 3.6 as well. Although fecal coliform and *E. coli* are different measures, the overall conclusions of the BCWP and this updated analysis are similar indicating widespread issues and further pollutant reductions needed, especially in wet-weather conditions.

The sites with larger data sets (BLC 1.2 and BLC 8.1) are showing improvement in recent years and there are some decreases in the precent reductions needed. Some of these improvements may be due to implementation that has occurred since the development of the BCWP. Potential factors influencing these trends and sources contributing to current impairments are evaluated in Section 4.1.

General summaries of the monitoring results are included for each site in Figure 3.4.

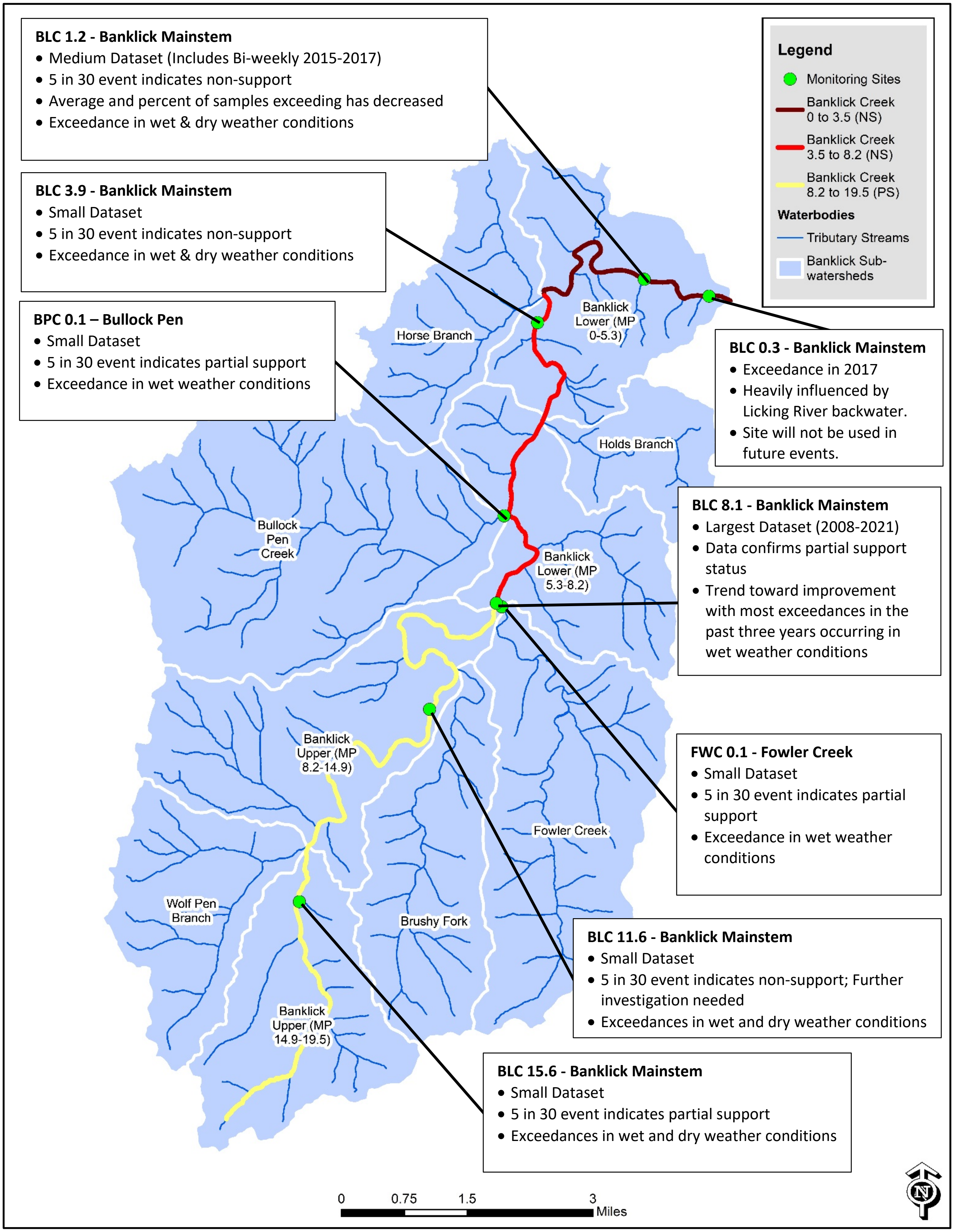


Figure 3.4 Summary of Monitoring Results for Sites in the Banklick Creek Watershed

4.0 Potential Sources of PCR Impairments and Current Efforts

The following sub-sections provide an overview of the potential sources of the PCR impairments. Each sub-section includes a comparison with the estimates of source loading information from the BCWP. These estimates were derived from the Watershed Assessment Tool (WAT) model, which was based on data up to 2010. In some cases, the magnitude of the identified source's impact is expected to be different than the WAT model due to land use changes, availability of additional data or implementation that has occurred. There are plans to update the model with current data and these updates will be incorporated into future reports when available. For this document, these potential changes to the source loading estimates are outlined in the narrative of the subsections below.

This pollutant source evaluation in this section along with Section 5.1, which provides more details on implementation since the BCWP, serves as the foundation for the future targeted implementation plan outlined in Section 5.2.

4.1 Centralized Wastewater

The majority of the watershed is served by public sanitary sewers, which is maintained by SD1 (Figure 4.1). However, there are still a number of individual parcels within the area that have septic systems or private package plants and are not connected to the centralized sanitary sewer system (Figure 4.2). All of the centralized wastewater sewers within the watershed flow to the SD1-owned and operated Dry Creek Wastewater Treatment Plant or the Western Regional Water Reclamation Facility where it is treated and discharged to the Ohio River.

The lower subwatershed includes an area that is served by combined sewers, while the other identified area is a separate sewer system. Bacteria loads to the stream associated from the public sanitary system are partly due to combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) identified in Figure 4.1. The BCWP estimated that almost 50% of the fecal coliform pollutant load was from CSOs and SSOs and when evaluating the loads for the lower subwatersheds that percentage increased to almost 75% (BCWP Figures 5.04-4 and 5.04-5). Based on the model for Northern Kentucky's amended consent decree, that percentage for the lower watersheds is likely still applicable. Table 4.1 displays the overflow volume at locations in the subwatersheds of Banklick Creek that have CSOs or SSOs.

Table 4.1 Modeled Overflow Volumes for CSOs and SSOs in Banklick Creek

Sub-watershed	2021	
	CSO (MG)	SSO (MG)
Banklick (Upper MP 8.2-14.9)	-	0.81
Fowler Creek	-	0.04
Bullock Pen	-	2.99
Horse Branch	-	1.06
Banklick (Lower MP 5.3-8.2)	-	2.26
Banklick (Lower MP 0-5.3)	20.48	10.39
CSO IDs	1840130, 1850158, 1870193, 1870194	

CSO represents the typical year overflow volume based on modeled data
SSO represents the 2-year 6-hour overflow volume based on modeled data

By the year 2040, SD1 will eliminate typical-year SSOs and recapture at least 85 percent of all typical-year CSOs to meet the requirements of Northern Kentucky's amended consent decree. This will be accomplished through a number of strategic projects specifically designed to address sewer overflows, which are further discussed in Section 5.

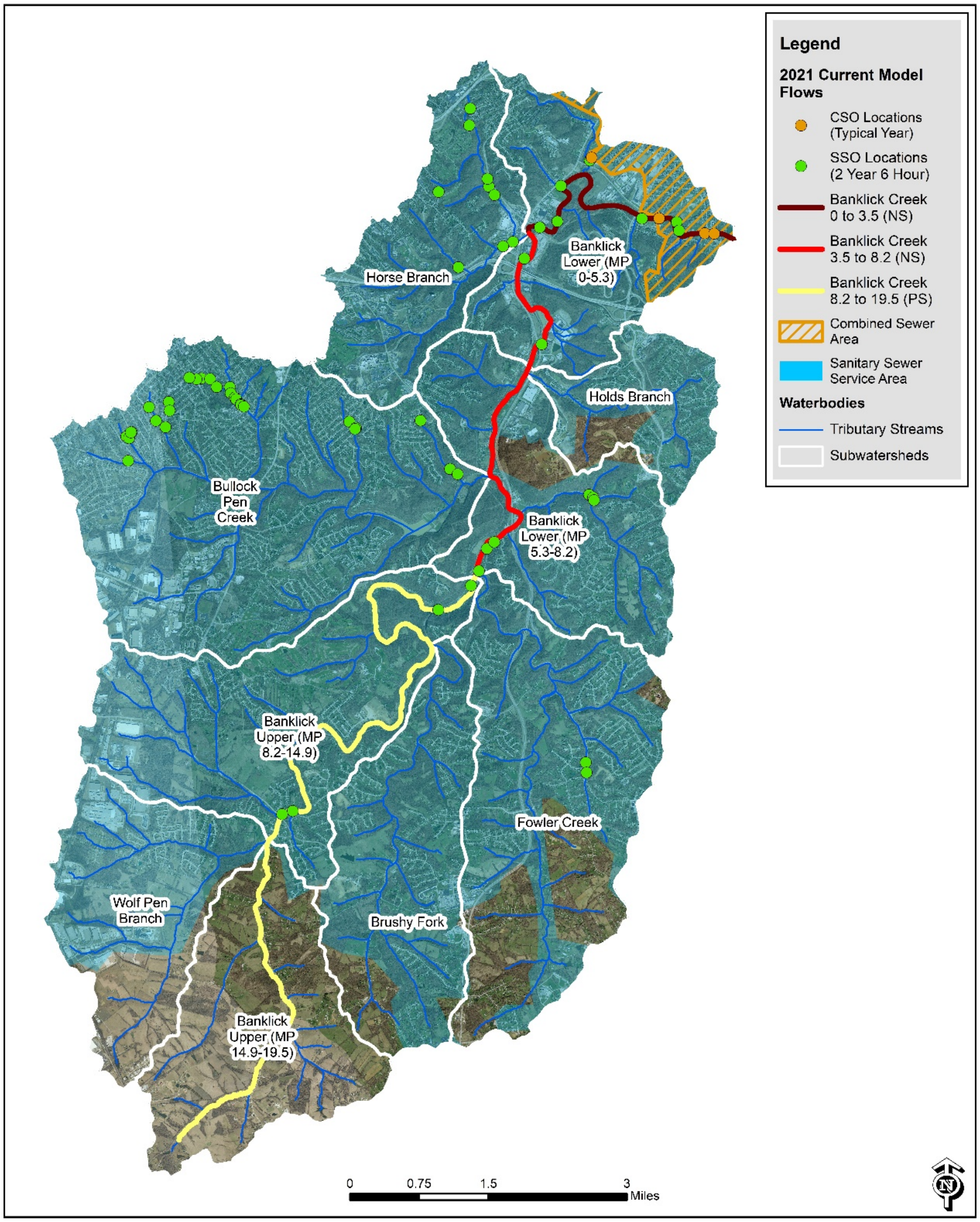


Figure 4.1 Centralized Wastewater and Locations of CSOs and SSOs

4.2 Onsite Wastewater

Some residences are served by onsite wastewater systems, especially those properties located in the upper portion of the watershed that is outside of the sanitary sewer service area. Most locations have septic systems with a few served by KPDES permitted units that discharge directly to a receiving stream. Table 4.2 provides an estimated number of parcels served by septic systems in each subwatershed and the number of individual permitted units. Figure 4.2 includes the locations of the parcels and units. The estimation of parcels with septic systems is based on data from the Kenton County Property Valuation Administration (PVA) overlayed with SD1 sanitary account data. These are general estimates and will be reviewed and revised as updated information is available.

Table 4.2 Estimated number of Septic Systems and KPDES Permitted Units in Banklick Creek subwatersheds

Subwatershed	Estimated Total Septic	KPDES Permitted Units
Banklick Upper (MP 14.9-19.2)	270	1 – Individual Home
Wolf Pen Branch	200	1 – Individual Home
Brushy Fork	290	-
Fowler Creek	660	3 – Individual Homes 1 – 30 Home Subdivision 1 – 8 Unit Apartment
Banklick Upper (MP 8.2-14.9)	180	-
Banklick Lower (MP 5.3-8.2)	130	-
Bullock Pen Creek	60	1 – Individual Home
Holds Branch	40	-
Horse Branch	30	-
Banklick Lower (MP 0-5.3)	60	-

Since 1982, the Northern Kentucky Health Department (NKHD) has reviewed and permitted septic systems for residents in the Northern Kentucky Area. NKHD also inspects existing septic systems and works with homeowners to maintain and repair failing systems. On average NKHD estimates that about 10% of the septic systems are failing due to needed repairs and lack of maintenance.

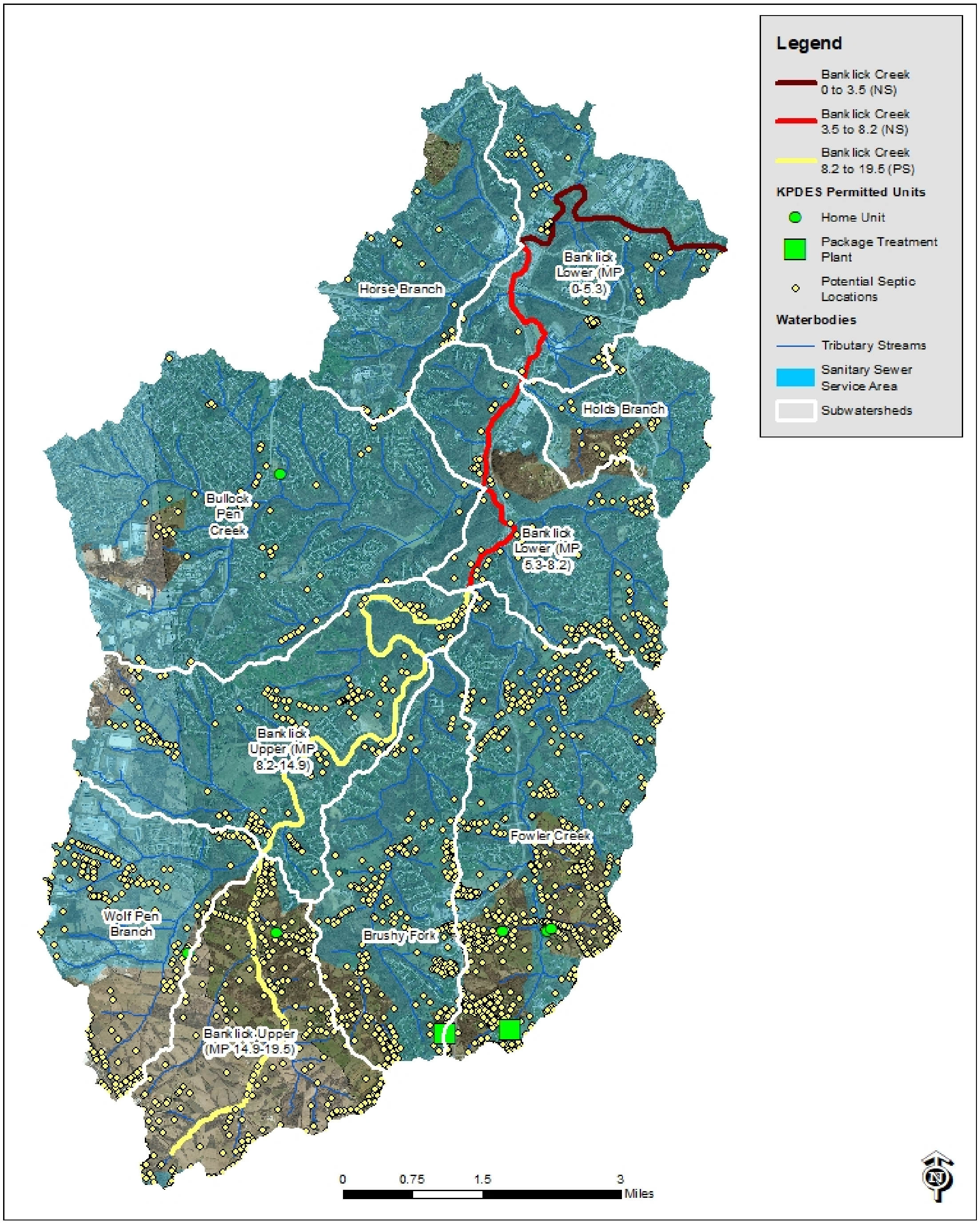


Figure 4.2 Locations of KPDES Permitted Units and Parcels likely to have Septic Systems

Over the years, NKHD has also identified areas served by septic systems that do not have the proper conditions (soils, adequate leach field areas, etc.) to support a traditional septic system design. There are currently areas within the watershed that NKHD has identified as hotspots for septic failures. These are included in table 4.3. Additional locations may be identified through future inspections.

Table 4.3 Septic Systems Hotspots in Banklick Creek

Subwatershed	Hotspot Location
Brushy Fork	Clustered locations on Peach Dr., Alvin Dr., and Apple/Cherry Dr.
Fowler Creek	Clustered locations on Walnut Hall Dr., Roselawn/Sidney Dr., Maple Tree/Bluegrass Dr. Locations along Don Victor Dr., Oliver Rd., Sugar Camp Rd., Senour Rd. and Taylor Mill Rd.
Banklick Upper (MP 8.2-14.9)	Locations along Richardson Rd. and Weaver Rd.
Banklick Lower (MP 5.3-8.2)	Locations along Sugar Camp Rd., Senour Rd. and Taylor Mill Rd.
Bullock Pen Creek	Locations along Richardson Rd. and Weaver Rd.
Holds Branch	Locations along Taylor Mill Rd.

As noted in Section 4.1 above, the BCWP estimated a large percent of the fecal coliform pollutant load was from CSOs and SSOs for the entire watershed. However, the load estimates for the upper watershed implementation area (Figure 5.1), which have no CSOs and few SSOs include allocations for septic systems and other nonpoint source pollution. The pollutant load estimates for septic system sources range from 6.9% in Fowler Creek to 0.8% in Banklick Upper (MP 8.2 – 14.9) (BCWP Figures 7.03-2 – 7.03-6) with an overall estimate of 2.9% for the area (BCWP Table 7.04-1).

Based on the updated septic locations, NKHD hotspot information, aging systems and expected failure rates, the pollutant loads associated with septic systems are expected to be higher than the original estimates, especially in relation to the agricultural sources. Preliminary findings from a 2024 EPA Office of Research and Development (EPA ORD) Microbial Source Tracking (MST) study in the Fowler Creek, Wolf Pen Branch and Holds Branch, also indicate septic sources as a likely contributor to *E. coli* from human sources. Based on these factors, failing septic systems are a high priority source to address through future implementation.

Section 5.0 includes more details on completed implementation and future implementation, specifically addressing hotspots that contain clusters of homes that are better candidates for centralized sewers and strategies to address these areas.

4.3 Municipal Separate Storm Sewer Systems (MS4) and Other Nonpoint Sources from Developed Lands

Municipal Separate Storm Sewer Systems (MS4)

The majority of the Banklick Creek watershed is designated as a Phase II Municipal Separate Storm Sewer System (MS4) area and includes developed land in the form of high to low intensity residential areas, commercial and industrial properties. The City of Florence and the City of Covington manage the MS4 program within their city boundaries and SD1 manages the program in the surrounding area (Figure 4.3). As part of the MS4 program, Florence, Covington and SD1 must implement programs to inspect storm sewer outfalls for the presence of illicit discharges.

If illicit discharges are identified the MS4 permit requires the permittee to implement plans to identify the source and eliminate the discharge. Example illicit discharges related to wastewater management systems include issues such as broken laterals, illegal connections of sanitary laterals to the storm system or failing septic systems entering the storm system. All of these can be sources of *E. coli* to surrounding streams.

Through the illicit discharge investigation process, SD1 has identified 77 wastewater related discharges within the SD1 MS4 area in the watershed since 2009. Thirty-one of these were discharges to the MS4, that were eliminated through the illicit discharge enforcement process, 36 were surface discharges turned over to the NKHD for enforcement, 7 were direct discharges to streams turned over to DOW and 3 were surface discharges associated with broken laterals and addressed by SD1's Collection Systems Department. As shown in the Figure 4.3, some of these are within the current Covington MS4 area. Until March 2021, SD1 was responsible for implementing the MS4 program for the city and these illicit discharges were eliminated prior to that date.

It is not likely that illicit discharges are a main source of the water quality impairments in the Banklick Creek, however through the continued implementation of the illicit discharge detection and elimination (IDDE) program, all detected and eliminated discharges will be reported and used to target future implementation and success monitoring.

Other Nonpoint Sources from Developed Lands

The BCWP estimated that about 18% of the fecal coliform pollutant load was from medium to high intensity developed lands and about 19% from low intensity developed lands (BCWP Figure 5.04-4). Much of the lower watershed was already built out during this time, so the percentage for those areas is likely still applicable. However, there has been extensive development in the upper watershed since that time.

Areas along the western border of the upper watershed that were zoned as agricultural have transitioned into commercial and industrial areas. In areas of medium and low intensity residential development with larger tracts of woodland areas, it's likely that wildlife and in some cases, pets may be other contributors to the PCR impairments. Preliminary findings from the 2024 EPA ORD study, microbial source tracking showed possible sources of *E. coli* from wildlife in the Holds Branch subwatershed, where deer were likely throughout residential areas, but little contribution from canine sources.

As noted in Section 4.1 and 4.2 SSOs/CSOs in the developed areas served by centralized sewers and failing septic systems in the areas served by onsite wastewater are likely the larger contributions to the pollutant load in these areas. However, implementation, especially related to residential education and improved practices, is included in Section 5.0.

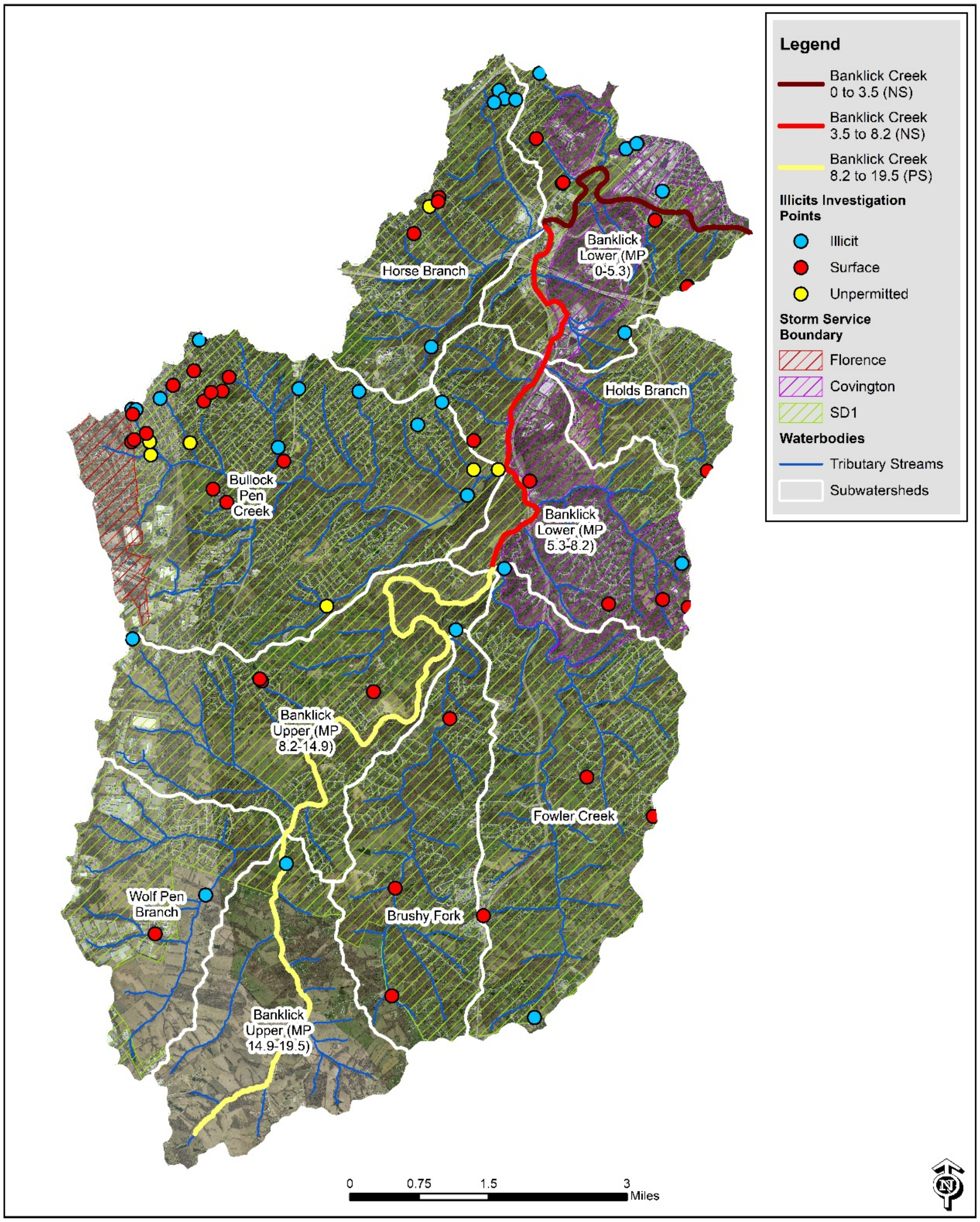


Figure 4.3 MS4 Areas and Illicit Discharge Investigations Associated with Wastewater

4.4 Agriculture

The majority of active agricultural land use is in the upper portion of the watershed (Figure 4.4). The estimated acres and percentages of agricultural land use in Table 4.4 are based on land use information from the Planning and Development Services of Kenton County and PVA data from

Boone County. These are estimates based on the classification of the property and do not necessarily indicate that active agriculture practices are occurring on the property.

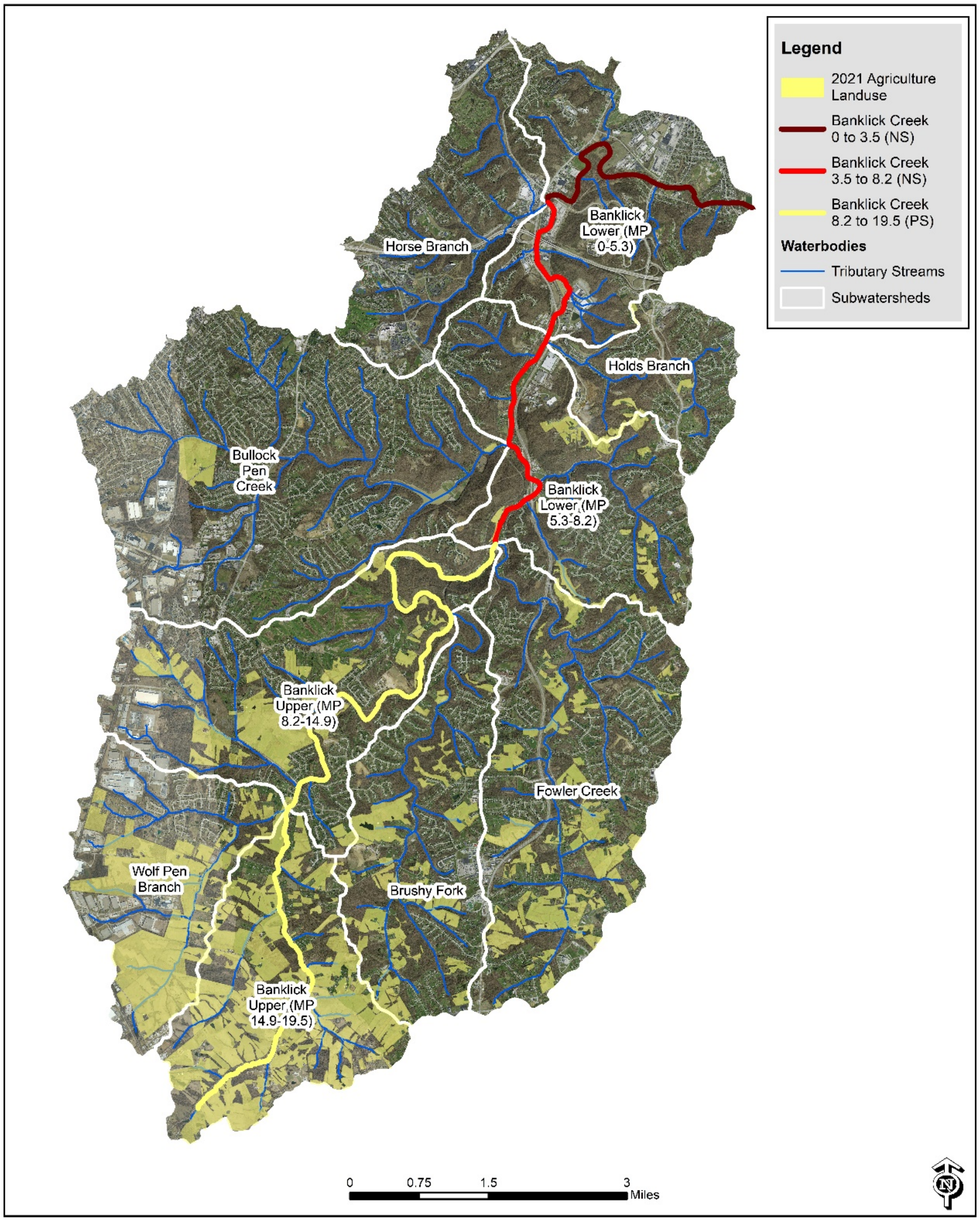


Figure 4.4 Agriculture Landuse within Banklick Creek Watershed

Table 4.4 Agriculture Landuse Acreage and Percent within Banklick Creek

Subwatershed	2021 Agriculture Landuse (acres)	% Subwatershed in Agriculture Landuse (2021)
Banklick Upper (MP 14.9-19.2)	1839.2	53%
Wolf Pen Branch	1094.6	39%
Brushy Fork	618.9	19%
Fowler Creek	759.8	15%
Banklick Upper (MP 8.2-14.9)	713.1	16%
Banklick Lower (MP 5.3-8.2)	198.6	6%
Bullock Pen Creek	117	2%
Holds Branch	32.5	2%
Horse Branch	-	-
Banklick Lower (MP 0-5.3)	-	-

The BCWP estimated that about 15% of the fecal coliform pollutant load was from agricultural lands (BCWP Figure 5.04-4) with little contribution in the lower watershed (1%, BCWP Figure 5.04-5) and greater in the upper watershed (58.1%, BCWP Figure 5.04-6). It's likely that contribution from agricultural areas has decreased, especially in the upper watershed. This is due to several factors. As noted in the sections above, some areas in the upper watershed that were zoned as agricultural have transitioned into commercial and industrial areas. Also, the contribution percentages may have been overestimated in the original WAT model where land was zoned as agricultural but not used in production (i.e. open fields with no livestock).

There are a few areas in the Banklick Upper (MP 14.9-19.2) and Wolf Pen Branch subwatersheds with small grazing areas along the streams where cattle may have limited access. These limited areas will continue to be assessed and targeted for future implementation through state cost-share and NRCS programs.

5.0 Implementation to Address Sources of PCR Impairments

The Banklick Creek Watershed Plan (BCWP) divided the watershed into two implementation areas (Figure 5.1). The lower portion of the watershed was identified as the SD1 target area, due to the concentration of SSOs, CSOs and planned remediation measures through the consent decree. The upper portion was identified as the Focus Area for nonpoint source implementation measures. Since that time, the BWC received approval from DOW to target 319(h)-funded implementation in the lower portion of the watershed as well.

As outlined in Section 4, the likely primary sources for the PCR impairments are SSOs/CSOs and failing septic systems, with some potential agricultural sources in the upper portion of the watershed. Based on the location of these sources, the BCWP approach to target sources in the lower and upper watersheds still applies to the PCR impairments.

Section 5.1 provides an overview of the implementation completed to date as part of the Banklick Creek Watershed Plan. Section 5.2 provides greater detail on the upcoming implementation associated with the SSOs/CSOs in the lower watershed and septic systems in the upper watershed. Appendix A organizes the upcoming implementation strategies within these areas.

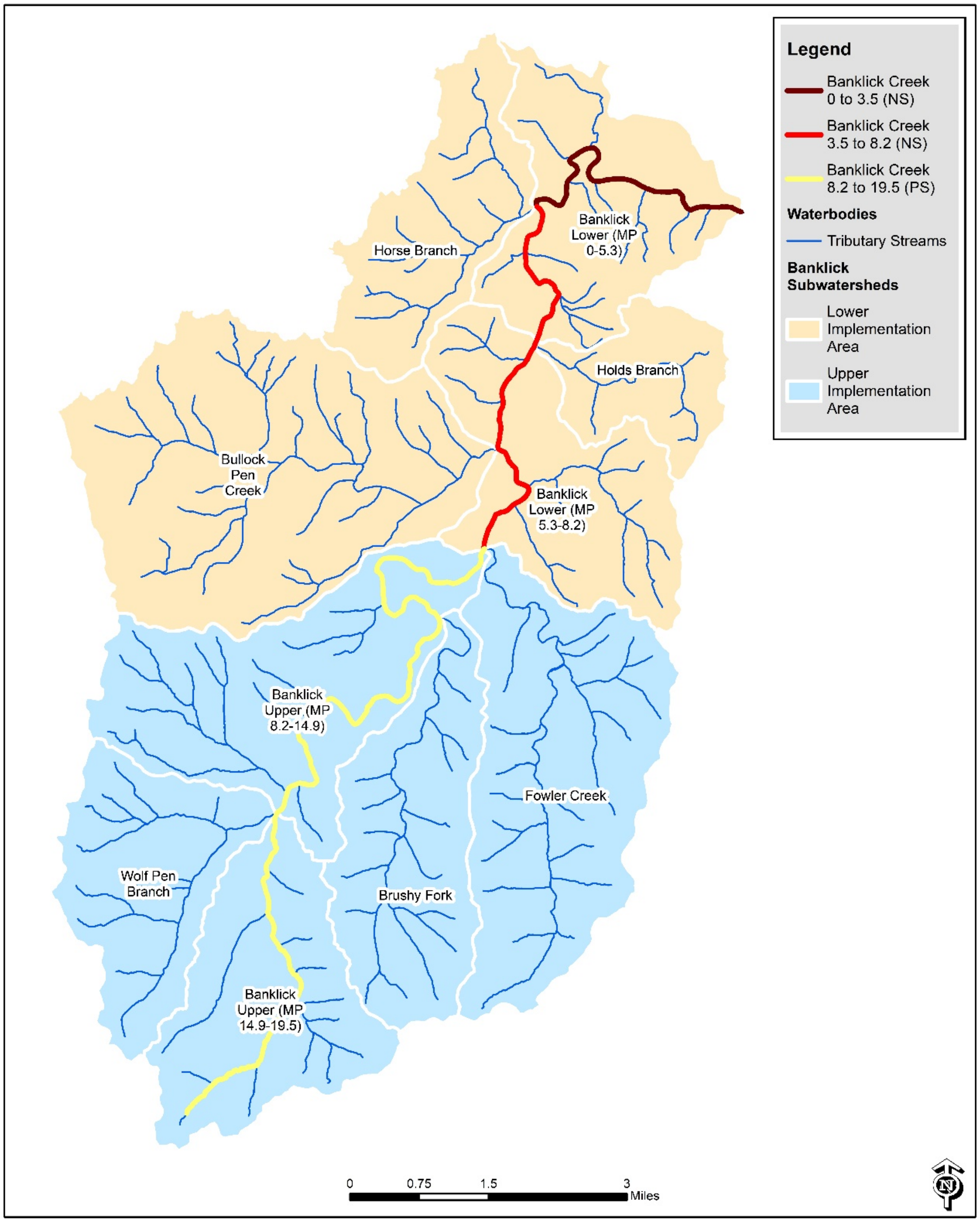


Figure 5.1 Upper and Lower Implementation Areas and Subwatersheds

5.1 Summary of Completed Banklick Creek Watershed Plan Implementation

The Banklick Watershed Council (BWC) established their septic assistance program in 2012. Since that time, they have provided $78,000 in 319(h) funds to homeowners to address septic system issues in the Fowler Creek, Brushy Fork and Banklick Upper MP 14.9-19.5 subwatersheds. Implementation has included 13 repairs, two pump outs as part of the repairs and 1 replacement. The BWC continues to implement a septic system improvement program, which is further discussed in Section 5.2. In 2019, the BWC partnered with the Ed-Mar Dairy farm to provide additional capacity in their manure management system located in the Banklick Upper MP 14.9-19.5 subwatershed. These project locations are included in Figure 5.2 and additional details about these projects addressing the PCR impairments as well as the other efforts of the BWC are outlined on their project website.

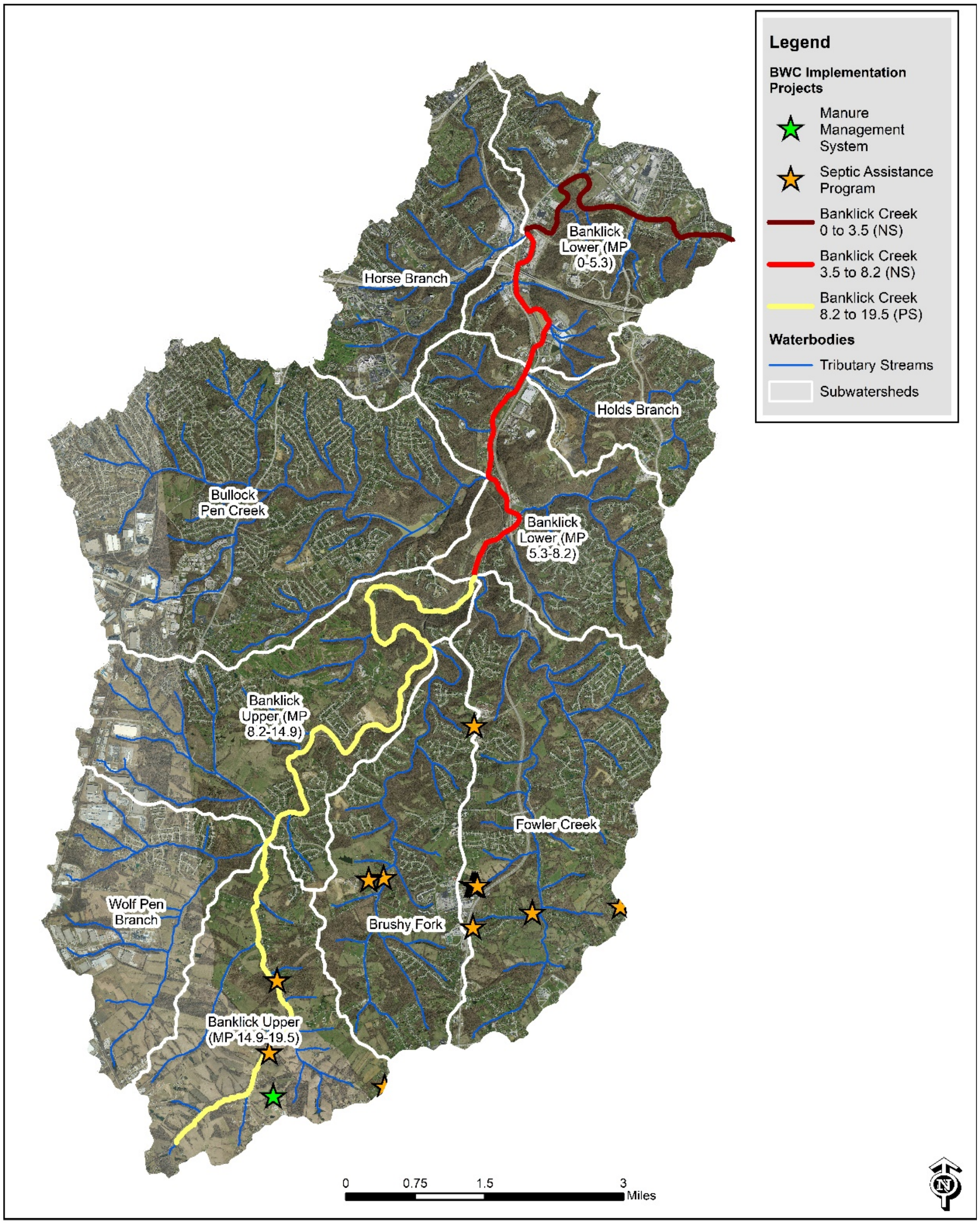


Figure 5.2 Completed Banklick Creek Watershed Plan Implementation

5.2 Planned and Upcoming Implementation

Planned Implementation to Address CSOs and SSOs

By the year 2040, SD1 will eliminate typical-year SSOs and recapture at least 85 percent of all typical-year CSOs to meet the requirements of Northern Kentucky's amended consent decree. This will be accomplished through a number of strategic projects specifically designed to address sewer overflows. Table 5.2 displays the overflow volume at locations in the subwatersheds of Banklick Creek that have CSOs or SSOs. These volumes are based on modeled data for events occurring in 2021, 2029 and 2040.

Table 5.2 Modeled Overflow Volumes for CSOs and SSOs in Banklick Creek

Sub-watershed	2021		2029		2040	
	CSO (MG)	SSO (MG)	CSO (MG)	SSO (MG)	CSO (MG)	SSO (MG)
Banklick (Upper MP 8.2-14.9)	-	0.81	-	1.61	-	0.00
Fowler Creek	-	0.04	-	0.37	-	0.00
Bullock Pen	-	2.99	-	2.98	-	0.00
Horse Branch	-	1.06	-	0.81	-	0.00
Banklick (Lower MP 5.3-8.2)	-	2.26	-	1.94	-	0.00
Banklick (Lower MP 0-5.3)	20.48	10.39	20.65	1.81	12.39	0.00

CSO represents the typical year overflow volume based on modeled data
SSO represents the 2-year 6-hour overflow volume based on modeled data

One item of note is the modeled increased volumes for some subwatersheds in 2029 due to ongoing development increasing flows into the sewer system. Projects outlined in the Updated Watershed Plan for Northern Kentucky at this time are conceptualized at a very broad planning level. Actual projects will likely present different results based upon optimizing the infrastructure that is constructed. The results of these projects that are constructed prior to 2029 will produce results that are compliant with the Amended Consent Decree. Also of note is that flow predictions in the model are coarse and conservative estimates and actual flows will vary depending on the development that may occur. SD1's ongoing system calibration will likely alter the overflow volumes presented. Based on developing information, new projects may be constructed in lieu of the projects defined in the Updated Watershed Plan, but only after approval from regulatory agencies. Updated information related to planned and constructed projects as well as updated modeling predictions will be provided in the annual progress report for this TMDL Alternative.

To meet the requirements of the amended consent decree, at least 85 percent of the three typical-year CSOs discharging to Banklick Creek (Figure 4.1) will be recaptured by 2040. Although the reduction of these typical-year CSOs will help to improve the water quality, with the location of the CSOs clustered at the mouth of Banklick Creek, the impacts will be confined to the very lower portion of the PCR impaired segment Banklick Creek 0.0 - 3.5. Due to the location throughout multiple subwatersheds, SSOs are likely a larger source contributing to the PCR impairments for impaired segments Banklick Creek 0.0 - 3.5 and 3.5 - 8.2 as well as portions of Banklick Creek 8.2 - 19.5. Due to this, the implementation outlined in this plan is focused on the SSO elimination identified in the [amended consent decree]and the projects outlined in [Updated Watershed Plan for Northern Kentucky]. The following is an overview of the currently proposed projects.

<u>2022-2029</u>

The Lakeview Equalization (EQ) Tank project includes an 8.6 million gallon above ground tank to store flows in excess of the downstream Lakeview PS capacity. EQ tanks are designed to provide additional storage during wet weather events, and slowly release the flow back into the sanitary system when capacity is available. The tank will be located on SD1 maintenance yard property adjacent to I-275 and Madison Pike and is sized to accommodate additional flow from storage and conveyance projects upstream to be completed by 2040 (see Section 6.2.2 of the UWSP). The model predicts that seven SSOs will be reduced or eliminated through these improvements (Figure 5.3).

The W6 Pump Station project will divert flow from the southwestern portion of the Lakeview service area to the Western Regional collection system through a 5 mgd pump station and a new 18-inch force main. The model predicts that five SSOs will be reduced or eliminated through these improvements (Figure 5.3). Note, the alignment of the force main shown in Figure 5.3 has since been revised to run along state route KY 536, which is slightly north of alignment shown along Maher Rd. in the figure. This update will be reflected in future progress reports.

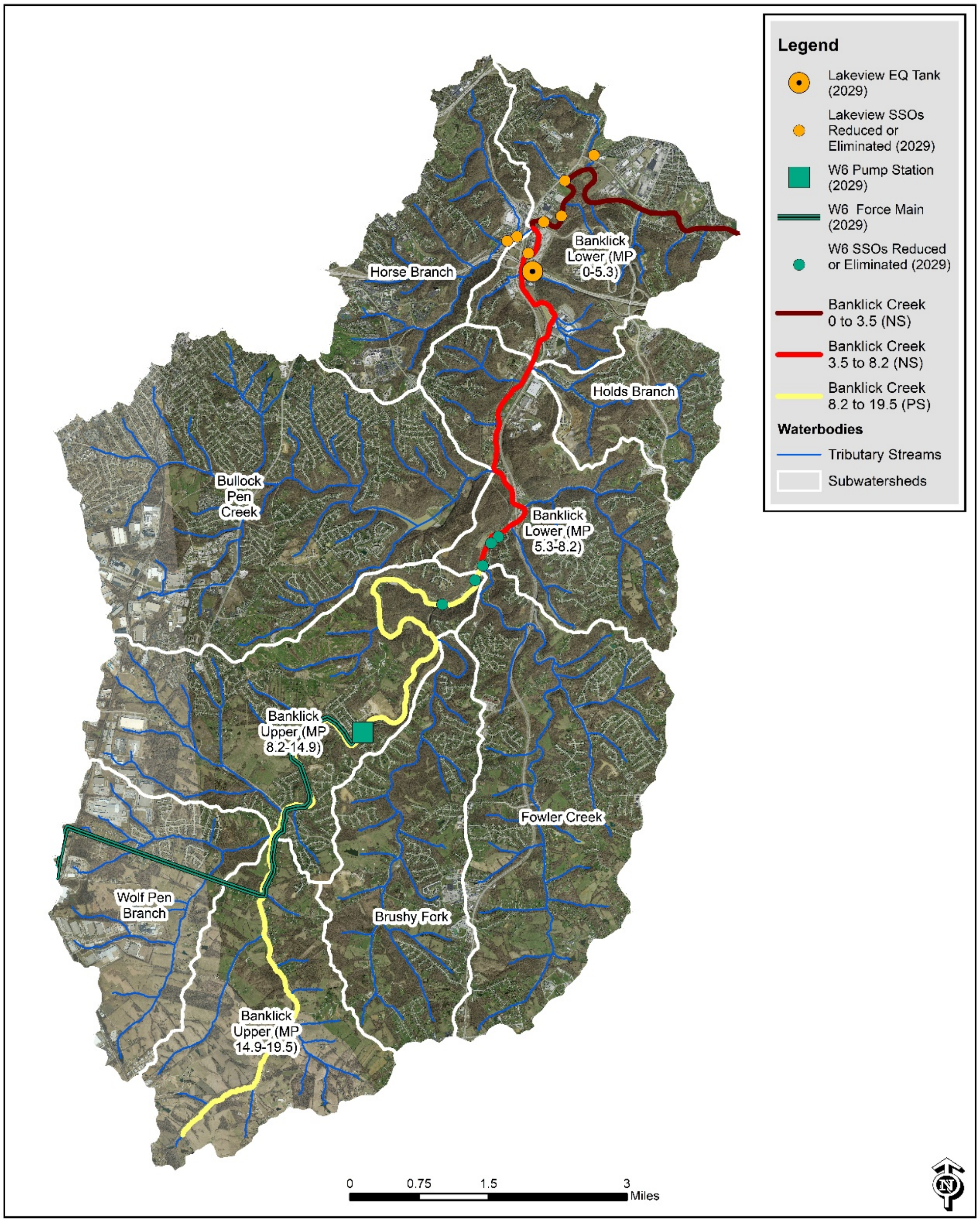


Figure 5.3 Updated Watershed Plan– Proposed Improvements by 2029

<u>2029-2034</u>

The Lakeview 2034 project builds upon the previous improvements and includes three proposed EQ facilities, pump station storage, and a portion of the ultimate conveyance improvements with the remaining improvements constructed by 2040 (see Section 7.2.3 of the UWSP). The model predicts that 20 SSOs will be reduced or eliminated through these improvements (Figure 5.3). The Western Regional 2034 project includes the remaining W6 improvements (EQ tank at the PS and conveyance upstream) and additional local conveyance (see Section 7.2.6 of the UWSP). The model predicts that 6 SSOs will be reduced or eliminated through these improvements (Figure 5.4).

The Banklick SSOs project includes a 2.6 mgd surface-storage tank and conveyance improvements (see Section 7.2.8 of the UWSP). The model predicts that three SSOs will be reduced or eliminated through these improvements (Figure 5.4).

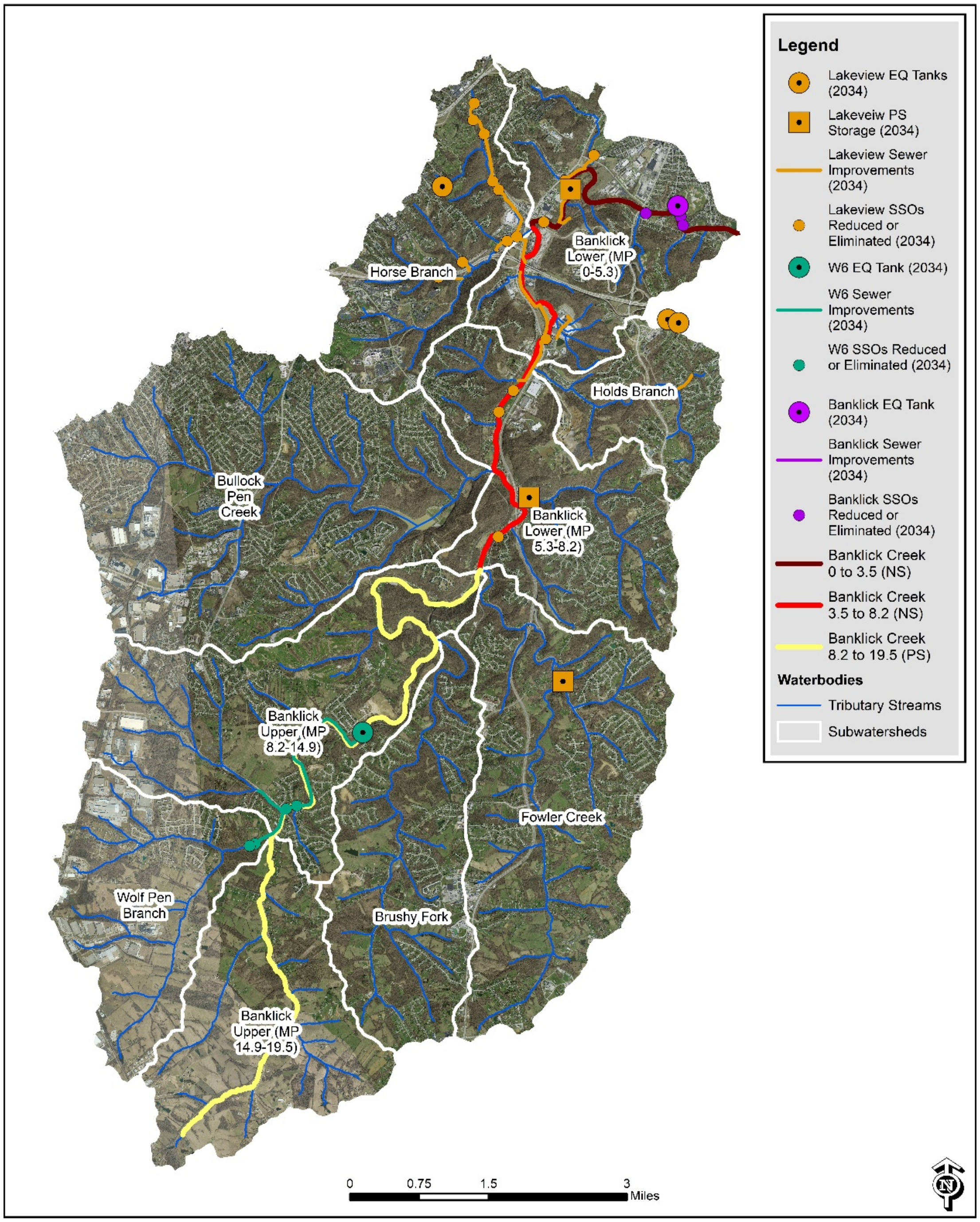


Figure 5.4 Updated Watershed Plan– Proposed Improvements by 2034

2034-2040

The Lakeview 2040 project addresses the remaining SSOs in the sewershed with conveyance improvements and by fully utilizing the EQ facilities constructed in 2029 and 2034 (see Section 8.2.2 of the UWSP). The model predicts that 30 SSOs will be reduced or eliminated through these improvements (Figure 5.5).

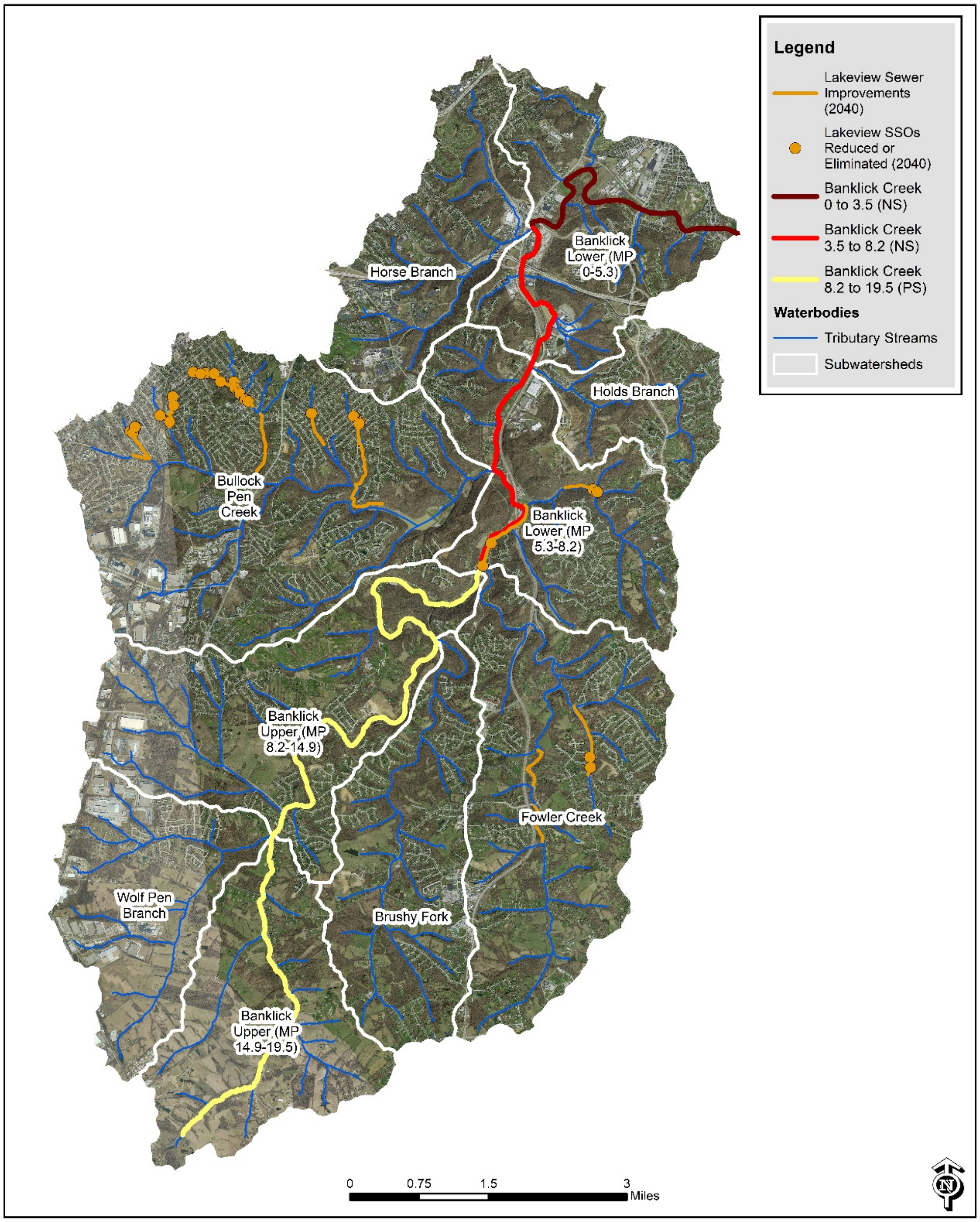


Figure 5.5 Updated Watershed Plan– Proposed Improvements by 2040

Based on developing information, new projects may be constructed in lieu of the projects defined in the plan and summarized above, but only after approval from regulatory agencies. Updated information related to planned and constructed projects as well as updated modeling predictions will be submitted to KDOW for review. Upon completion of the projects by 2040, SD1 will eliminate typical-year SSOs to meet the requirements of Northern Kentucky's amended consent decree.

Appendix A includes tables outlining the SSO elimination efforts as well as other proposed bacteria reduction activities recommended for each subwatershed.

Ongoing Maintenance to Prevent CSOs and SSOs Additionally, as part of ongoing Capacity, Management, Operations and Maintenance (CMOM) efforts, SD1 continues to address sanitary issues on a prioritized basis throughout the Northern Kentucky region. Annually, SD1 implements a program to systematically repair and replace aging and damaged sanitary sewer infrastructure, perform capacity upgrades to the existing systems and develop plans for new systems. This information will be reviewed and used to continue to target future water quality improvement activities within the watershed.

Implementation to Address Failing Septic Systems

As noted in Section 4.2 and Table 4.3, the Brushy Fork and Fowler Creek subwatersheds have failing septic systems in 6 clustered areas where traditional septic systems are not viable options for many homes and residents experience frequent failures. This is due to soil type, lot size or a combination of factors. Figure 5.6 identifies these areas and the number of homes served by septic systems.

The BWC, NKHD and SD1 worked with the City of Independence and Kenton County to review and prioritize these areas for sewer extension projects. The Peach Dr., Walnut Hall, Alvin Dr., and Maple Tree/ Bluegrass Dr. areas were selected. Current efforts include surveying the residents to determine interest in sanitary sewers, securing easements and finalizing sewer extension designs with the goal of completing sanitary sewer connections and septic decommissions by December 2026. If additional funding and opportunities become available in the future, the partners will work to address other septic hotspot clusters.

The KPDES permitted package treatment plant serving a 30-home subdivision in the southern portion of the Fowler Creek watershed (Table 4.2, Figure 4.2) was recently decommissioned and connected to the sanitary sewer.

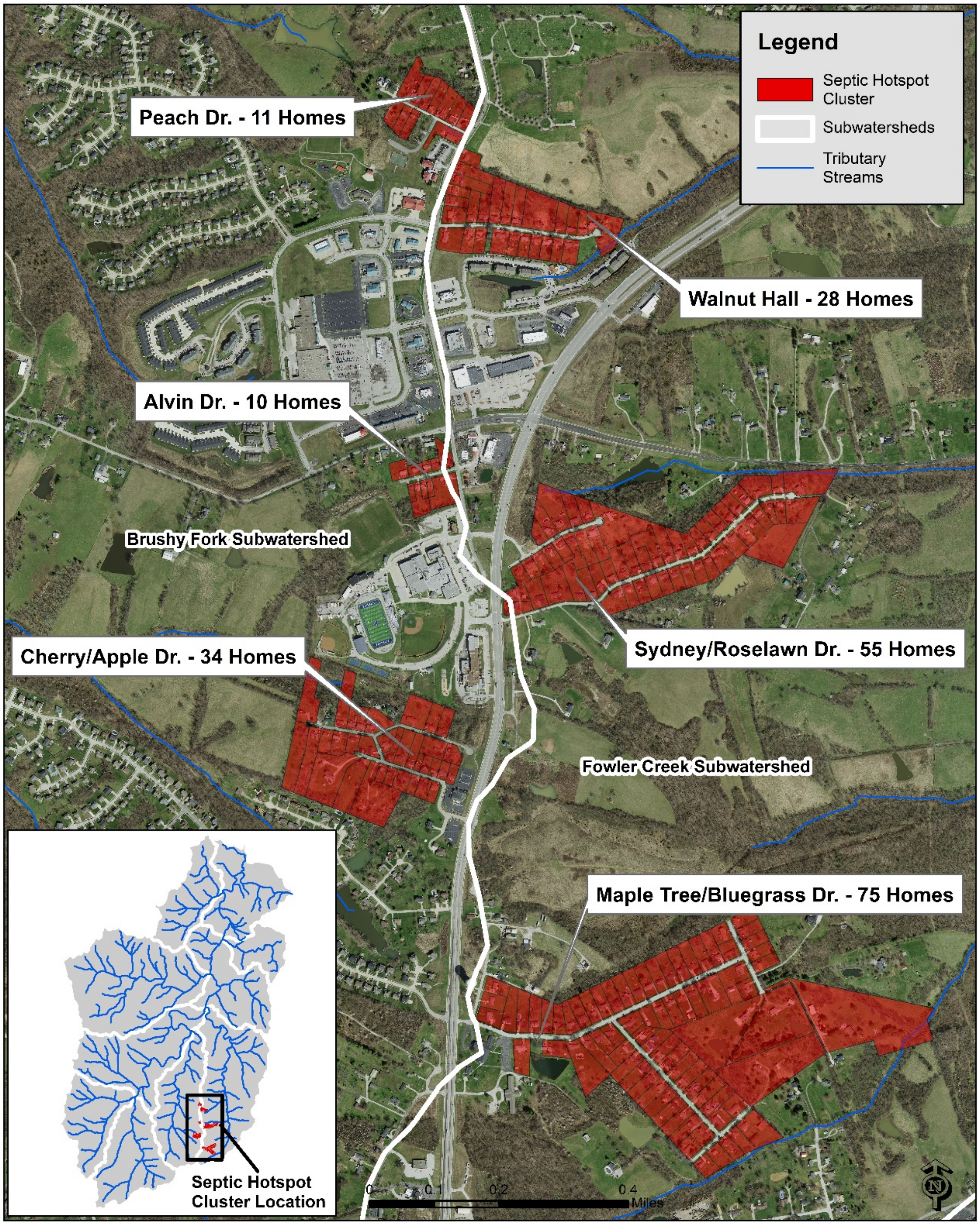


Figure 5.6 Septic Hotspot Clusters within Brushy Fork and Fowler Creek Subwatersheds

6.0 Success Monitoring and Reporting

All activities identified in the Appendix A tables for each subwatershed will be tracked and submitted to KDOW regularly, at minimum prior to each Integrated Report cycle. SD1 is in the process of updating the monitoring approach within the region. As a result, four established sites including BLC 3.9, BLC 8.1, BLC 15.6 and BPC 0.1 will be part of the monitoring program. All four sites were sampled ten times from April through October in 2022. Beginning in 2023, Site BLC 8.1 will be sampled 10 times every year. Sites BLC 3.9, BLC 15.6 and BPC 0.1 will be sampled 10 times every four years, with the next planned year in 2026 unless a more effective monitoring strategy is identified. Prior to each sampling year, SD1 will review factors such as areas with implementation to determine if supplemental sites should be added for that year. This includes adding a site within the lower impaired segment, Banklick Creek 0.0 to 3.5, to evaluate implementation addressing the CSOs within this segment.

SD1 will analyze and report the results of these events to KDOW regularly at least once each Integrated Report cycle. These results will serve as a screening tool for in-stream water quality improvements.

SD1 will review the results with KDOW and periodically evaluate whether the plan is on track for achieving water quality standards. As projects are implemented and the results show a trend towards improvement, SD1 will coordinate with KDOW to determine the appropriate monitoring plan for determining attainment of water quality standards.

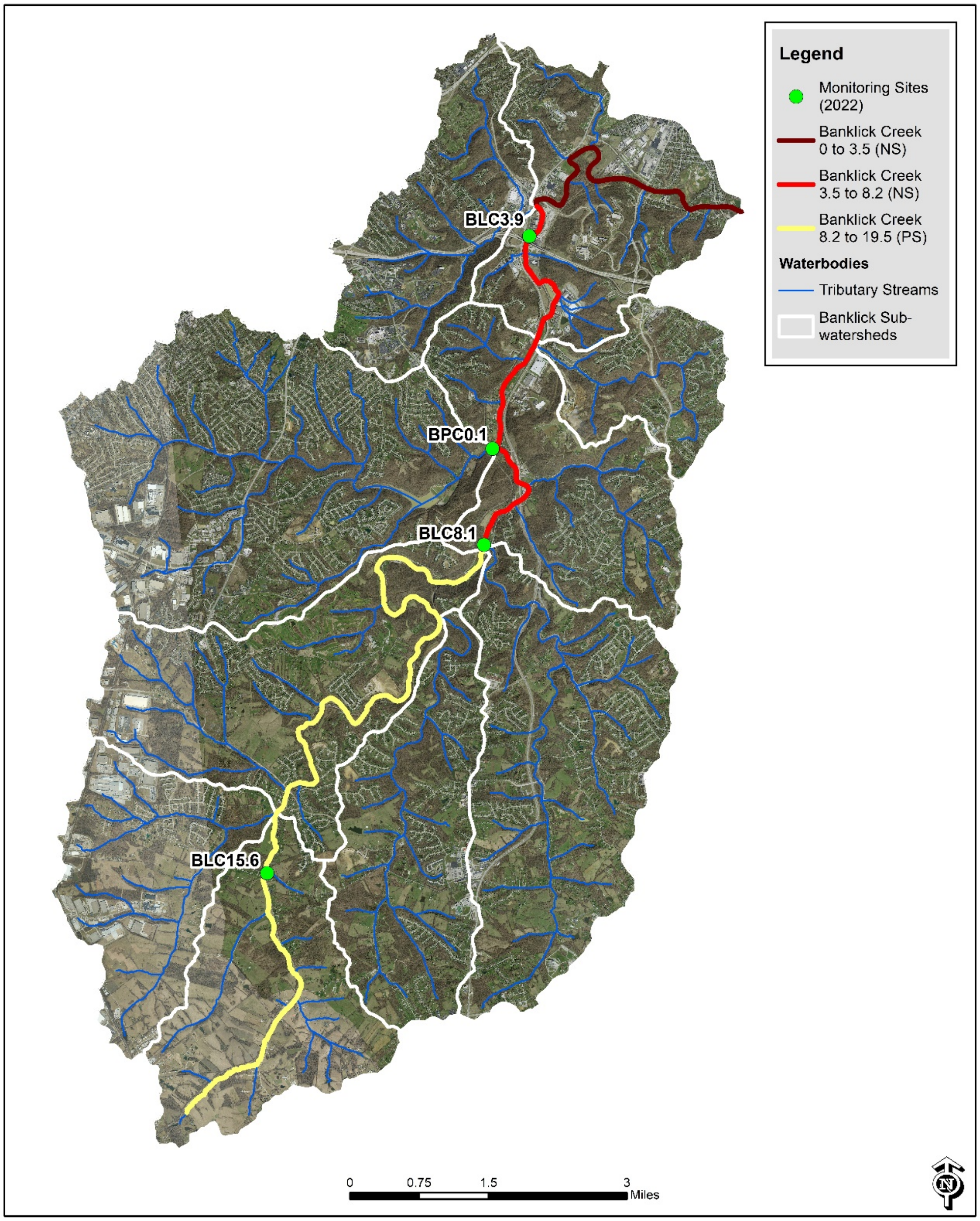


Figure 6.1 Monitoring Sites for 2022 and Future Cycles

7.0 Appendices

7.0 Appendices

(Note: Titles below are linked to the first page of the corresponding appendix)

Appendix A: Implementation Tables

Focus Subwatershed(s)	BMP Category (Activity Description)	Action Items	Key Partners *	Potential Funding Mechanism	Proposed Implementation Timeframe
Lower Watershed including Banklick Lower MP 0-5.3, Banklick Lower MP 5.3-8.2, Horse Branch, Bullock Pen and Holds Branch	Consent Decree - SSO Elimination Projects**	1. Lakeview - EQ Tank, and W6 - Pump Station and Force Main	SD1	Sanitary Utility Budget	2023 - 2029
		2. Lakeview - EQ Facilities, PS Storage, Sewer Improvements, W6 EQ Tank, Sewer improvements and Banklick Sewer Improvements			2029 - 2034
		3. Lakeview Sewer improvements			2034 - 2040
	Other Sanitary Improvements	1. Continue to implement the CMOM program in the SD1 service area	SD1	Sanitary Utility Budget	Ongoing
		2. Document all repairs, improvements and upgrades for the sanitary system within the watershed			
	IDDE Program Implementation	1. Continue to implement the MS4 IDDE programs in SD1 Storm Water Service Areas	SD1	Storm Water Utility Budget	Ongoing with MS4 permit renewals
		2. Document and track eliminated illicit discharges associated with wastewater (failing septics, broken laterals, etc.)			
	Pet Waste Management	1. Develop educational materials and programing to inform and encourage the public to properly manage pet waste	BWC/ SD1/ Cities and County Parks Dept.	319(h) Funding, Storm Water Utility Budget, Other Grants	2024-2028
		2. Establish pet waste disposal stations in key locations such as parks and community areas			
	Incremental Improvement Monitoring	1. Collect E.coli grab samples from established sites and additional sites (if needed) based on implementation sites	SD1	SD1	Ongoing
		2. Review results and document any improvement			
	Success Monitoring for 303(d) Delisting	1. Coordinate with KDOW to determine delisting monitoring approach	SD1	SD1	Determined by results of Incremental Improvement Monitoring
		2. Submit monitoring plan to DOW and ensure data collection is covered under approved QAPP			
		3. Collect E.coli grab samples and submit data results to DOW for Integrated Report			
Delist 303(d) segments - Banklick Creek 0.0 - 3.5 and Banklick Creek 3.5 - 8.2					
*SD1 - Sanitation District No. 1 of Northern Kentucky, BWC - Banklick Watershed Council					
**SSO Elimination Projects are based on the projects and timeline outlined in SD1's Updated Watershed Plan for Northern Kentucky. Any future updates to the watershed plan that may impact the projects or timeline will be reported on in the annual progress report.					

Appendix A: Implementation Tables (cont.)

Focus Subwatershed(s)	BMP Category (Activity Description)	Action Items	Key Partners *	Potential Funding Mechanism	Proposed Implementation Timeframe
Upper Watershed including Banklick Upper MP 8.2-14.9, Banklick Upper MP 14.9-19.5, Fowler Creek, Brushy Fork and Wolf Pen Branch	Consent Decree - SSO Elimination Projects**	1. W6 - Pump Station and Force Main	SD1	Sanitary Utility Budget	2023 - 2029
		2. W6 EQ Tank and Sewer improvements			2029 - 2034
		3. Lakeview Sewer improvements			2034 - 2040
	Other Sanitary Improvements	1. Continue to implement the CMOM program in the SD1 service area	SD1	Sanitary Utility Budget	Ongoing
		2. Document all repairs, improvements and upgrades for the sanitary system within the watershed			
	Eliminate Septic System Hotspot Clusters	1. Replace failing septic systems in prioritized clustered hotspot locations through sewer extension projects.	Kenton County/ City of Independence/ BWC/ SD1	Sanitary Utility Budget	2023 - 2026
	Septic System Improvements	1. Continue septic system improvement projects throughout the watershed in areas that support functioning systems	BWC	319(h) Funding	Ongoing
	IDDE Program Implementation	1. Continue to implement the MS4 IDDE programs in SD1 Storm Water Service Areas	SD1	Storm Water Utility Budget	Ongoing with MS4 permit renewals
		2. Document and track eliminated illicit discharges associated with wastewater (failing septics, broken laterals, etc.)			
	Pet Waste Management	1. Develop educational materials and programing to inform and encourage the public to properly manage pet waste	BWC/ SD1/ Cities and County Parks Dept.	319(h) Funding, Storm Water Utility Budget, Other Grants	2024-2028
		2. Establish pet waste disposal stations in key locations such as parks and community areas			
	Incremental Improvement Monitoring	1. Collect E.coli grab samples from established sites and additional sites (if needed) based on implementation sites	SD1	SD1	Ongoing
		2. Review results and document any improvement			
	Success Monitoring for 303(d) Delisting	1. Coordinate with KDOW to determine delisting monitoring approach	SD1	SD1	Determined by results of Incremental Improvement Monitoring
		2. Submit monitoring plan to DOW and ensure data collection is covered under approved QAPP			
		3. Collect E.coli grab samples and submit data results to DOW for Integrated Report			
Delist 303(d) segments - Banklick Creek 0.0 - 3.5, Banklick Creek 3.5 - 8.2 and Banklick 8.2 - 19.5					

*SD1 - Sanitation District No. 1 of Northern Kentucky, BWC - Banklick Watershed Council

**SSO Elimination Projects are based on the projects and timeline outlined in SD1's Updated Watershed Plan for Northern Kentucky. Any future updates to the watershed plan that may impact the projects or timeline will be reported on in the annual progress report.

BASE FLOW CHARACTERIZATION
FIELD MONITORING & SAMPLING PLAN
FOR NORTHERN KENTUCKY WATERSHEDS
PHASE 3
2016-2019

Northern Kentucky Sanitation District No.1
1045 Eaton Drive
Fort Wright, KY 41017

April 2016

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1. *Introduction*

Sanitation District No. 1 (SD1) a clean water agency that serves over 30 communities in Campbell, Kenton, and Boone Counties, Kentucky as both the wastewater and storm water utility, is implementing a watershed management approach to cost-effectively meet numerous regulatory requirements (e.g., Combined Sewer Overflow (CSO) Program and Municipal Separate Storm Sewer System (MS4) Program). Additionally, SD1 has entered into a Consent Decree (CD) with state and federal environmental regulators to address sewer overflows in these communities. In complying with these regulatory requirements, SD1 is applying an adaptive approach for identifying impairments and prioritizing areas for action. This approach will help ensure that available resources are most effectively used. SD1 has developed an Adaptive Watershed Management Plan that includes Watershed Characterization in sixteen sub watersheds to relate in-stream conditions to watershed characteristics. The results of this Watershed Characterization will be used to identify impaired watersheds and prioritize them for consideration of control alternatives.

An initial element of the Plan is to establish baseline conditions throughout the three county area. Initial surveys were conducted in 2006 and continued through 2010. The 2006 surveys included two rounds of sampling at approximately 50 sites; where as in 2007 and 2008, the program was expanded to include 75 sites to be sampled once annually. In 2009-2010 the program was expanded to include 77 total sites. The 2011 season was a 'catch-up' year, with only five sites sampled. In the 2012 season, only sites within the East Basin were sampled. The 2012 sampling year marked the beginning of the Phase 2 portion of the monitoring program. Sites in the East Basin were originally sampled in 2007, and were resampled in 2012. During the 2013 season, only sites in the Central Basin were sampled and during the 2014 season, sites were sampled in the North Basin. During the 2015 sampling season the West Basin was sampled.

Beginning in 2016, sampling will be back in the East Basin and will then rotate each year to a separate basin: 2017 Central Basin, 2018 North Basin and 2019 West Basin.

The following base flow characterization *Field Monitoring and Sampling Plan* (FMSP) is designed to ensure that all monitoring activities undertaken result in representative data necessary to support the characterization of the watershed being sampled. Dry weather water quality sampling will be conducted to characterize current base flow stream conditions.

Monitoring and sampling stations have been selected to provide appropriate coverage to meet the assessment and modeling needs of the watershed characterization process.

1.1 Program Overview

This FMSP describes the water quality monitoring program for the base flow watershed characterization of Northern Kentucky streams. The purpose of the FMSP is three fold:

- To supplement the Quality Assurance Project Plan (QAPP)
- To provide project and field staff with an understanding of the program and how to complete the base flow monitoring program; and,
- To define the level of effort and analytical needs.

The FMSP is intended to provide practical assistance in obtaining representative and reliable data in a technically sound and safe manner.

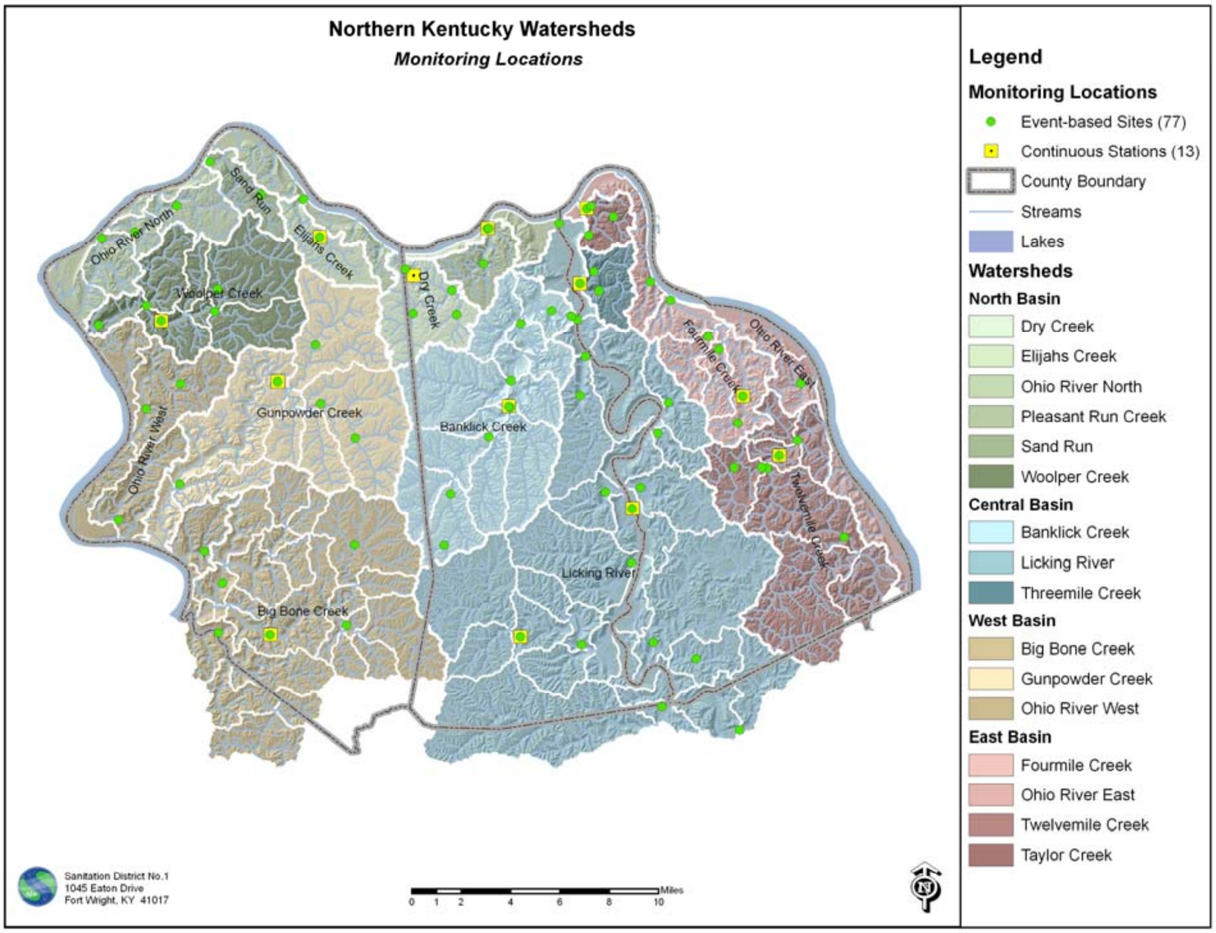
The procedures and protocols presented in this document address the following water quality and quantity monitoring program components:

- Monitoring and sampling criteria
- Stream water quality monitoring
- Sample handling and transportation
- QA/QC requirements
- Program Health and Safety

This program was designed to collect data that will be used to assess base flow water quality concerns identified in Northern Kentucky watersheds. The base flow data collected in Northern Kentucky streams is required to support water quality modeling, and pollutant source identification. The monitoring and sampling program will be conducted during the contact recreation season May 1st – October 31st.

Figure 1 shows locations in the watersheds of the Northern Kentucky area that have been identified as monitoring and sampling stations. The sampling locations shown in Figure 1 are discussed in more detail in Section 3.

Figure 1 Monitoring and Sampling Stations



1.2 Monitoring Team

The monitoring team consists of the Project Manager, the Field Manager, and sampling crew. Responsibilities of key team members are listed in Table 1.

Table 1 Team Member Responsibilities

Position	SD1 Team Member	Responsibilities
Project Manager	Mindy Scott	• Assess suitability of sampling events • Perform System Audits • Circulation of reports and results • Staff Training • Review Reporting • Ensure necessary resources are available • Creation of event reports • QA/QC review
Field Manager	Elizabeth Fet	• Implementation of FMSP • Initiate sampling events • Coordinate with laboratory • Mobilize field crews • Collection and review of field logs, lab results, and other program documentation • Ongoing management of field staff and equipment

Prior to the first sampling event, a flowchart will be created which contains all members of the different sampling crews and laboratory contacts along with their respective contact numbers (home, work, pager, and/or cellular numbers). This will allow for a network of communication prior to and during the monitored events. A communication network for the sampling team is essential to the ability to adapt the sampling program to changing environmental or weather conditions and/or equipment malfunctions.

2. *MONITORING AND SAMPLING CRITERIA*

The objective of the base flow monitoring and sampling program is to characterize water quality during the contact recreational season under dry weather conditions by providing current background data in each watershed.

The criteria used to define a dry weather monitoring and sampling event include:

- No precipitation in the watershed 72 hours before the event; and,
- Dry weather conditions must prevail throughout the monitoring and sampling event.
- Sampling must take place during the contact recreational season beginning May 1st and ending October 31st.

One round of dry weather monitoring will be completed each year. The goal will be to conduct the sampling by basin. The sampling will be distributed throughout the monitoring period by basin to characterize Northern Kentucky streams during typical base flow conditions.

The dry weather criteria will serve as the minimum requirements for initiating sampling. Local conditions may require these criteria to be modified as the study progresses. Best professional judgment will be necessary to assess the suitability of a particular dry weather sampling event.

3. *Stream Characterization*

Stream monitoring and sampling will be conducted at designated stations along Northern Kentucky streams as shown in Figure 1. Water quality monitoring and sampling will be conducted as follows:

- One round of water quality monitoring will be sampled at all sites in the designated basin during base flow conditions according to the surface water quality monitoring program protocols;
- All sites will be characterized on-site for in-stream water quality measurements (temperature, dissolved oxygen, pH, conductivity and turbidity).

Table 2 describes each of the stations as depicted in Figure 1. Station selection was based on an initial watershed reconnaissance, which focused upon suitable site configuration for stream sampling and location relative to key pollutant source inputs. Once final sampling locations were identified, latitude and longitude coordinates were obtained with a Global Positioning System (GPS) unit and recorded.

Standard operating procedures (SOPs) referenced in the following sections are provided in Appendix A.

Table 2 Base Flow Sampling Locations

Station ID	Stream	Location	Study Basin
BLC0.3	Banklick	Route 177 at Banklick	Central
BLC1.2	Banklick	Route 16 bridge on Winston Avenue	Central
BLC3.9	Banklick	Eaton Drive bridge	Central
BLC8.1	Banklick	Richardson Road bridge	Central
BLC11.6	Banklick	Independence Station Road	Central
BLC15.6	Banklick	Maher Road bridge	Central
BPC0.1	Bullock Pen	Bridge on Bullock Pen Road	Central
FWC0.1	Fowler	Bridge on Marshall Road	Central
BMC0.7	Bowman	Bridge on 177, park on Conley Rd.	Central
CRC2.5	Cruises	Bridge on Hempfling Road	Central
CRC8.1	Cruises	USGS Station on Route 17 near Piner, KY	Central
DCC0.4	DeCoursey	Locust Pike Road	Central
DCC2.2	DeCoursey	Bridge on Porter Rd off Rt 177	Central
GRC0.5	Grassy	Bridge on Rt 177, just passed the Pendleton Co. line	Central
LIR0.5	Licking	5th St Bridge in Covington	Central
LIR4.9	Licking	Kenton County Water Intake	Central
LIR19.3	Licking	Visalia Bridge on Rt 536	Central
LIR35.5	Licking	Bridge @ Butler, KY	Central
PHC2.3	Phillips	Gravel pull off on side of Morningview Rd.	Central
PLC1.8	Plum	Bridge @ intersection of Hissem and Aulick Rd	Central
POC0.9	Pond	Bridge on Indian Trace @ intersection with Joann Ln	Central
RFC0.9	Riffle	Rt 915 south of Licking Valley Baptist Church	Central
SCC0.6	Scaffold	Bridge on Rifle Range Rd off Rt 915	Central
STC1.2	Steep	Bridge on Case Rd off Steep Cr. Rd	Central
THC0.4	Threemile	USGS Station on Johns Hill Rd	Central
THC0.5-NBT0.8	North Branch Threemile	Moock Rd, bridge to Woodland Hills Condos	Central
THC1.4	Threemile	Gibson Lane	Central
FMC0.5	Fourmile	Silver Grove Pump Station off Rt 8	East
FMC6.9	Fourmile	USGS Gage Station on Poplar Ridge Rd	East
FMC8.2	Fourmile	Off 547, bridge on Appleblossom Ln	East
OWC0.4	Owl	Rt 547 to Owl Creek Road	East
TUC0.4	Tug	Bridge on Darlington Road	East
TEC1.3	Tenmile	Intersection of Ten Mile and Fender Rd	East
TIC0.2	Threemile	Upstream of Highland Heights PS on Blangey Rd	East
TYC0.6	Taylor	USGS Station on Donnermeyer Dr under I-471	East
TYC1.6-UNT0.4	Taylor	Alexandria Pike in Southgate, KY	East
TYC0.9-WLC1.3	Woodlawn	Waterworks Road	East
TYC0.7-CVR0.2	Covert Run	Across from Ben Flora Gym on Tiger Lane	East
TMC1.9	Twelvemile	Bridge @ intersection of 1566 & 2921	East
TMC3.0	Twelvemile	USGS Gage Station on 1997	East
TMC3.9	Twelvemile	Bridge on Route 10	East
TMC9.3	Twelvemile	Intersection of Route 10 and California Cross Rds	East

Table 2 continued

BRC0.3	Brush	Bridge on Route 10	East
BRC2.0	Brush	Eastern Regional Water Reclamation Facility	East
DRC1.4	Dry	Bridge @ Dry Creek WWTP	North
DRC4.4	Dry	On Eubanks Rd of Anderson Rd off Buttermilk	North
DRC5.9	Dry	Bridge on Shinkle Rd in residential area	North
DRC3.0-WFD1.5	Dry	Bridge on Erlanger Rd off Houston Rd	North
EJC0.3	Elijah	Bridge on Rt 8	North
EJC2.8	Elijah	USGS gage station on Elijah Creek Rd	North
GAC1.7	Garrison	First bridge on Garrison Cr. Rd.	North
PRC0.3	Pleasant	Bridge on Oak St	North
PRC2.0	Pleasant	Bridge over Bromley Crescent Springs Rd @ Amsterdam	North
PRC0.4-UNT0.0	Pleasant	Oak Street behind the BINGO hall	North
SDR0.6	Sand	End of Rt 8, beyond end of state maintenance	North
SDR4.0	Sand	Thornwilde Subdivision	North
SEC1.6	Second	End of Second Creek Road	North
TAC0.5	Taylor	Lawrenceburg Ferry Rd	North
WPC1.4	Woolper	Bridge on Rt 20	North
WPC5.0	Woolper	USGS station on Woolper Rd	North
WPC8.8	Woolper	Bridge on Rt 338	North
ALF0.1	Allen Fork	Huffman-Clifford Bridge on Easton Lane from Rt 338	North
ASF0.0	Ashbys Fork	Intersection of Ashby & Woolper Rd	North
BBC3.9	Big Bone	Off Rt 1925 to Bender Rd	West
MLC3.0	Mud Lick	USGS Station, bridge @ US 42	West
MLC12.0	Mud Lick	Richwood pump station, on Rt 338	West
BSF1.8	Big South Fork	US 42 to bridge on South Fork Church Rd	West
MCF1.7	McCoys Fork	I-75 to Walton-Verona exit	West
GPC4.6	Gunpowder	Sullivan road; path by bus turn around	West
GPC14.7	Gunpowder	USGS gage station and SD1 pump station	West
GPC17.9	Gunpowder	Oakbrook Rd and Limaburg Rd	West
SFG2.6	South Fork Gunpowder	Woodcreek Rd bridge off Pleasant Valley	West
SFG5.3	South Fork Gunpowder	Bridge on Gunpowder Rd to Grace Fellowship Church	West
LAC1.4	Landing	Bridge on Rt 338 at inter.of Big Bone Church/Ryle Rd	West
LIC1.6	Lick	Bridge on Rt 338, near East Bend Power Plant	West
MDC1.8	Middle	Bridge on Waterloo Road	West
MDC5.5	Middle	Middle Creek Road by barn	West

3.1 On-Site Water Quality Measurements

All sites will be subject to on-site measurements during sampling events. On-site measurements will include DO, pH, temperature, conductivity and turbidity.

On-site water quality instrumentation will be calibrated and maintained in accordance with *Standard Operating Procedures Hydrolab Series 5 Water Quality Instrumentation.*

3.2 Dry Weather Sampling

Most sampling locations are accessible by bridges or by wading during dry weather. A minimum of 72 hours without precipitation will be required prior to the beginning of a sampling event, and dry weather conditions must prevail throughout sampling.

Table 3 presents the monitoring schedule for the surface water sampling program for dry weather monitoring. All sampling will be performed by SD1 staff. Base flow samples will be collected as grab samples in accordance with *Standard Operating Procedures for the Collection of Discrete Water Samples.* Dry weather sampling events will be completed by basin, utilizing two person crews as described in Table 3.

All grab samples will be collected with a sampling pole, stainless steel bucket or glove method. Sampling events will start at the downstream site and progress upstream. This approach to dry weather sampling is designed to collect a representative sample of base flow conditions in the stream. Immediately after sample collection, on-site measurements will be taken as previously described.

Table 3 Base Flow Monitoring Schedule

Study Basin	**Watershed**	**Base flow (1 Basin/year)**				
		# of Sites	2016	2017	2018	2019
Central	**Licking**	4		X		
Central	**Banklick**	8		X		
Central	**Threemile**	3		X		
Central	Bowman	1		X		
Central	Cruises	2		X		
Central	Decoursey	2		X		
Central	Grassy	1		X		
Central	Phillips	1		X		
Central	Plum	1		X		
Central	Pond	1		X		
Central	Riffle	1		X		
Central	Scaffold	1		X		
Central	Steep	1		X		
		27		**27**		
East	**Fourmile**	5	X			
East	**Twelvemile**	6	X			
East	**Taylor**	4	X			
East	Tenmile	1	X			
East	Threemile	1	X			
		17	**17**			
North	**Woolper**	5			X	
North	**Elijahs**	2			X	
North	**Dry Creek**	4			X	
North	**Pleasant Run**	3			X	
North	**Sand Run**	2			X	
North	Garrison	1			X	
North	Second	1			X	
North	Taylor	1			X	
		19			**19**	
West	**Gunpowder**	5				X
West	**Big Bone**	5				X
West	Landing	1				X
West	Lick	1				X
West	Middle	2				X
		14				**14**

3.3 Summary

Table 4 presents a summary of the field monitoring and sampling plan for Northern Kentucky watersheds.

Table 4 Summary of Water Quality Monitoring and Sampling Program

Type	Locations	Description	Parameters
Base flow Sampling	77 total locations, throughout Northern Kentucky 4 basins (North, Central, West, East)	***<u>Dry Weather</u>*** ♦ 1 basin per year ♦ 1 grab sample per site	♦ On-site measurements will include: ***temperature, dissolved oxygen, pH, conductivity and turbidity.*** ♦ Water quality parameters will include: ***bacteria (EC and FC), nitrogen (TKN, NH_3, NO_3-NO_2), phosphorus (total and ortho), total suspended solids, and $CBOD_5$.***

Table 5 summarizes the number of samples to be collected exclusive of quality control protocols.

Table 5 Summary of Number of Samples to be Collected

Task	East Basin	Central Basin	North Basin	West Basin
Year Sampled	2016	2017	2018	2019
No. of Events	1	1	1	1
No. of Sites	17	27	19	14
Bacteria				
E. coli	17	27	19	14
Nutrients				
NH_3	17	27	19	14
NO_3- NO_2	17	27	19	14
TKN	17	27	19	14
Total Phosphorus	17	27	19	14
Ortho Phosphate (field filtered)	17	27	19	14
Solids				
TSS	17	27	19	14
Other				
$CBOD_5$	17	27	19	14
Total Sample Load	**136**	**216**	**152**	**112**
QA/QC Samples are not included.				

4. *FIELD MEASUREMENTS*

In-stream dissolved oxygen, temperature, pH, conductivity, and turbidity will be measured using appropriate field instruments concurrent with sample collection at each of the sampling locations. Each on-site parameter will be measured at each location during each sampling event. Table 6 lists the parameters, location of measurement at each site, and method of measurement.

Field measurements will be conducted following the Standard Operating Procedures in Appendix A. Field instruments will be calibrated before initiating monitoring activities for each event. A post-monitoring calibration check will also be conducted at the end of each monitoring event. All calibration and maintenance activities will be documented on the Multiprobe Instrumentation Calibration and QA Sheet (see Appendix A).

Measurements will be documented on the Field Data Sheet (see Appendix C). Documentation will include: date/time, location, type of measurement, personnel, equipment and associated calibration specifications, and general site observations (e.g., weather conditions).

Table 6. Field Measurements

Parameter	Location of Measurement	Method
Temperature	Mid-channel, mid-depth where possible	Hydrolab
Conductivity		
pH		
Dissolved Oxygen		
Turbidity		

5. *SAMPLING HANDLING AND CUSTODY*

The following sections outlines the sample labeling procedures, sample handling, chain-of-custody and record keeping required.

5.1 Sample Labeling

All samples will be assigned a unique identification code such that all necessary information can be attained from the sample label. The labels will be available in an electronic template and can be printed once the information has been added to the template. The code will identify the following:

Label: ___ ___ ___ ___. ___

1 2 3 4 5

Characters 1-5: Sample Site ID

Example: FMC0.5

In addition to the label, the sample bottles will be clearly marked using waterproof ink with the following information:

- Client – SD1
- Analyses – List of requested analyses to be performed from the container
- Preservative – Preservative in sample container
- Date – Date sample was collected
- Time – Time sample was collected
- Crew – Crew identification

5.2 Sampling Collection, Handling and Transport

General guidelines for sample collection are listed below. Refer to *Standard Operating Procedures for the Collection of Discrete Water Samples* for detailed procedures.

- All samples collected in intermediate sampling containers should be transferred to their appropriate laboratory sample bottle as quickly as possible.
- Sampling location codes will be used to distinguish each distinct sampling location.
- Sample labels and chains of custody must be filled out completely.

The following procedures will be followed when handling and transporting samples:

- Samples will be preserved using ice and transported in sample coolers. It should be ensured that plenty of ice is used for each sample cooler to maintain the temperatures inside the cooler at approximately 4^{o} C.
- Laboratory chain-of-custody forms will be included with all sample submissions. Field staff will keep copies.
- Sample bottles and coolers should be handled with care to prevent breakage/spillage.
- All sample bottle labels must be properly completed and placed firmly on each bottle by the field sampling crews.

5.3 Chain-of-Custody

Field crews will complete chain-of-custody forms to document the transfer of sample custody to the designated custodian and subsequent personnel, see Appendix B. Signatures of all personnel involved in the collection, transport, and receipt of each sample will be recorded on the chain-of-custody forms.

In certain instances, sample custody will be transferred to runners to transport the samples directly to the laboratory at designated times during sampling to avoid missing holding times. The chain-of-custody form outlines sample location, identification, collection time and date, and specific parameters to be analyzed for each sample. A properly completed chain-of-custody form must accompany all samples.

Use of the chain-of-custody form will terminate when laboratory personnel receive the samples and sign the form. The laboratory will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the chain-of-custody form. Any discrepancy between the sample bottle and the chain-of-custody form, any leaking sample containers, or any other abnormal situation will be reported to the Laboratory Manager. The Laboratory Manager will inform the Project Manager of any such problem, and corrective actions will be discussed and implemented.

5.4 Field Logs and Records

Field crews will document all activities associated with the monitoring program at each monitoring site, including unusual or anomalous conditions. In addition, a description of any problems encountered during the monitoring period and/or any deviations to the FMSP will also be documented. This information may subsequently be used for data interpretation and analyses.

All pertinent information will be recorded on Field Data Sheets which are included as Appendix C.

At the conclusion of each monitored event, all Field Data Sheets will be submitted to the Field Manager to serve as a chronological representation of the monitored event. At a minimum each data field sheet should include the following information:

- Project name, site/river name, sample type;
- Crew identification, date, start time/end time;
- Weather conditions, stream conditions, site conditions;
- Physical parameter data (on-site measurements);
- On-site water quality meter identification number used to measure physical parameter data;
- Field observations.

In addition, the recreational use survey form (also provided in Appendix A) will be completed at each site and submitted to the Field Manager at the conclusion of each monitored event. The recreational use survey should include the following information:

- Project name, site/river name, sample type;
- Crew identification, date, start time/end time;
- Photo file name and corresponding description;
- Description of recreational uses observed at the site; and,
- Description of other human evidence of use.

All entries will be completed with a permanent ink pen with no erasures, correction fluid, or tape used. Erroneous entries will be noted using a single line drawn through the mistake that is then dated and initialed.

5.5 Sample Containers and Preservation

Table 7 presents details of sample containers and preservatives to be used. The laboratory will provide all bottles pre-preserved.

Table 7 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Maximum Storage Time
Bacteria				
E. coli	Pre-Sterilized Polyethylene or Glass	120 ml	Add $Na_2S_2O_7$ [1] Refrigerate to 4°C	12 hours[2]
Nutrients				
NH_3 TKN NO_3-NO_2 Total Phosphorus	Polyethylene or Glass	1000 ml	Add H_2SO_4, pH<2 Refrigerate to 4°C	28 days
Ortho Phosphate	Polyethylene or Glass	120 ml	Field filter Refrigerate to 4°C	48 hours
Conventional				
TSS	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	7 days
$CBOD_5$	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	48 hours

1. Sodium Thiosulfate ($Na_2S_2O_7$) prevents continuation of bacteriocidal action.
2. The maximum allowable holding time for bacteria samples will be 12 hours with a goal of 6 hours when practical.

6. QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The purpose of any quality assurance/quality control (QA/QC) program is to ensure that all sampling protocols and procedures are followed such that samples are representative of the water quality to which they are associated. The program is designed to be a systematic process, which together with the laboratory QA/QC program ensures a high degree of confidence in the data collection. The proposed QA/QC program includes the following elements:

- Training of all field staff;
- Field quality control procedures;
- Equipment cleaning protocol;
- QA/QC samples; and,
- Equipment calibration.

6.1 Training

Training sessions will be carried out for all field staff on proper sampling, sample handling and submission and general field procedures. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field crews will receive training involving the operation, maintenance and calibration of water quality meters, and all other on-site equipment used throughout the field program. SOPs for all program elements will be distributed to staff and available at all times.

6.2 *Field Quality Control*

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, necessary precautions must be taken to protect samples from contamination and deterioration. Procedures detailed in *Standard Operating Procedures for the Collection of Discrete Water Samples* and *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation* will be followed to ensure field quality control.

6.3 *Equipment Cleaning Protocol*

All sampling equipment (i.e. intermediate containers, sampling buckets, etc.) will follow the QA/QC protocol outlined in *Standard Operating Procedures for the Collection of Discrete Water Samples* to ensure representative sample collection. When using the sampling pole or stainless steel bucket, only step 2 (Blank Water Rinse) of the decontamination procedure needs to be utilized.

6.4 *QA/QC Samples*

The monitoring team will use three types of QA/QC samples collected in the field to assist in validating chemical data sets – sample duplicates, equipment blanks, and field blanks. Each type of QA/QC sample is described in the following sections. Tables 8 and 9 present the schedule and number of QA/QC samples to be collected during the field program.

Table 8 QA/QC Sample Schedule

Crew	**Dry Weather / Base Flow Sampling**			
	East Basin	Central Basin	North Basin	West Basin
Day 1	BEB*,Dup, FB, MB, AEB*	BEB*, Dup, FB, MB, AEB*	BEB*, Dup, FB, MB, AEB*	BEB*, Dup, FB, MB, AEB*
Day 2	BEB*, FB, MB, AEB*	BEB*, FB, MB, AEB*	BEB*, FB, MB, AEB*	BEB*, FB, MB, AEB*
Day 3		BEB*, FB, MB, AEB*		
BEB = Before Equipment Blank MB= Method Blank Dup = Duplicate AEB = After Equipment Blank FB = Field Blank * = As needed				

Table 9 Number of QA/QC Samples

Base Flow Sampling	Field Blanks[2]	Equipment Blanks[3]	Method Blanks[4]	Duplicate Samples[5]	Total per Event
Day 1	1	6	1	1	18
Day 2	1	4	1	0	8
Day 3			1	0	
Totals	**6**	**10**	**6**	**4**	**26**

1. Each QA/QC sample set is performed on the complete series of samples submitted for laboratory analysis.
2. One set of field blanks per day will be collected during each day of the event.
3. Two sets of equipment blanks (BEB, AEB) per day will be collected during each day of the event only if a bucket was used during sampling.
4. One set of method blanks (at one site) per day will be collected during each day of the event.
5. One set of duplicates (at one site) will be collected during each sampling event.

6.4.1 Sample Duplicates

Sample duplicates will be collected for laboratory analysis for each parameter. The purpose of these analyses is to evaluate sample collection precision by comparing the duplicate analytical results. One set of duplicate samples at a sampling location, randomly identified, will be collected by each field crew during the sampling event. Duplicates will be rotated among streams between sampling rounds. Approximately 10 percent of the samples will be collected in duplicate.

6.4.2 Equipment Blanks

Equipment blanks will be collected for laboratory analysis for all parameters. The purpose of these analyses is to assess potential cross-contamination of samples by the equipment, including intermediate sample containers. These blanks will be taken before each sampling shift (BEB) and at the conclusion of each sampling shift (AEB) by each crew.

6.4.3 Method Blanks

Method blanks (MB) will be collected for laboratory analysis for orthophosphate only. The purpose of these analyses is to assess potential cross-contamination of samples by the method in which the sample was collected. These blanks will be taken at the conclusion of each sampling shift by each crew.

6.4.4 Field Blanks

Field blanks will be collected for laboratory analysis for all parameters. The purpose of these analyses is to determine if samples collected have been contaminated by field handling and cleaning methods. Each field crew will collect these blanks immediately following the collection of the AEB equipment blanks.

6.5 Equipment Calibration

On-site physical parameters will be measured in-stream by water quality meters and recorded on data sheets. These instruments will be calibrated each sampling day before use according to the manufactures operating manual as outlined in *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation*.

At the conclusion of the sampling event, each meter will be checked with the standards used during calibration. The purpose of these readings is to evaluate the meter's precision (electronic drift) by comparing the readings recorded during calibration and the readings recorded during the check at the end of the sampling day.

At the conclusion of each sampling event, all Calibration Sheets will be submitted to the Field Manager to serve as a record of the meter's performance during the sampling event.

7. PROGRAM SAFETY

The most critical component of a sampling program is crew safety. Safety is of paramount importance as stream sampling can be extremely dangerous. The element of danger is accentuated if personnel are unfamiliar with their surroundings and/or procedures, consequently staff must be properly trained in both safety and monitoring procedures, following a well thought out program.

With stream monitoring, common sense is essential. Two hazards that field staff may face more often, especially if wet weather occurs during sampling, are high stream conditions and slippery footing. If stream levels are deemed to be too high or too fast, under no circumstances should any field staff enter the stream or operate near its banks. With surfaces being wet and slippery, special care must be taken when walking and working around bridges.

Wading is one of the easiest methods to collect samples from many streams, and it may also be extremely dangerous. Wading permits the investigator to examine stream flow and decide where to sample. Rubber boots or even chest-high waders are standard equipment. If the wader has any uncertainty about their ability to wade a stream, they should be attached by a rope to a rigid mooring and wear an approved floatation device.

If creek conditions are high and fast, field staff will wear a safety belt or harness and will be appropriately tethered when working in close proximity to the creek. Along with being attached by rope, field staff must wear an approved floatation device.

There must be a minimum of two field staff working together during any sampling event.

7.1 General Safety Practices

- Water depth during wading operations must be checked with a pole before steps are taken.
- When wading equipment is worn, the support straps must be outside the clothing.
- In all situations field parties are required to leave accurate sampling schedules and expected itineraries in the office.
- Sampling must never be carried out in weather that is considered by the Field Manager or field member to be hazardous to the well-being of the field staff and/or equipment.
- Field staff are required to wear approved floatation devices and be tethered if conditions warrant use.
- First aid kits will be issued to all field crews.
- Each field crew will have a cellular phone and have been instructed on emergency procedures and numbers.
- Each field crew will report upon leaving and returning from any sampling or field work to their Field Manager.
- Each field crew will have appropriate lights, markers, etc. to be able to perform their work safely under poor visibility/nightfall.
- Each field crew will have the appropriate road safety equipment as required.

7.2 Health Hazards

Disease causing bacteria, viruses, and parasites are always present in sewers and discharge streams. They occur in both liquid sewage and dry sludge which coats pipes, and other surfaces. The serious threats are Hepatitis A (virus), Hepatitis B (virus), Tetanus (bacteria), Typhoid (bacteria), and Polio (virus). Proper hygiene methods must be followed. Wash hands before eating or smoking. Protective clothing must be laundered and equipment kept clean. Workers should avoid touching their eyes to prevent an inflammation. Cuts and abrasions of the skin should be covered by bandages or gloves to minimize the chance of infection by organisms.

Appendix A

Standard Operating Procedures for Field Monitoring and Sampling

Standard Operating Procedures

for the

Collection of Discrete Water Samples

Northern Kentucky Sanitation District No. 1
1045 Eaton Drive
Fort Wright, KY 41017

Revision Number: 1
September 2006

Introduction

This document describes the procedures for the collection of discrete water samples in Northern KY watersheds by Sanitation District No.1. These methods allow for the collection of grab or composite samples utilizing various sample collection techniques. This standard operating procedures document (SOP) has been developed to maintain consistent data collection procedures, and to ensure the quality of the data collected.

1.0.0 Field Equipment

The following equipment is needed to implement the sampling techniques.

- Stainless Steel Bucket w/ Rope
- Sampling Pole
- Kemmerer Sampling Bottle Kit
- Churn Sample Splitter
- Chemical Decontamination Agent (Solvent or Weak Acid)
- Chemical Waste Bucket
- Blank Water (Distilled or Reagent Grade Deionized – RGDI)
- Sample Bottles
- Coolers and Ice
- Scrub Brush
- Disposable Gloves
- Field Sampling Plan
- Permanent Marker (Sharpie)

Individuals handling solvents or acids should wear rubber gloves and eye protection to prevent possible injuries.

The following parameters can be collected with the ensuing sampling techniques: bacteria (fecal coliform and *E. coli*), oxygen demand (BOD_5 , $CBOD_5$, COD), chlorophyll *a*, nutrients (total phosphorus, orthophosphate, nitrate-nitrite, Total Kjeldahl Nitrogen, ammonia), total hardness, metals, and solids (TSS, TDS).

Refer to Attachment 1 for an alternative collection procedure for parameters that do not require preservatives utilizing the glove method.

Refer to Attachment 2 for filtration procedures for orthophosphate collection.

2.0.0 Preparation

Before collecting samples, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative, and the name of the collecting entity and sampling crew member) on all bottles using a permanent marker and affix the labels to the bottles. Ideally, the labels are filled out (except date and time) and attached to the sample bottles before the sampling event occurs. In addition to the sample label, identify the lid of each container with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers should be wiped down or washed with a mild soap and thoroughly rinsed if it has any contaminants present. In addition all sampling equipment must be inspected for proper operation.

The sampler's hands should be washed with a mild soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the sample bottles or lids.

3.0.0 Procedures

Keep all sampling bottles closed until they are ready to be filled. At each collection site, the sampler will wear a new set of gloves for decontamination procedures and new set of gloves for sample collection. If sampling from a boat or structure, collect the sample from the upstream side. Avoid placing the sampling device in contact with the streambed or bank. Once the sample is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.1.0 Stainless Steel Bucket

Prior to sampling, the stainless steel bucket must be inspected to ensure that is in good condition, and that the nylon rope is not torn or frayed.

3.1.1 Decontamination Procedures

The stainless steel bucket must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the outer lip and the inside of the bucket with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the bucket thoroughly with the chemical.
- Discard the chemical into the waste container.
- Rinse the inside of the bucket with blank water.
- Discard the blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat Step 3.

3.1.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – River Rinse

- Rinse the bucket with river water by submerging the bucket into the stream at the collection site.
- Remove the bucket from the stream and discard its contents downstream of where the sample will be collected.

Step 2 – Sample Collection

- Lower the bucket into the stream to obtain a surface grab sample.
- Remove the bucket from the stream.
- Fill the required sample bottles.

3.2.0 Sampling Pole

The pole must be inspected to ensure it is clean and all parts are working properly. Prior to sampling, ensure the bottle is properly attached and snapper band is securely fastened. Once pole is extended, verify that the locking mechanism is secured.

3.2.1 Decontamination Procedures

The sampling pole and bottle attachment must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the entire pole with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the entire pole with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Blank Water Rinse

- Rinse the bottle attachment with blank water.
- Discard blank water.
- Repeat Step 2.

3.2.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – Sample Collection

- Attach a clean unpreserved bottle onto the pole.
- Lower the bottle into the stream to obtain a surface grab sample.
- Make sure the bottle does not touch the bottom of the stream and try to avoid floating debris entering the bottle.
- Remove the bottle from the stream.
- Repeat as necessary to fill the required sample bottles. (Attempt to proportional divide the sample volume equally between sample bottles in order to average out any temporal variations.)
- Detach the bottle from the pole and:
  - a) If using a sample bottle, place in the cooler.
  - b) If using a transfer bottle, discard when finished.

3.3.0 Kemmerer Sampling Bottle

Prior to sampling, the Kemmerer must be inspected to ensure that the triggering mechanism is functioning properly, and that the nylon rope is not torn or frayed.

3.3.1 Decontamination Procedures

The Kemmerer must be cleaned before each sample is collected.

Step 1 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the Kemmerer thoroughly with the chemical.
- Purge a small amount of the chemical from the drain valve into the waste container.
- Open the top and discard the remaining chemical into the waste container.
- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve into the waste container.
- Open the top and discard the remaining blank water into the waste container.

Step 2 – Blank Water Rinse

- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve.
- Discard the remaining blank water.
- Repeat Step 2.

3.3.2 Sample Collection Procedures

Discrete water column grab samples (most often used for deep water sampling from a boat) are collected using the following procedures.

Step 1 – River Rinse

- Open the Kemmerer bottle.
- Rinse the Kemmerer with river water by submerging it into the stream at the collection site.
- Remove the Kemmerer from the stream.

Step 2 – Sample Collection

- Lower the Kemmerer to the appropriate depth (utilize the boat fathometer to determine mid-depth and bottom depth).

  a) Surface – Lower the Kemmerer to a depth of approximately one-foot below the surface.
  b) Mid-Depth – Lower the Kemmerer to the appropriate depth.
  c) Bottom – Lower the Kemmerer to a depth of approximately two-feet from the bottom (If Kemmerer contacts bottom sediment, repeat decontamination procedures before sample collection).

- Activate the closing mechanism of the Kemmerer to acquire sample volume.
- Remove the Kemmerer from the stream.
- Purge a small amount of sample volume from the drain valve.
- Fill the required sample bottles.

3.4.0 Churn Sample Splitter

Prior to sampling, the churn sample splitter must be inspected to ensure that is in good condition, and that it is functioning properly.

3.4.1 Decontamination Procedures

The churn sample splitter must be cleaned before sub-samples are homogenized. In addition, the appropriate sample collection device must also be cleaned (stainless steel bucket – 3.1, sampling pole – 3.2 or Kemmerer – 3.3).

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the plunger and the inside of the churn splitter with an Alconox detergent solution (blank water).
- Purge a small amount of the wash solution from the spigot.
- Discard the remaining detergent solution.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Weak Acid (Optional)

- Rinse the plunger and the inside of the churn splitter thoroughly with the chemical.
- Purge a small amount of the chemical from the spigot into the waste container.
- Discard the remaining chemical into the waste container.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot into the waste container.
- Discard the remaining blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat Step 3.

3.4.2 Sample Collection Procedures

Sub-samples (vertical or horizontal), obtained with a stainless steel bucket, sampling pole or Kemmerer bottle are homogenized into composite samples using the following procedures.

Step 1 – River Rinse

- River rinse by filling the churn splitter with the sampling device at the collection site.
- Purge a small amount of the stream water from the spigot.
- Discard the remaining contents.

Step 2 – Sample Collection

- Obtain sub-samples following either stainless steel bucket, sampling pole, or Kemmerer collection procedures.
- Fill the churn splitter with approximately equal volumes from each sub-sample.

Step 3 – Homogenizing Sub-samples

- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.0.0 Quality Assurance
Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1.0 Duplicate Samples
To collect duplicate grab samples fill the required bottles from the same stainless steel bucket, sampling pole, or Kemmerer. To collect duplicate composite samples fill the required bottles from the Churn Splitter sample volume.

4.2.0 Blanks
Blanks should be collected during each day of the survey. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blanks
Pour blank water from an unopened container directly into the sample bottle.

4.2.2 Equipment Blanks
Equipment blanks should be collected at the beginning and end of each survey day.

Stainless Steel Bucket

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the stainless steel bucket with enough blank water to fill the sample bottles.
- Fill the required sample bottles.

Sampling Pole

- The method for this device does not require a blank.

Kemmerer Bottle

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the Kemmerer with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the Kemmerer.
- Fill the required sample bottles.

Churn Sample Splitter

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the appropriate collection device (Kemmerer or stainless steel bucket) with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the appropriate collection device.
- Pour the blank water from the collection device into the churn splitter.
- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.2.3 Trip Blanks (Optional)
Depending on study design, a trip blank may be utilized. This is a sample of RGDI water taken from the laboratory to the sampling site and returned to the laboratory unopened.

5.0.0 Chain of Custody Procedures
All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

Attachment 1
Collection of Unpreserved Parameters Utilizing the Glove Method

Introduction
This attachment describes the procedures for the collection of grab samples into unpreserved bottles utilizing the glove method. This method has been implemented to eliminate the use of sampling equipment (i.e. stainless steel bucket or Kemmerer) for collecting surface samples. The elimination of equipment reduces cleaning procedures and possible sources of contamination. In addition, this method significantly reduces sampling time.

1.0 Field Equipment
The following equipment is needed to implement the Glove Method collection technique.

- Disposable Gloves
- Sterilized Unpreserved Sample Bottles
- Cooler and Ice
- Permanent Marker (Sharpie)
- 1 Gallon Container of Blank Water (Distilled or RGDI)
- Anti-Bacteria Soap
- Knife

2.0 Preparation
Before collecting the sample, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative and the name of the collecting entity and crew member) using a permanent marker and affix the label to the bottle. Ideally, the label is filled out (except data and time) and attached to the sample bottle before the sampling event occurs. In addition to the sample label, identify the lid of the bottle with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers may be wiped down or washed with a mild soap and thoroughly rinsed if they have any contaminants present.

The sampler's hands should be washed with anti-bacteria soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the bottle or lid.

3.0 Procedures
Keep sample bottles closed until they are to be filled. At the collection site, the sampler will wear a new set of gloves and detach the lock mechanism from the lid. Fill the bottle by holding the bottle upright and plunging it into the stream directed toward the current. Keep the lid closed (so as not to lose the dechlorination tablet) until you have reached a depth of 6 to 12 inches below the surface. When the sample is collected, leave ample air space in the bottle to facilitate mixing by shaking. Avoid placing the sample bottle in contact with the streambed or bank. If sampling from a boat or structure, collect the sample from the upstream side.

Fill the bottle to the appropriate level (if more water is collected than needed, carefully pour out the excess) and properly close the lid. If taking a bacteria sample shake the bottle for 30 seconds to expedite dissolving the dechlorination tablet.

After the sample is collected and sealed, the sample bottle should be placed in a cooler and covered with crushed ice. A new set of sterile gloves will be worn for each sample collected.

4.0 QA Samples
Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1 Duplicate Samples
To collect duplicate samples, plunge bottles into the river and fill one immediately after another.

4.2 Blanks
Blanks should be collected at the completion of each survey day. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blank
Pour blank water from an unopened gallon container directly into the sample bottle.

4.2.2 Method Blank
With a clean pocketknife, cut off the top of the container used for the first field blank. Simulate stream collection by plunging the bottle, while wearing gloves, into the cut open gallon container. Keep the bottle upright and let the water flow over the top of the bottle until it is filled.

5.0 Chain of Custody Procedures
All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

If the sample bottles used have a tie, this tie must be cut in order to open the bottle, and should provide a measure of sample security and integrity.

6.0 Reference
USEPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA/600/8-78/017.

Attachment 2
Collection of Orthophosphate Samples

Introduction
This attachment describes the additional procedures needed for the collection of orthophosphate samples.

1.0 Additional Field Equipment
The following additional equipment is needed to implement the orthophosphate filtration method.

- Disposable 60cc Syringes (Luer-Lok tip)
- Disposable 25 mm Filter Cartridges (1μm Glass Fiber Filter and 0.45μm Nylon Membrane Filter)
- Sample Bottles

2.0 Procedures
A new disposable syringe and filter cartridge (syringe filtration unit) will be used for each sample.

2.1 Decontamination Procedures
The syringe filtration units must be cleaned before each sample is filtered.

Step 1 - Blank Water Rinse
- Rinse the inside of the syringe by plunging 50mls of blank water through the housing.
- Attach the filter cartridge to the syringe.
- Rinse the inside of the entire unit by plunging 50mls of blank water through the unit.

2.2 Sample Collection Procedures
Samples can be filtered from the Kemmerer bottle, sampling pole, stainless steel bucket, or churn splitter using the following procedures.

Step 1 – Sample Filtration/Collection

Fill the syringe filtration unit with sample from the appropriate collection device.
Place the plunger into the syringe.
Purge a small amount of sample volume through the filter.
Discharge water through the filtration unit into a sample bottle.
Repeat the previous three bullets until enough sample has been filtered into the sample bottle.
Discard the syringe filtration unit.

3.0 Quality Assurance

Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

3.1 Duplicate Samples

To collect duplicate samples continue to fill the syringe filtration unit from the same Kemmerer, sampling pole, or stainless steel bucket drop and filter into the required bottles.

3.2 Blanks

Blanks should be collected during each day of the survey. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.2.1 Field Blanks

Pour blank water from an unopened container directly into the sample bottle.

3.2.2 Equipment Blanks

Equipment blanks should be collected at the beginning and end of each survey day.

Unfiltered Equipment Blank

An equipment blank utilizing the appropriate collection device should be collected at the beginning of each survey day.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the required sample bottle.

Filtered Equipment Blank

An equipment blank utilizing the syringe filtration unit should be collected at the end of each survey day. The syringe filtration unit is decontaminated using the previously outlined procedure before the blank is collected.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the syringe filtration unit with sample from the appropriate collection device.
- Place the plunger into the syringe.
- Purge a small amount of blank water through the filter.
- Discharge water through the filtration unit into a sample bottle.
- Repeat the previous three bullets until enough volume has been filtered into the sample bottle.
- Discard the syringe filtration unit.

Standard Operating Procedures

for

Hydrolab Series 5
Water Quality Instrumentation

Sanitation District No. 1 of Northern Kentucky
1045 Eaton Drive
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Revision Number: 1
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Introduction
This document contains information and directions on using Hydrolab water quality instrumentation (DS5 Water Quality Multiprobe and Surveyor® 4a Water Quality Data Display). This standard operating procedures document (SOP) has been developed to maintain properly functioning equipment, and to ensure the quality of the data collected.

1.0.0 Instrumentation Maintenance
The following procedures are to be utilized to maintain the Hydrolab instrumentation.

1.1.0 DS5 Multiprobe
The outside housing of the sonde should be kept free of sediments, bio-films, oils, etc. by cleaning with soap and water. The storage cup must be installed (filled with tap water) at all times when the unit is not in use to protect the sensors from damage and from drying out. Refer to section 6.1.1 of the *DS5 User's Manual*. The unit's operating range is 23°F to 122°F (-5°C to 50°C). Exposure of the unit to temperatures outside of this range may result in mechanical or electronic damage. Refer to section 5.1.2 of the *DS5 User's Manual*. The DS5 contains an internal lithium system battery that is good for approximately two years. Refer to section 6.2.3 of the *DS5 User's Manual* for replacement procedures.

1.1.1 Temperature Sensor
The temperature sensor should be kept clean from deposits, otherwise it does not require any scheduled maintenance. Refer to section 6.9 of the *DS5 User's Manual*.

1.1.2 Luminescent Dissolved Oxygen (LDO) Sensor
LDO sensor is not affected by fouling or other debris, unless the growth is an organism that locally consumes or produces oxygen, such as barnacles, or algae growing on the sensor cap. Nevertheless, the manufacturer recommends periodic maintenance to remove contaminates such as oil, biological growth, dirt, etc. Sensor maintenance should be conducted after every deployment cycle. Refer to the Instruction Sheet – **Hach LDO Sensor** in the *DS5 User's Manual*. Yearly maintenance of the sensor should include the replacement of the sensor cap.

1.1.3 pH Sensor
The pH reference electrolyte and porous reference junction should be replaced at least twice a year. Refer to section 6.8 of the *DS5 User's Manual* for these procedures. The pH glass electrode can be generally cleaned with a cotton ball/"Q" tip using mild detergent and water; while a cotton ball/"Q" tip with methanol can be used to remove any oil, sediment or biological growth on the glass, as needed. Once maintenance has been performed on the sensor, the sensor should re-equilibrate for approximately 12 hours in tap water before it is calibrated, especially if methanol has been used. If the 12-hour re-equilibrate period cannot be met, record the estimated re-equilibrate time in the Comments section of the Sanitation District No.1 Multiprobe Instrumentation Calibration & QA Sheet and note if stable "instream" readings are achievable before calibration.

1.1.4 Conductivity Sensor
The annular rings inside the slot in the sensor housing of the conductivity sensor should be cleaned with a small bottle brush using a mild detergent and water, as needed. Methanol and a cotton swab should be used to remove any films or deposits on the electrodes. Refer to section 6.6 of the *DS5 User's Manual* for these procedures.

1.1.5 Self –Cleaning Turbidity Sensor
The self-cleaning turbidity sensor offers higher accuracy turbidity measurements and a wiper mechanism to reduce the effects of fouling. An internal motor automatically wipes the optical face at the start of every measurement. Turbidity sensor maintenance is required when any of the optical surfaces have a coating, or when a zero check using Hach StablCal <0.1 reads>0.9 NTU. Refer to the Instruction Sheet – **Self-Cleaning Turbidity Sensor** in the *DS5 User's Manual*. During unattended deployment, the turbidity wiper should be replaced every 3 months, or as needed (a gap should not be present between the wiper and the lens after reattachment).

1.1.6 Depth Sensor
The depth sensor generally does not need maintenance. If deposits (calcium, biological growth, etc.) begin forming in the port rinse with a very weak acid, such as acetic. Refer to the Sensor Specific Instruction Sheet of the *DS5 User's Manual*.

1.1.7 Circulator
The circulator is used during deployment to ensure adequate flow across the sensors for reliable readings. Refer to section 6.1.3 of the *DS5 User's Manual*.

1.1.8 Internal Battery Power
The DS5 contains an optional internal battery pack that is installed during manufacturing that consists of 8 "C" alkaline batteries that provide 12 volts when fully charged. When the battery pack becomes exhausted (below 6.4 volts) the batteries should be replaced in order for the logger to continue unattended monitoring. Refer to section 6.2 of the *DS5 User's Manual* for replacement procedures. The DS5 also contains an internal lithium system battery that is good for approximately two years. Refer to section 6.2.3 of the *DS5 User's Manual* for replacement procedures.

1.2.0 Surveyor® 4a Data Display
The data display should be protected from mechanical shock and excessive vibrations. The unit's operating range is 23°F to 122°F (-5°C to 50°C). Exposure of the unit to temperatures outside of this range may result in mechanical or electronic damage. Refer to section 3.1 of the *Surveyor 4 User's Manual* for maintenance and cleaning procedures.

1.2.1 Surveyor® 4a Internal Battery Power
The Surveyor 4a contains an internal 7.2-volt rechargeable nickel metal hydride battery. The battery power is exhausted at 6.5 volts and should be recharged for approximately 3.5 hours to ensure a full charge. The Surveyor 4a also contains an internal lithium system battery that is good for approximately two years. Refer to section 3.1 of the *Surveyor 4 User's Manual* for charging and replacement procedures.

1.2.2 Internal Barometer
The barometric pressure sensor does not require any scheduled maintenance. The sensor should be calibrated every six months and checked monthly with an accurate mercury barometer or the barometric pressure provided by the local weather service, corrected to site altitude. Refer to appendix 3 of the *Surveyor 4 User's Manual*.

1.3.0 External Rechargeable Battery Pack
The external rechargeable battery pack provides 12 volts when fully charged. The battery pack is exhausted below 9 volts and should be recharged for 12 hours to ensure a full charge. To prevent "charge memory", recharge the battery pack only when the battery power is exhausted. Refer to section 3.3 of the *DS5 User's Manual*.

1.4.0 Cables
Cables should be kept clean and protected from abrasion, unnecessary tension, repetitive flexure (fatigue), and bending over sharp radii (such as a bridge railing). Connections that plug into terminals are not waterproof and should be kept dry at all times. When cables are not in use, be sure to insert all dummy plugs and dust caps to protect the electrical connectors. Refer to section 6.3.2 of the *DS5 User's Manual*.

1.5.0 Flow Cell
The pressure in the flow cell should not exceed 15psi. Refer to section 5.2.5 of the *DS5 User's Manual*.

2.0.0 Instrumentation Setup
Communication to the *DS5* for setup or calibration can be established via the *Surveyor 4a* or a computer using Hydras 3LT software. The following settings should be configured for normal operation.

2.1.0 Parameter Display
For routine monitoring the following parameter display should be utilized. Refer to section 4.1 of the *DS5 User's Manual.*

- Date/Time Format – MDY/HMS
- Temperature – Celsius
- LDO – mg/L
- LDO – Percent Saturation
- pH – units
- Specific Conductance – μS/cm
- Turbidity – NTU
- Depth25 – Feet
- Battery – Choose appropriate display (internal vs. external and/or volts vs. % remaining)
- Radix – Decimal Point
- Interval – 000001

2.2.0 Parameter Setup
For routine monitoring, the following sensor setup should be utilized. Refer to section 4.1 of the *DS5 User's Manual.*

- Specific Conductance – mS/cm, Fresh Water Temperature Compensation, Autorange
- Salinity – ppt, Method 2311

2.2.1 Using the Surveyor for Parameter Setup
Refer to section 4.1.1 of the *DS5 User's Manual.*

2.2.2 Using Hydras 3 LT for Parameter Setup
Refer to section 4.1.2 of the *DS5 User's Manual.*

2.2.0 System Setup
For routine monitoring the following system setup should be utilized. Refer to *DS5 User's Manual* for additional information.

- Circulator – On during use, Off during calibration
- Audio – Off during normal profiling use, On during logging runs
- Terminal Baud Rate – 19200
- Autolog – Off during normal profiling use, On during logging runs

2.3.0 SDI-12 Setup
For SDI-12 communications with an external data logger the following setup should be utilized. Refer to **Appendix B External Communications** of the *DS5 User's Manual.*

- SDI Address – 1
- SDI Delay – 120 (Note: multiprobe has 5 second built in delay, thus actual delay = 125)

3.0.0 Instrumentation Calibration

Refer to section 4.2 of the *DS5 Users Manual* for sensor calibration procedures. The multiprobe and the standards must be at thermal equilibrium before the calibration procedures are performed. If a stand is used to hold the sonde during calibration, secure the sonde only around the end caps, **never** around the housing. Use either distilled or deionized water as rinse water during the calibration procedures. The multiprobe should be calibrated and post checked after each use to track any electronic drift. Record all calibration information on the Sanitation District No.1 Multiprobe Instrumentation Calibration & QA Sheet – Attachment A.

3.1.0 Procedures

Multiprobe calibration is performed using the stated procedures for each parameter as described. If calibration fails, refer to the appropriate section under Multiprobe Maintenance, Section 6.1 of the *DS5 User's Manual.* After performing the recommended maintenance, reattempt the calibration procedure.

The multiprobe sensor accuracy for each parameter (utilizing certified standards) is stated as follows:

LDO: ± 0.1 mg/L (0 - 8 mg/L)	Conductivity: ± 1% of reading (± 10 µS/cm for a 1000 standard)
± 0.2 mg/L (>8 mg/L)	Turbidity: ± 1 % (0 - 100 NTUs)
pH: ± 0.2 units	± 5 % (400 – 3,000 NTUs)

3.2.0 Temperature

The temperature sensor is factory-set and does not require further calibration. Refer to section 4.2.4 of the *DS5 User's Manual*. The accuracy of the sensor is ± 0.1°C.

3.3.0 Luminescent Dissolved Oxygen (LDO)

There are three standard methods for calibrating the LDO sensor. Each method requires a single point calibration for measurement of concentration in mg/l. In order to calibrate the sensor for percent saturation reading, the local barometric pressure (corrected to local altitude above sea level) must be determined independently by the user and input into the software during calibration. Once calibrated, the sensor reading is verified to an oxygen solubility calculation as a QA/QC check. Refer to the Sanitation District No.1 Multiprobe Instrumentation Dissolved Oxygen Calibration Technical Sheet (Attachment B) for the elevation correction factors and the oxygen solubility calculation. In order to retain calibration accuracy between multiple deployments, store with sensor fully immersed in water at all times. Calibration will be completed by using of Method 1 – **Air Saturated Water.** Refer to the Instruction Sheet **– Hach LDO Sensor** in the *DS5 User's Manual*.

3.4.0 pH

Refer to section 4.2.8 of the *DS5 User's Manual* for pH calibration procedures. Since in-stream pH levels are generally above 7.0, the pH sensor is calibrated using a standard of 10.0 to determine the slope. If levels below 7.0 are expected, calibrate using a standard of 4.0 to determine the slope.

3.5.0 Conductivity

Refer to section 4.2.5 of the *DS5 User's Manual* for specific conductance calibration procedures. Since in-stream conductivity concentrations are generally below 1000µS/cm the specific conductance sensor is calibrated using a standard of 1000µS/cm to determine the slope. If lower concentrations are expected, calibrate using a standard of 500µS/cm to determine the slope.

3.6.0 Turbidity

Refer to the Instruction Sheet **– Self-Cleaning Turbidity** Sensor in the *DS5 User's Manual* for turbidity calibration procedures. Since in-stream turbidity readings can be highly variable the turbidity sensor is calibrated using a standard of 800 NTUs to determine the slope. If the sensor fails to properly calibrate, reset the sensor.

3.7.0 Depth
Refer to the **Sensor Specific Instruction Sheet** of the *DS5 User's Manual* for depth calibration procedures. The depth sensor is zeroed in air at the monitoring site to account for the current barometric pressure.

3.8.0 Time
Refer to the **Sensor Specific Instruction Sheet** of the *DS5 User's Manual* to enter the correct time (HHMMSS) and date (MMDDYY).

3.9.0 Quality Assurance/Quality Control
The following procedures are to be utilized to preserve and maintain QA/QC for the calibration of the Hydrolab instrumentation.

3.9.1 QA Standards
Calibration standards may be reused between calibration periods by employing procedures that prevent contamination. Only the quantity of standard used during the actual sensor calibration is saved for reuse. The quantity of standard used for the sensor rinse should always be discarded. Refer to the appropriate calibration section for each sensor in the *DS5 User's Manual.* Standard that is retained for reuse is kept in clean polyethylene bottles with Teflon sealed caps. Used standard is never remixed with the certified standard in the original container. Fresh or "certified" standard is continually added to the polyethylene bottles during the calibration steps to replenish the quantity used for the sensor rinses.

The standards original container is identified with date received and date opened using a permanent marker. Standards that have exceeded the manufacturer's expiration date are discarded.

3.9.2 QC Calibration Sheets
Calibration sheets are retained as quality control records and are reviewed to address individual multiprobe/sensor issues that may arise, such as electronic "drift".

4.0.0 Data Logging Setup & Data Retrieval
Refer to Section 4.3.3.1 & 4.3.3.2 of the *DS5 User's Manual* for logging and data retrieval.

4.1.0 Logging Setup
Before the DS5 is setup for an unattended logging run, check the logging status in regards to available memory and remove any nonessential files, if needed. In addition, make sure the status of the audio, circulator, and enabled parameters are correct before the logging run is setup. Enable Autolog if desired.

Make sure the DS5 is correctly deployed before the logging run begins.

4.2.0 Retrieval
Once the DS5 has been retrieved from an unattended logging run, check the logging status in regards to the created log file. The log file should be transferred from the DS5 as soon as practicable (refer to Section 4.3.3.2 of the *DS5 User's Manual*). Transfer the log file from the DS5 to a computer in spreadsheet importable form by utilizing the Hydras 3LT software (when specifying a file name for the transfer, save the log file with a .csv extension, this will allow the log file to be directly opened in Microsoft Excel).

5.0.0 Attended Profiling
The DS5 can be utilized for discrete profiling at different stream depths or equipped with a flow cell for continuous profiling (e.x. surface profiling on a boat utilizing a pitot tube) or pumping.

5.1.0 Quality Assurance
- The unit should be recalibrated after each use to assess sensor drift.
- The unit should be cleaned periodically to maintain sensor performance.

6.0.0 Unattended Deployment

The DS5 can be positioned upright (probes pointing down) or horizontally for deployment. Avoid placing the unit in areas of swift currents, areas that might receive deep deposits of sediment during periods of heavy rainfall, or areas where potential vandalism may occur. Attempt to use any available protection that a site may provide (e.x. attach to downstream of bridge piling to protect from floating debris).

6.1.0 Temporary/Portable Installations

PVC piping can be utilized as a protective capsule to house the multiprobe at unsecured locations.

6.1.1 Specifications

- Cut 4" diameter PVC pipe to the desired length (approximately 3') to create protective sleeve.
- Drill approximately 1" diameter holes throughout the sleeve to allow adequate water flow through the capsule.
- Drill approximately 3/4" diameter holes throughout the top of the end caps.
- Glue one end cap to the bottom of the sleeve.
- Place the other end cap on the open end of the sleeve and drill 5/8" hole through the end cap and the sleeve.
- Place a ½" bolt through the end cap and the sleeve and secure with two nuts.

6.1.2 Deployment

- Wrap the DS5 with duct insulation (keeping away from the probes).
- Place the DS5 into the PVC capsule (probes pointing down).
- Place the top end cap on the PVC capsule and align the 5/8" holes.
- Suspend the DS5 inside of the PVC capsule with the ½" bolt passing through the capsule and the DS5 bail.
- Secure the PVC capsule to an appropriate structure with heavy-duty cables and locks.

6.1.3 Quality Assurance

- The unit should be cleaned and recalibrated at least once a week depending on water quality conditions (i.e. solids loading and biological growth – bio-films).
  - Download the logging file and check the battery status.
  - Clean and recalibrate the sensors.
  - Setup the next logging file.
- Use portable unit to check permanent station readings before and after calibration.
- Use portable unit to check temporary station readings (logged data) between calibration schedules to assess sensor drift.

7.0.0 References

Hydrolab DS5X, DS5, and MS5 Water Quality Multiprobes, User Manual. February 2006 Edition 3. Hach Company.

Surveyor® 4 Water Quality Data Display, User's Manual. Revision D. Hydrolab Corporation. April 1999.

Hydras 3 LT Quick Start, Software Manual. December 2005 Edition 2. Hach Company.

Attachment A: SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION CALIBRATION & QA SHEET

Instrument Model ______________ Serial Number ______________
Date ________ Analyst(s) ________ Instrument I.D. ______________
Site Location ______________ Note ______________

CALIBRATION READINGS	POST CHECK READINGS
1) Dissolved Oxygen (DO) Elevation (ft) ⇒ Correction Factor ______ Uncorrected BP Conversion (mmHg) ______ Temperature (°C) ______ Probe DO Reading (mg/L) ______ Percent Saturation ______ O_2 Solubility Calculation (mg/L) ______ Comments: Air Saturated Water	1) Dissolved Oxygen (DO) Elevation (ft) ⇒ Correction Factor ______ Uncorrected BP Conversion (mmHg) ______ Temperature (°C) ______ Probe DO Reading (mg/L) ______ Percent Saturation ______ O_2 Solubility Calculation (mg/L) ______ Comments: ______
2) Conductivity Standard (µS/cm) — Reading — Adjusted ______ ______ ______ ______ ______ ______ Comments: Specific Conductance	2) Conductivity Standard (µS/cm) — Reading ______ ______ ______ ______ Comments: Specific Conductance
3) pH Buffer — Reading — Adjusted 4.00 ______ ______ 7.00 ______ ______ 10.00 ______ ______ Comments: ______	3) pH Buffer — Reading 4.00 ______ 7.00 ______ 10.00 ______ Comments: ______
4) Turbidity Standard (NTU) — Reading — Adjusted ______ ______ ______ ______ ______ ______ Comments: ______	4) Turbidity Standard (NTU) — Reading ______ ______ ______ ______ Comments: ______

NOTE: Do NOT make adjustments during Post Check. Simply record values observed.

Attachment B: SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION DISSOLVED OXYGEN CALIBRATION TECHNICAL SHEET

Pressure Conversions

1. Inches to Metric Conversion
   1in = 25.4mm
   Example: 30.15in * (25.4mm/1in) = 765.8mm

2. Corrected to Uncorrected Pressure Conversion
   Obtain the corrected pressure from the National Weather Service.
   Corrected Pressure - (2.5 * (Elevation/100)) = Uncorrected Pressure
   Example: 765.8mm - (2.5 * (455/100)) = 754.4mm

Table 1: Barometric pressure correction factors for selected monitoring sites.

Stream	Site	Gage Datum	Correction
Banklick Creek	KY Route 1829	540.3	13.5
Cruises Creek	KY Route 17	656.9	16.4
Elijahs Creek	Elijahs Creek Road	759.1	19.0
Four Mile Creek	Popular Ridge Road	535.2	13.4
Gunpowder Creek	Camp Ernest Road	683.1	17.1
Mud Lick Creek	KY Route 14	487.7	12.2
Twelve Mile Creek	KY Route 1997	505.9	12.6
Woolper Creek	Woolper Road	490.7	12.3

Note: Gage Datum = feet above mean sea level
Note: Correction = mm Hg

Table 2: Barometric pressure correction factors for selected sites.

Stream	Site	Elevation	Correction
Ohio River	Markland Normal Pool	455	11.4
Licking River	12th Street	460	11.5
District Office	Prep Room	505	12.6

Note: Elevation = approximate feet above mean sea level
Note: Correction = mm Hg

SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION
DISSOLVED OXYGEN CALIBRATION TECHNICAL SHEET

Oxygen Solubility Calculation

To verify the probe DO reading, utilize the following steps.

1. Determine the DO solubility of the standard's temperature at 760mm
   Example: Stable Temperature = 20.7°C
   From Table 2 -- 20.7°C at 760mm = 8.96mg/L

2. Determine the DO solubility of the standard's temperature at the current pressure
   Example: 20.7°C, 754.4mm Hg
   DOsol(760mm Hg) * Current Pressure / 760mm Hg
   = DOsol(Current Pressure)
   8.96 * (754.4/760) = 8.89mg/L

Table 2: Solubility of oxygen in water in equilibrium with air at 760mm Hg pressure and 100% relative humidity (EAWAG 1973). Units = mg/L

(°C)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	14.60	14.56	14.52	14.48	14.44	14.40	14.36	14.33	14.29	14.25
1	14.21	14.17	14.13	14.09	14.05	14.02	13.98	13.94	13.90	13.87
2	13.83	13.79	13.75	13.72	13.68	13.64	13.61	13.57	13.54	13.50
3	13.46	13.43	13.39	13.36	13.32	13.29	13.25	13.22	13.18	13.15
4	13.11	13.08	13.04	13.01	12.98	12.94	12.91	12.88	12.84	12.81
5	12.78	12.74	12.71	12.68	12.64	12.61	12.58	12.55	12.52	12.48
6	12.45	12.42	12.39	12.36	12.33	12.29	12.26	12.23	12.20	12.17
7	12.14	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90	11.87
8	11.84	11.81	11.78	11.76	11.73	11.70	11.67	11.64	11.61	11.58
9	11.56	11.53	11.50	11.47	11.44	11.42	11.39	11.36	11.34	11.31
10	11.28	11.25	11.23	11.20	11.17	11.15	11.12	11.10	11.07	11.04
11	11.02	10.99	10.97	10.94	10.91	10.89	10.86	10.84	10.81	10.79
12	10.76	10.74	10.72	10.69	10.67	10.64	10.62	10.59	10.57	10.55
13	10.52	10.50	10.47	10.45	10.43	10.40	10.38	10.36	10.34	10.31
14	10.29	10.27	10.24	10.22	10.20	10.18	10.15	10.13	10.11	10.09
15	10.07	10.04	10.02	10.00	9.98	9.96	9.94	9.92	9.89	9.87
16	9.85	9.83	9.81	9.79	9.77	9.75	9.73	9.71	9.69	9.67
17	9.65	9.63	9.61	9.59	9.57	9.55	9.53	9.51	9.49	9.47
18	9.45	9.43	9.41	9.39	9.37	9.36	9.34	9.32	9.30	9.28
19	9.26	9.24	9.23	9.21	9.19	9.17	9.15	9.13	9.12	9.10
20	9.08	9.06	9.05	9.03	9.01	8.99	8.98	8.96	8.94	8.92
21	8.91	8.89	8.87	8.86	8.84	8.82	8.81	8.79	8.77	8.76
22	8.74	8.72	8.71	8.69	8.67	8.66	8.64	8.63	8.61	8.59
23	8.58	8.56	8.55	8.53	8.51	8.50	8.48	8.47	8.45	8.44
24	8.42	8.41	8.39	8.38	8.36	8.35	8.33	8.32	8.30	8.29
25	8.27	8.26	8.24	8.23	8.21	8.20	8.18	8.17	8.16	8.14
26	8.13	8.11	8.10	8.08	8.07	8.06	8.04	8.03	8.01	8.00
27	7.99	7.97	7.96	7.94	7.93	7.92	7.90	7.89	7.88	7.86
28	7.85	7.84	7.82	7.81	7.80	7.78	7.77	7.76	7.74	7.73
29	7.72	7.70	7.69	7.68	7.66	7.65	7.64	7.63	7.61	7.60
30	7.59	7.57	7.56	7.55	7.54	7.52	7.51	7.50	7.49	7.47

APPENDIX B

NORTHERN KY SANITATION DISTRICT NO.1
CHAIN OF CUSTODY

SANITATION DISTRICT NO.1 OF NORTHERN KENTUCKY
1045 Eaton Drive
Fort Wright, KY 41017
Phone: (859)578-7460   Fax: (859)331-2436

Chain Of Custody Record

Page ______ of ______

Project Name	**Watershed**	**Survey Location**

Contact Person	**Sampler(s) Signature**	**Survey Type (Circle One)** Wet or Dry	

Lab ID	Sample ID Code	Date	Time	Composite / Grab	Pole / Bucket / Glove	Sample Location	No. of Containers	Analysis Required									Remarks
								E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate					

Relinquished By: Sampler	Date	Time	Accepted By: Lab Runner	Date	Time	Remarks
Relinquished By: Lab Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

APPENDIX C

NORTHERN KY SANITATION DISTRICT NO.1
FIELD DATA SHEET

SANITATION DISTRICT NO.1 FIELD DATA SHEET

PROJECT NAME: ______________________ DATE: ______________________

SITE / STREAM NAME: ______________________ START TIME: ______________________

SITE LOCATION: ______________________ END TIME: ______________________

LABORATORY: ______________________ SAMPLERS: ______________________

SAMPLE TYPE

GRAB COMPOSITE

CIRCLE ONE

SAMPLE MATRIX

SEDIMENT WATER

CIRCLE ONE

EQUIPMENT ID: MULTIPROBE SONDE: ______________________

STREAM CONDITIONS: ______________________

SITE CONDITIONS: ______________________

WEATHER CONDITIONS: SUNNY CLOUDY OVERCAST WINDY RAIN SNOW AIR TEMP (F): ______

(CIRCLE APPROPRIATE CONDITIONS)

PROJECT DESCRIPTOR: ______________________

SITE / SAMPLE ID (BANK & DEPTH)	TEMP. (C)	pH	D.O. (mg/L)	SP. COND. (µS/cm)	TURBIDITY (NTU)	FLOW	SAMPLE TIME

FIELD OBSERVATIONS:

IF FOUND, RETURN TO:
SANITATION DISTRICT NO.1
1045 EATON DRIVE
FORT WRIGHT, KY 41017
(859) 578-7460

BIWEEKLY SAMPLING
FIELD MONITORING & SAMPLING PLAN
FOR NORTHERN KENTUCKY WATERSHEDS
2015-2017

Northern Kentucky Sanitation District No.1
1045 Eaton Drive
Fort Wright, KY 41017

2015

TABLE OF CONTENTS

Figures

Tables

Appendices

1. INTRODUCTION

Sanitation District No. 1 (SD1), a clean water agency that serves over 30 communities in Campbell, Kenton and Boone Counties, Kentucky, as both the wastewater and storm water utility, is implementing a watershed management approach to cost-effectively meet numerous regulatory requirements (e.g., Combined Sewer Overflow (CSO) Program and Municipal Separate Storm Sewer System (MS4) Program). Additionally, SD1 has entered into a Consent Decree (CD) with state and federal environmental regulators to address sanitary overflows in these communities. In complying with these regulatory requirements, SD1 is applying an adaptive approach for identifying impairments and prioritizing areas for action. This approach will help ensure that available resources are most effectively used. SD1 has developed an Adaptive Watershed Management Plan that identifies Watershed Characterization in sixteen sub watersheds to relate in-stream conditions to watershed characteristics. The results of this Watershed Characterization will be used to identify impaired watersheds and prioritize them for consideration of control alternatives.

SD1 initiated a comprehensive watershed wide monitoring program in 2006 that involved the collection of in-stream water quality data in each of the sixteen watersheds in Northern Kentucky to characterize background conditions in the region. These sixteen watersheds represent varying conditions with respect to the amount of development, as well as sources of stream pollution. The variation in the stream conditions can range from undeveloped watersheds that have been categorized as “exceptional” waters by the State, while other watersheds are more highly developed and are identified as “impaired” by the State. As a result of the vast differences between these watersheds, SD1 has implemented a biweekly sampling program over a two year period to further characterize stream conditions under a wide range of environmental conditions at 20 locations throughout Northern Kentucky.

The following biweekly sampling *Field Monitoring and Sampling Plan* (FMSP) is designed to ensure that all monitoring activities undertaken result in representative data necessary to support the characterization of the watershed being sampled.

Monitoring and sampling stations have been selected to provide appropriate coverage to meet the assessment and modeling needs of the watershed characterization process.

1.1 Program Overview

This FMSP describes the water quality monitoring program for the biweekly sampling of Northern Kentucky streams. The purpose of the FMSP is three fold:

- To supplement the Quality Assurance Project Plan (QAPP)

- To provide project and field staff with an understanding of the program and how to complete the base flow monitoring program; and,
- To define the level of effort and analytical needs.

The FMSP is intended to provide practical assistance in obtaining representative and reliable data in a technically sound and safe manner.

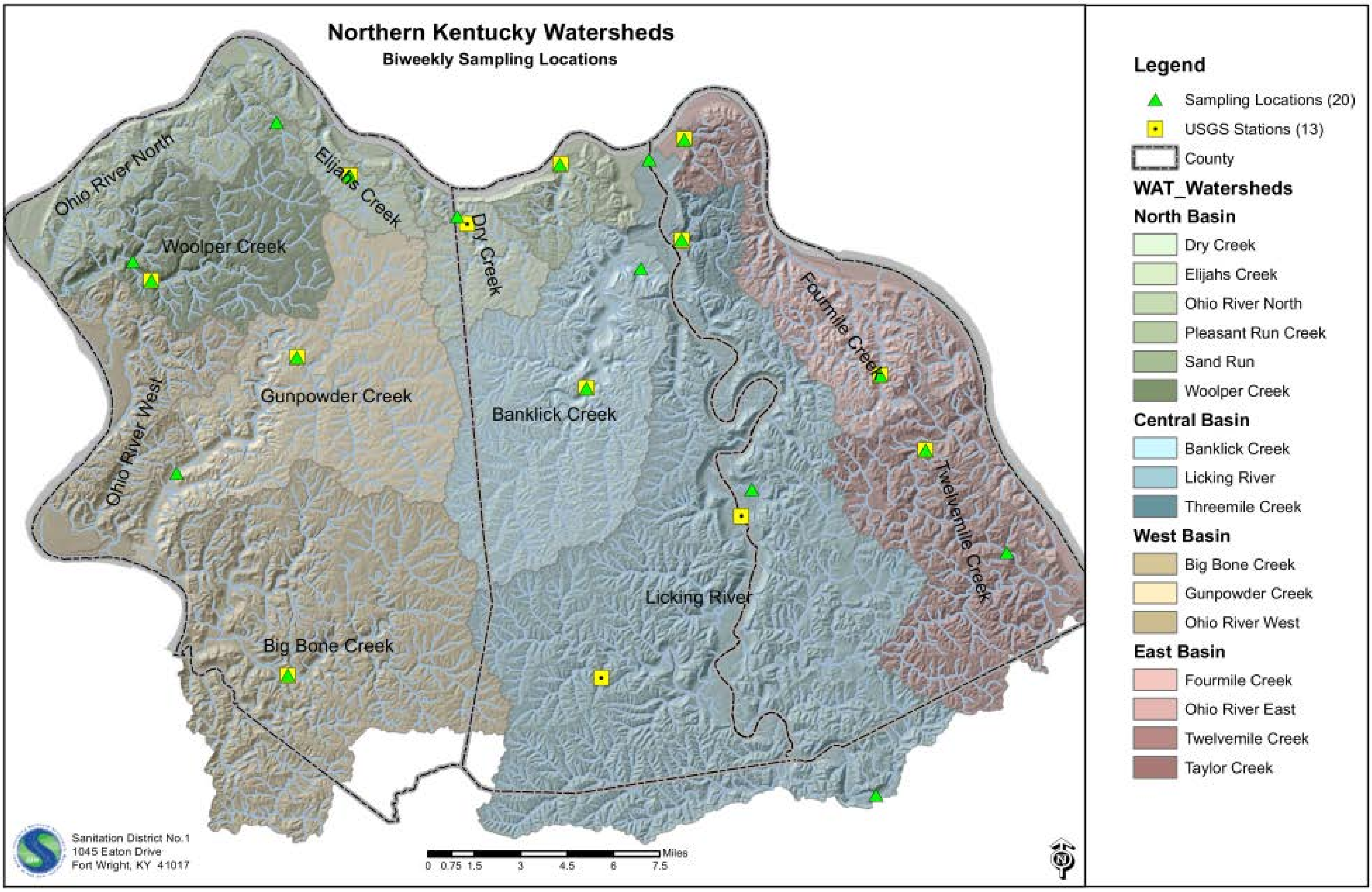
The procedures and protocols presented in this document address the following water quality and quantity monitoring program components:

- Monitoring and sampling criteria
- Stream water quality monitoring
- Sample handling and transportation
- QA/QC requirements
- Program Health and Safety

This program was designed to collect data that will be used to assess variation of water quality concerns identified in Northern Kentucky watersheds. The biweekly data collected in Northern Kentucky streams is required to support water quality modeling, and pollutant source identification. The monitoring and sampling program will be conducted from July 2015 - November 2015, April 2016 – November 2016, and April 2017 – June 2017.

Figure 1 shows locations in the watersheds of the Northern Kentucky area that have been identified as monitoring and sampling stations. The sampling locations shown in Figure 1 are discussed in more detail in Section 3.

Figure 1 Monitoring and Sampling Stations



1.2 Monitoring Team

The monitoring team consists of the Project Manager, the Field Manager, and sampling crew. Responsibilities of key team members are listed in Table 1.

Table 1 Team Member Responsibilities

Position	SD1 Team Member	Responsibilities
Project Manager	Mindy Scott	• Assess suitability of sampling events • Perform System Audits • Circulation of reports and results • Staff Training • Review Reporting • Ensure necessary resources are available • Creation of event reports • QA/QC review
Field Manager	Elizabeth Fet	• Implementation of FMSP • Initiate sampling events • Coordinate with laboratory • Mobilize field crews • Collection and review of field logs, lab results, and other program documentation • Ongoing management of field staff and equipment

Prior to the first sampling event, a flowchart will be created which contains all members of the different sampling crews and laboratory contacts along with their respective contact numbers (home, work, and/or cellular numbers). This will allow for a network of communication prior to and during the monitored events. A communication network for the sampling team is essential to the ability to adapt the sampling program to changing environmental or weather conditions and/or equipment malfunctions.

2. *MONITORING AND SAMPLING CRITERIA*

The objective of the biweekly monitoring and sampling program is to represent varying conditions with respect to the amount of development, as well as sources of stream pollution in each watershed. SD1 is implementing this program over a two year period to further characterize stream conditions under a wide range of environmental conditions.

The criteria used to define the biweekly weekly sampling include:

- Once sampling starts, it will occur every two weeks
- Weather conditions will vary, but sampling will be conducted unless deemed unsafe

The goal will be to conduct the sampling in varying weather conditions. The sampling will be distributed throughout the monitoring period by basin to characterize Northern Kentucky streams during fluctuating flow conditions.

Local conditions may require these criteria to be modified as the study progresses. Best professional judgment will be necessary to assess the suitability of a particular biweekly sampling event.

3. *STREAM CHARACTERIZATION*

Stream monitoring and sampling will be conducted at designated stations along Northern Kentucky streams as shown in Figure 1. Water quality monitoring and sampling will be conducted as follows:

- Samples will be collected at all sites on the designated day every other week according to the surface water quality monitoring program protocols;
- All sites will be characterized on-site for in-stream water quality measurements (temperature, dissolved oxygen, pH, conductivity and turbidity).

Table 2 describes each of the stations as depicted in Figure 1. Station selection was based on an initial watershed reconnaissance, which focused upon suitable site configuration for stream sampling and location relative to key pollutant source inputs. Once final sampling locations were identified, latitude and longitude coordinates were obtained with a Global Positioning System (GPS) unit and recorded.

Standard operating procedures (SOPs) referenced in the following sections are provided in Appendix A.

Table 2 Biweekly Monitoring Locations

Basin	Watershed/Sites	Locations	Description
Central	Licking (3)	LIR0.5	Fourth Street Bridge Covington, KY
		LIR35.5	Butler, KY
		POC0.9	Bridge on Indian Trace by Joann Lane
	Banklick (2)	BLC1.2	Route 16 Bridge Winston Ave
		BLC8.1	Richardson Road Bridge (USGS)
	Threemile (1)	THC0.7	Threemile Creek Road (USGS)
East	Fourmile (2)	FMC0.5	Silver Grove Pump Station Route 8
		FMC6.9	Poplar Ridge Road (USGS)
	Twelvemile (2)	TMC3.0	Route 1997 (USGS)
		TMC9.3	Intersection of Route 10 and California Cross
	Taylor (1)	TYC0.6	Donnermeyer Drive under 471 (USGS)
North	Woolper (2)	ASF0.0	Intersection of Ashby and Woolper Road
		WPC5.0	Woolper Road (USGS)
	Elijahs (1)	EJC2.8	Elijah Creek Road (USGS)
	Dry Creek (1)	DRC1.4	Dry Creek WWTP (USGS)
	Pleasant Run (1)	PRC0.3	Bridge on Oak Street (USGS)
	Sand Run (1)	SDR4.0	Thornwilde Subdivision
West	Gunpowder (2)	GPC4.6	Sullivan Road
		GPC14.7	Camp Ernst Road (USGS)
	Big Bone (1)	MLC3.0	Bridge at US 42 (USGS)
		20 total sites	

3.1 On-Site Water Quality Measurements

All sites will be subject to on-site measurements during sampling events. On-site measurements will include DO, pH, temperature, conductivity and turbidity.

On-site water quality instrumentation will be calibrated and maintained in accordance with *Standard Operating Procedures Hydrolab Series 5 Water Quality Instrumentation.*

3.2 Biweekly Sampling

Most sampling locations are accessible by bridges or by wading. Table 3 presents the monitoring schedule for the surface water sampling program for biweekly sampling. All sampling will be performed by SD1 staff. Biweekly samples will be collected as grab samples in accordance with *Standard Operating Procedures for the Collection of Discrete Water Samples.* Biweekly sampling events will be completed by day, utilizing two person crews as described in Table 3.

All grab samples will be collected with a sampling pole, stainless steel bucket or glove method. Sampling events will start at the downstream site and progress upstream. This approach to biweekly sampling is designed to collect a representative sample of current conditions in the stream. Immediately after sample collection, on-site measurements will be taken as previously described.

Table 3 Biweekly Monitoring Schedule

Day One

Watershed	Site	Description
Big Bone	MLC3.0	Bridge at US 42 (USGS)
Gunpowder	GPC4.6	Sullivan Road
	GPC14.7	Camp Ernst Road (USGS)
Woolper	WPC5.0	Woolper Road (USGS)
	ASF0.0	Intersection of Ashby and Woolper Road
Elijahs	EJC2.8	Elijah Creek Road (USGS)
Sand Run	SDR4.0	Thornwilde Subdivision

Day Two

Watershed	Site	Description
Licking River	POC0.9	Bridge on Indian Trace by Joann Lane
	LIR35.5	Butler, KY
Twelvemile	TMC9.3	Intersection of Route 10 and California Crossroads
	TMC3.0	Route 1997 (USGS)
Fourmile	FMC6.9	Poplar Ridge Road (USGS)
	FMC0.5	Silver Grove Pump Station Route 8

Day Three

Watershed	Site	Description
Banklick	BLC8.1	Richardson Road Bridge
	BLC1.2	Route 16 Bridge Winston Avenue
Threemile	THC0.7	Threemile Creek Road (USGS)
Taylor	TYC0.6	Donnermeyer Drive under 471 (USGS)
Licking	LIR0.5	Fourth Street Bridge
Pleasant Run	PRC0.3	Bridge on Oak Street
Dry Creek	DRC1.4	Dry Creek WWTP (USGS)

3.3 Summary

Table 4 presents a summary of the field monitoring and sampling plan for Northern Kentucky watersheds.

Table 4 Summary of Water Quality Monitoring and Sampling Program

Type	Locations	Description	Parameters
Biweekly Sampling	20 total locations, throughout Northern Kentucky 4 basins (North, Central, West, East)	♦ Samples collected every two weeks at the same locations ♦ 1 grab sample per site	♦ On-site measurements will include: ***temperature, dissolved oxygen, pH, conductivity and turbidity.*** ♦ Water quality parameters will include: ***bacteria (EC), nitrogen (TKN, NH_3, NO_3-NO_2), phosphorus (total and ortho), total suspended solids, and $CBOD_5$.***

Table 5 summarizes the number of samples to be collected exclusive of quality control protocols.

Table 5 Summary of Number of Samples to be Collected

Task	Day One	Day Two	Day Three
Day Sampled	Tuesday	Wednesday	Thursday
No. of Events per week	1	1	1
No. of Sites	7	6	7
Bacteria			
E. coli	7	6	7
Nutrients			
NH_3	7	6	7
NO_3- NO_2	7	6	7
TKN	7	6	7
Total Phosphorus	7	6	7
Ortho Phosphate (field filtered)	7	6	7
Solids			
TSS	7	6	7
Other			
$CBOD_5$	7	6	7
Total Sample Load	**56**	**48**	**56**

4. *Field Measurements*

In-stream dissolved oxygen, temperature, pH, conductivity, and turbidity will be measured using appropriate field instruments concurrent with sample collection at each of the sampling locations. Each on-site parameter will be measured at each location during each sampling event. Table 6 lists the parameters, location of measurement at each site, and method of measurement.

Field measurements will be conducted following the Standard Operating Procedures in Appendix A. Field instruments will be calibrated before initiating monitoring activities for each event. A post-monitoring calibration check will also be conducted at the end of each monitoring event. All calibration and maintenance activities will be documented on the Multiprobe Instrumentation Calibration and QA Sheet (see Appendix A).

Measurements will be documented on the Field Data Sheet (see Appendix C). Documentation will include: date/time, location, type of measurement, personnel, equipment and associated calibration specifications, and general site observations (e.g., weather conditions).

Table 6. Field Measurements

Parameter	Location of Measurement	Method
Temperature	Mid-channel, mid-depth where possible	Hydrolab
Conductivity		
pH		
Dissolved Oxygen		
Turbidity		

5. *SAMPLING HANDLING AND CUSTODY*

The following sections outlines the sample labeling procedures, sample handling, chain-of-custody and record keeping required.

5.1 Sample Labeling

All samples will be assigned a unique identification code such that all necessary information can be attained from the sample label. The labels will be available in an electronic template and can be printed once the information has been added to the template. The code will identify the following:

Label: ___ ___ ___ ___. ___

1 2 3 4 5

Characters 1-5: Sample Site ID

Example: FMC0.5

In addition to the label, the sample bottles will be clearly marked using waterproof ink with the following information:

- Client – SD1
- Analyses – List of requested analyses to be performed from the container
- Preservative – Preservative in sample container
- Date – Date sample was collected
- Time – Time sample was collected
- Crew – Crew identification

5.2 Sampling Collection, Handling and Transport

General guidelines for sample collection are listed below. Refer to *Standard Operating Procedures for the Collection of Discrete Water Samples* for detailed procedures.

- All samples collected in intermediate sampling containers should be transferred to their appropriate laboratory sample bottle as quickly as possible.
- Sampling location codes will be used to distinguish each distinct sampling location.
- Sample labels and chains of custody must be filled out completely.

The following procedures will be followed when handling and transporting samples:

- Samples will be preserved using ice and transported in sample coolers. It should be ensured that plenty of ice is used for each sample cooler to maintain the temperatures inside the cooler at approximately 4^{o} C.
- Laboratory chain-of-custody forms will be included with all sample submissions. Field staff will keep copies.
- Sample bottles and coolers should be handled with care to prevent breakage/spillage.
- All sample bottle labels must be properly completed and placed firmly on each bottle by the field sampling crews.

5.3 Chain-of-Custody

Field crews will complete chain-of-custody forms to document the transfer of sample custody to the designated custodian and subsequent personnel, see Appendix B. Signatures of all personnel involved in the collection, transport, and receipt of each sample will be recorded on the chain-of-custody forms.

In certain instances, sample custody will be transferred to runners to transport the samples directly to the laboratory at designated times during sampling to avoid missing holding times. The chain-of-custody form outlines sample location, identification, collection time and date, and specific parameters to be analyzed for each sample. A properly completed chain-of-custody form must accompany all samples.

Use of the chain-of-custody form will terminate when laboratory personnel receive the samples and sign the form. The laboratory will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the chain-of-custody form. Any discrepancy between the sample bottle and the chain-of-custody form, any leaking sample containers, or any other abnormal situation will be reported to the Laboratory Manager. The Laboratory Manager will inform the Project Manager of any such problem, and corrective actions will be discussed and implemented.

5.4 Field Logs and Records

Field crews will document all activities associated with the monitoring program at each monitoring site, including unusual or anomalous conditions. In addition, a description of any problems encountered during the monitoring period and/or any deviations to the FMSP will also be documented. This information may subsequently be used for data interpretation and analyses.

All pertinent information will be recorded on Field Data Sheets which are included as Appendix C.

At the conclusion of each monitored event, all Field Data Sheets will be submitted to the Field Manager to serve as a chronological representation of the monitored event. At a minimum each data field sheet should include the following information:

- Project name, site/river name, sample type;
- Crew identification, date, start time/end time;
- Weather conditions, stream conditions, site conditions;
- Physical parameter data (on-site measurements);
- On-site water quality meter identification number used to measure physical parameter data;
- Field observations.

All entries will be completed with a permanent ink pen with no erasures, correction fluid, or tape used. Erroneous entries will be noted using a single line drawn through the mistake that is then dated and initialed.

5.5 Sample Containers and Preservation

Table 7 presents details of sample containers and preservatives to be used. The laboratory will provide all bottles pre-preserved.

Table 7 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Maximum Storage Time
Bacteria				
E. coli	Pre-Sterilized Polyethylene or Glass	120 ml	Add $Na_2S_2O_7$ [1] Refrigerate to 4°C	12 hours[2]
Nutrients				
NH_3 TKN NO_3-NO_2 Total Phosphorus	Polyethylene or Glass	1000 ml	Add H_2SO_4, pH<2 Refrigerate to 4°C	28 days
Ortho Phosphate	Polyethylene or Glass	120 ml	Field filter Refrigerate to 4°C	48 hours
Conventional				
TSS	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	7 days
$CBOD_5$	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	48 hours

1. Sodium Thiosulfate ($Na_2S_2O_7$) prevents continuation of bacteriocidal action.
2. The maximum allowable holding time for bacteria samples will be 12 hours with a goal of 6 hours when practical.

6. QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The purpose of any quality assurance/quality control (QA/QC) program is to ensure that all sampling protocols and procedures are followed such that samples are representative of the water quality to which they are associated. The program is designed to be a systematic process, which together with the laboratory QA/QC program ensures a high degree of confidence in the data collection. The proposed QA/QC program includes the following elements:

- Training of all field staff;
- Field quality control procedures;
- Equipment cleaning protocol;
- QA/QC samples; and,
- Equipment calibration.

6.1 Training

Training sessions will be carried out for all field staff on proper sampling, sample handling and submission and general field procedures. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field crews will receive training involving the operation, maintenance and calibration of water quality meters, and all other on-site equipment used throughout the field program. SOPs for all program elements will be distributed to staff and available at all times.

6.2 Field Quality Control

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, necessary precautions must be taken to protect samples from contamination and deterioration. Procedures detailed in *Standard Operating Procedures for the Collection of Discrete Water Samples* and *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation* will be followed to ensure field quality control.

6.3 Equipment Cleaning Protocol

All sampling equipment (i.e. intermediate containers, sampling buckets, etc.) will follow the QA/QC protocol outlined in *Standard Operating Procedures for the Collection of Discrete Water Samples* to ensure representative sample collection. When using the sampling pole or stainless steel bucket, only step 2 (Blank Water Rinse) of the decontamination procedure needs to be utilized.

6.4 QA/QC Samples

The monitoring team will use three types of QA/QC samples collected in the field to assist in validating chemical data sets – sample duplicates, equipment blanks, and field blanks. Each type of QA/QC sample is described in the following sections. Tables 8 and 9 present the schedule and number of QA/QC samples to be collected during the field program.

Table 8 QA/QC Sample Schedule

Biweekly Sampling			
Day	Tuesday	Wednesday	Thursday
	Dup*, FB, MB	Dup*, FB, MB	BEB, Dup, FB, MB, AEB

BEB = Before Equipment Blank MB= Method Blank Dup = Duplicate

AEB = After Equipment Blank FB = Field Blank * = Dup will rotate between days

Table 9 Number of QA/QC Samples

Base Flow Sampling	Field Blanks[2]	Equipment Blanks[3]	Method Blanks[4]	Duplicate Samples[5]	Total per Event
Day 1	1	0	1	1	3
Day 2	1	0	1	0	2
Day 3	1	2	1	0	4
Totals	**3**	**2**	**3**	**1**	**9**

1. Each QA/QC sample set is performed on the complete series of samples submitted for laboratory analysis.
2. One set of field blanks per day will be collected during each day of the week.
3. Two sets of equipment blanks (BEB, AEB) per day will be collected during each day of the event only if a bucket was used during sampling (Thursday).
4. One set of method blanks (at one site) per day will be collected during each day of the event.
5. One set of duplicates (at one site) will be collected during each week.

6.4.1 Sample Duplicates

Sample duplicates will be collected for laboratory analysis for each parameter. The purpose of these analyses is to evaluate sample collection precision by comparing the duplicate analytical results. One set of duplicate samples at a sampling location, randomly identified, will be collected by each field crew during the sampling event. Duplicates will be rotated among streams between sampling rounds. Approximately 10 percent of the samples will be collected in duplicate.

6.4.2 Equipment Blanks

Equipment blanks will be collected for laboratory analysis for all parameters. The purpose of these analyses is to assess potential cross-contamination of samples by the equipment, including intermediate sample containers. These blanks will be taken before each sampling shift (BEB) and at the conclusion of each sampling shift (AEB) by each crew.

6.4.3 Method Blanks

Method blanks (MB) will be collected for laboratory analysis for orthophosphate only. The purpose of these analyses is to assess potential cross-contamination of samples by the method in which the sample was collected. These blanks will be taken at the conclusion of each sampling shift by each crew.

6.4.4 Field Blanks

Field blanks will be collected for laboratory analysis for all parameters. The purpose of these analyses is to determine if samples collected have been contaminated by field handling and cleaning methods. Each field crew will collect these blanks immediately following the collection of the AEB equipment blanks.

6.5 Equipment Calibration

On-site physical parameters will be measured in-stream by water quality meters and recorded on data sheets. These instruments will be calibrated each sampling day before use according to the manufactures operating manual as outlined in *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation*.

At the conclusion of the sampling event, each meter will be checked with the standards used during calibration. The purpose of these readings is to evaluate the meter's precision (electronic drift) by comparing the readings recorded during calibration and the readings recorded during the check at the end of the sampling day.

At the conclusion of each sampling event, all Calibration Sheets will be submitted to the Field Manager to serve as a record of the meter's performance during the sampling event.

7. Program Safety

The most critical component of a sampling program is crew safety. Safety is of paramount importance as stream sampling can be extremely dangerous. The element of danger is accentuated if personnel are unfamiliar with their surroundings and/or procedures, consequently staff must be properly trained in both safety and monitoring procedures, following a well thought out program.

With stream monitoring, common sense is essential. Two hazards that field staff may face more often, especially if wet weather occurs during sampling, are high stream conditions and slippery footing. If stream levels are deemed to be too high or too fast, under no circumstances should any field staff enter the stream or operate near its banks. With surfaces being wet and slippery, special care must be taken when walking and working around bridges.

Wading is one of the easiest methods to collect samples from many streams, and it may also be extremely dangerous. Wading permits the investigator to examine stream flow and decide where to sample. Rubber boots or even chest-high waders are standard equipment. If the wader has any uncertainty about their ability to wade a stream, they should be attached by a rope to a rigid mooring and wear an approved floatation device.

If creek conditions are high and fast, field staff will wear a safety belt or harness and will be appropriately tethered when working in close proximity to the creek. Along with being attached by rope, field staff must wear an approved floatation device.

There must be a minimum of two field staff working together during any sampling event.

7.1 General Safety Practices

- Water depth during wading operations must be checked with a pole before steps are taken.
- When wading equipment is worn, the support straps must be outside the clothing.
- In all situations field parties are required to leave accurate sampling schedules and expected itineraries in the office.
- Sampling must never be carried out in weather that is considered by the Field Manager or field member to be hazardous to the well-being of the field staff and/or equipment.
- Field staff are required to wear approved floatation devices and be tethered if conditions warrant use.
- First aid kits will be issued to all field crews.
- Each field crew will have a cellular phone and have been instructed on emergency procedures and numbers.
- Each field crew will report upon leaving and returning from any sampling or field work to their Field Manager.
- Each field crew will have appropriate lights, markers, etc. to be able to perform their work safely under poor visibility/nightfall.
- Each field crew will have the appropriate road safety equipment as required.

7.2 Health Hazards

Disease causing bacteria, viruses, and parasites are always present in sewers and discharge streams. They occur in both liquid sewage and dry sludge which coats pipes, and other surfaces. The serious threats are Hepatitis A (virus), Hepatitis B (virus), Tetanus (bacteria), Typhoid (bacteria), and Polio (virus). Proper hygiene methods must be followed. Wash hands before eating or smoking. Protective clothing must be laundered and equipment kept clean. Workers should avoid touching their eyes to prevent an inflammation. Cuts and abrasions of the skin should be covered by bandages or gloves to minimize the chance of infection by organisms.

Appendix A

Standard Operating Procedures for Field Monitoring and Sampling

Standard Operating Procedures

for the

Collection of Discrete Water Samples

Northern Kentucky Sanitation District No. 1
1045 Eaton Drive
Fort Wright, KY 41017

Revision Number: 1
September 2006

Introduction

This document describes the procedures for the collection of discrete water samples in Northern KY watersheds by Sanitation District No.1. These methods allow for the collection of grab or composite samples utilizing various sample collection techniques. This standard operating procedures document (SOP) has been developed to maintain consistent data collection procedures, and to ensure the quality of the data collected.

1.0.0 Field Equipment

The following equipment is needed to implement the sampling techniques.

- Stainless Steel Bucket w/ Rope
- Sampling Pole
- Kemmerer Sampling Bottle Kit
- Churn Sample Splitter
- Chemical Decontamination Agent (Solvent or Weak Acid)
- Chemical Waste Bucket
- Blank Water (Distilled or Reagent Grade Deionized – RGDI)
- Sample Bottles
- Coolers and Ice
- Scrub Brush
- Disposable Gloves
- Field Sampling Plan
- Permanent Marker (Sharpie)

Individuals handling solvents or acids should wear rubber gloves and eye protection to prevent possible injuries.

The following parameters can be collected with the ensuing sampling techniques: bacteria (fecal coliform and *E. coli*), oxygen demand (BOD_5, $CBOD_5$, COD), chlorophyll *a*, nutrients (total phosphorus, orthophosphate, nitrate-nitrite, Total Kjeldahl Nitrogen, ammonia), total hardness, metals, and solids (TSS, TDS).

Refer to Attachment 1 for an alternative collection procedure for parameters that do not require preservatives utilizing the glove method.

Refer to Attachment 2 for filtration procedures for orthophosphate collection.

2.0.0 Preparation

Before collecting samples, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative, and the name of the collecting entity and sampling crew member) on all bottles using a permanent marker and affix the labels to the bottles. Ideally, the labels are filled out (except date and time) and attached to the sample bottles before the sampling event occurs. In addition to the sample label, identify the lid of each container with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers should be wiped down or washed with a mild soap and thoroughly rinsed if it has any contaminants present. In addition all sampling equipment must be inspected for proper operation.

The sampler's hands should be washed with a mild soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the sample bottles or lids.

3.0.0 Procedures

Keep all sampling bottles closed until they are ready to be filled. At each collection site, the sampler will wear a new set of gloves for decontamination procedures and new set of gloves for sample collection. If sampling from a boat or structure, collect the sample from the upstream side. Avoid placing the sampling device in contact with the streambed or bank. Once the sample is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.1.0 Stainless Steel Bucket

Prior to sampling, the stainless steel bucket must be inspected to ensure that is in good condition, and that the nylon rope is not torn or frayed.

3.1.1 Decontamination Procedures

The stainless steel bucket must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the outer lip and the inside of the bucket with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the bucket thoroughly with the chemical.
- Discard the chemical into the waste container.
- Rinse the inside of the bucket with blank water.
- Discard the blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat Step 3.

3.1.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – River Rinse

- Rinse the bucket with river water by submerging the bucket into the stream at the collection site.
- Remove the bucket from the stream and discard its contents downstream of where the sample will be collected.

Step 2 – Sample Collection

- Lower the bucket into the stream to obtain a surface grab sample.
- Remove the bucket from the stream.
- Fill the required sample bottles.

3.2.0 Sampling Pole

The pole must be inspected to ensure it is clean and all parts are working properly. Prior to sampling, ensure the bottle is properly attached and snapper band is securely fastened. Once pole is extended, verify that the locking mechanism is secured.

3.2.1 Decontamination Procedures

The sampling pole and bottle attachment must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the entire pole with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the entire pole with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Blank Water Rinse

- Rinse the bottle attachment with blank water.
- Discard blank water.
- Repeat Step 2.

3.2.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – Sample Collection

- Attach a clean unpreserved bottle onto the pole.
- Lower the bottle into the stream to obtain a surface grab sample.
- Make sure the bottle does not touch the bottom of the stream and try to avoid floating debris entering the bottle.
- Remove the bottle from the stream.
- Repeat as necessary to fill the required sample bottles. (Attempt to proportional divide the sample volume equally between sample bottles in order to average out any temporal variations.)
- Detach the bottle from the pole and:
    a) If using a sample bottle, place in the cooler.
    b) If using a transfer bottle, discard when finished.

3.3.0 Kemmerer Sampling Bottle

Prior to sampling, the Kemmerer must be inspected to ensure that the triggering mechanism is functioning properly, and that the nylon rope is not torn or frayed.

3.3.1 Decontamination Procedures

The Kemmerer must be cleaned before each sample is collected.

Step 1 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the Kemmerer thoroughly with the chemical.
- Purge a small amount of the chemical from the drain valve into the waste container.
- Open the top and discard the remaining chemical into the waste container.
- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve into the waste container.
- Open the top and discard the remaining blank water into the waste container.

Step 2 – Blank Water Rinse

- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve.
- Discard the remaining blank water.
- Repeat Step 2.

3.3.2 Sample Collection Procedures

Discrete water column grab samples (most often used for deep water sampling from a boat) are collected using the following procedures.

Step 1 – River Rinse

- Open the Kemmerer bottle.
- Rinse the Kemmerer with river water by submerging it into the stream at the collection site.
- Remove the Kemmerer from the stream.

Step 2 – Sample Collection

- Lower the Kemmerer to the appropriate depth (utilize the boat fathometer to determine mid-depth and bottom depth).

  a) Surface – Lower the Kemmerer to a depth of approximately one-foot below the surface.
  b) Mid-Depth – Lower the Kemmerer to the appropriate depth.
  c) Bottom – Lower the Kemmerer to a depth of approximately two-feet from the bottom (If Kemmerer contacts bottom sediment, repeat decontamination procedures before sample collection).

- Activate the closing mechanism of the Kemmerer to acquire sample volume.
- Remove the Kemmerer from the stream.
- Purge a small amount of sample volume from the drain valve.
- Fill the required sample bottles.

3.4.0 Churn Sample Splitter

Prior to sampling, the churn sample splitter must be inspected to ensure that is in good condition, and that it is functioning properly.

3.4.1 Decontamination Procedures

The churn sample splitter must be cleaned before sub-samples are homogenized. In addition, the appropriate sample collection device must also be cleaned (stainless steel bucket – 3.1, sampling pole – 3.2 or Kemmerer – 3.3).

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the plunger and the inside of the churn splitter with an Alconox detergent solution (blank water).
- Purge a small amount of the wash solution from the spigot.
- Discard the remaining detergent solution.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Weak Acid (Optional)

- Rinse the plunger and the inside of the churn splitter thoroughly with the chemical.
- Purge a small amount of the chemical from the spigot into the waste container.
- Discard the remaining chemical into the waste container.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot into the waste container.
- Discard the remaining blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat Step 3.

3.4.2 Sample Collection Procedures

Sub-samples (vertical or horizontal), obtained with a stainless steel bucket, sampling pole or Kemmerer bottle are homogenized into composite samples using the following procedures.

Step 1 – River Rinse

- River rinse by filling the churn splitter with the sampling device at the collection site.
- Purge a small amount of the stream water from the spigot.
- Discard the remaining contents.

Step 2 – Sample Collection

- Obtain sub-samples following either stainless steel bucket, sampling pole, or Kemmerer collection procedures.
- Fill the churn splitter with approximately equal volumes from each sub-sample.

Step 3 – Homogenizing Sub-samples

- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.0.0 Quality Assurance
Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1.0 Duplicate Samples
To collect duplicate grab samples fill the required bottles from the same stainless steel bucket, sampling pole, or Kemmerer. To collect duplicate composite samples fill the required bottles from the Churn Splitter sample volume.

4.2.0 Blanks
Blanks should be collected during each day of the survey. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blanks
Pour blank water from an unopened container directly into the sample bottle.

4.2.2 Equipment Blanks
Equipment blanks should be collected at the beginning and end of each survey day.

Stainless Steel Bucket
- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the stainless steel bucket with enough blank water to fill the sample bottles.
- Fill the required sample bottles.

Sampling Pole
- The method for this device does not require a blank.

Kemmerer Bottle
- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the Kemmerer with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the Kemmerer.
- Fill the required sample bottles.

Churn Sample Splitter
- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the appropriate collection device (Kemmerer or stainless steel bucket) with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the appropriate collection device.
- Pour the blank water from the collection device into the churn splitter.
- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.2.3 Trip Blanks (Optional)
Depending on study design, a trip blank may be utilized. This is a sample of RGDI water taken from the laboratory to the sampling site and returned to the laboratory unopened.

5.0.0 Chain of Custody Procedures
All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

Attachment 1
Collection of Unpreserved Parameters Utilizing the Glove Method

Introduction
This attachment describes the procedures for the collection of grab samples into unpreserved bottles utilizing the glove method. This method has been implemented to eliminate the use of sampling equipment (i.e. stainless steel bucket or Kemmerer) for collecting surface samples. The elimination of equipment reduces cleaning procedures and possible sources of contamination. In addition, this method significantly reduces sampling time.

1.0 Field Equipment
The following equipment is needed to implement the Glove Method collection technique.

- Disposable Gloves
- Sterilized Unpreserved Sample Bottles
- Cooler and Ice
- Permanent Marker (Sharpie)
- 1 Gallon Container of Blank Water (Distilled or RGDI)
- Anti-Bacteria Soap
- Knife

2.0 Preparation
Before collecting the sample, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative and the name of the collecting entity and crew member) using a permanent marker and affix the label to the bottle. Ideally, the label is filled out (except data and time) and attached to the sample bottle before the sampling event occurs. In addition to the sample label, identify the lid of the bottle with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers may be wiped down or washed with a mild soap and thoroughly rinsed if they have any contaminants present.

The sampler's hands should be washed with anti-bacteria soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the bottle or lid.

3.0 Procedures
Keep sample bottles closed until they are to be filled. At the collection site, the sampler will wear a new set of gloves and detach the lock mechanism from the lid. Fill the bottle by holding the bottle upright and plunging it into the stream directed toward the current. Keep the lid closed (so as not to lose the dechlorination tablet) until you have reached a depth of 6 to 12 inches below the surface. When the sample is collected, leave ample air space in the bottle to facilitate mixing by shaking. Avoid placing the sample bottle in contact with the streambed or bank. If sampling from a boat or structure, collect the sample from the upstream side.

Fill the bottle to the appropriate level (if more water is collected than needed, carefully pour out the excess) and properly close the lid. If taking a bacteria sample shake the bottle for 30 seconds to expedite dissolving the dechlorination tablet.

After the sample is collected and sealed, the sample bottle should be placed in a cooler and covered with crushed ice. A new set of sterile gloves will be worn for each sample collected.

4.0 QA Samples
Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1 Duplicate Samples
To collect duplicate samples, plunge bottles into the river and fill one immediately after another.

4.2 Blanks
Blanks should be collected at the completion of each survey day. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blank
Pour blank water from an unopened gallon container directly into the sample bottle.

4.2.2 Method Blank
With a clean pocketknife, cut off the top of the container used for the first field blank. Simulate stream collection by plunging the bottle, while wearing gloves, into the cut open gallon container. Keep the bottle upright and let the water flow over the top of the bottle until it is filled.

5.0 Chain of Custody Procedures
All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

If the sample bottles used have a tie, this tie must be cut in order to open the bottle, and should provide a measure of sample security and integrity.

6.0 Reference
USEPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA/600/8-78/017.

Attachment 2
Collection of Orthophosphate Samples

Introduction
This attachment describes the additional procedures needed for the collection of orthophosphate samples.

1.0 Additional Field Equipment
The following additional equipment is needed to implement the orthophosphate filtration method.

- Disposable 60cc Syringes (Luer-Lok tip)
- Disposable 25 mm Filter Cartridges (1µm Glass Fiber Filter and 0.45µm Nylon Membrane Filter)
- Sample Bottles

2.0 Procedures
A new disposable syringe and filter cartridge (syringe filtration unit) will be used for each sample.

2.1 Decontamination Procedures
The syringe filtration units must be cleaned before each sample is filtered.

Step 1 - Blank Water Rinse

- Rinse the inside of the syringe by plunging 50mls of blank water through the housing.
- Attach the filter cartridge to the syringe.
- Rinse the inside of the entire unit by plunging 50mls of blank water through the unit.

2.2 Sample Collection Procedures
Samples can be filtered from the Kemmerer bottle, sampling pole, stainless steel bucket, or churn splitter using the following procedures.

Step 1 – Sample Filtration/Collection

Fill the syringe filtration unit with sample from the appropriate collection device.
Place the plunger into the syringe.
Purge a small amount of sample volume through the filter.
Discharge water through the filtration unit into a sample bottle.
Repeat the previous three bullets until enough sample has been filtered into the sample bottle.
Discard the syringe filtration unit.

3.0 Quality Assurance

Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

3.1 Duplicate Samples

To collect duplicate samples continue to fill the syringe filtration unit from the same Kemmerer, sampling pole, or stainless steel bucket drop and filter into the required bottles.

3.2 Blanks

Blanks should be collected during each day of the survey. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.2.1 Field Blanks

Pour blank water from an unopened container directly into the sample bottle.

3.2.2 Equipment Blanks

Equipment blanks should be collected at the beginning and end of each survey day.

Unfiltered Equipment Blank

An equipment blank utilizing the appropriate collection device should be collected at the beginning of each survey day.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the required sample bottle.

Filtered Equipment Blank

An equipment blank utilizing the syringe filtration unit should be collected at the end of each survey day. The syringe filtration unit is decontaminated using the previously outlined procedure before the blank is collected.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the syringe filtration unit with sample from the appropriate collection device.
- Place the plunger into the syringe.
- Purge a small amount of blank water through the filter.
- Discharge water through the filtration unit into a sample bottle.
- Repeat the previous three bullets until enough volume has been filtered into the sample bottle.
- Discard the syringe filtration unit.

Standard Operating Procedures

for

Hydrolab Series 5
Water Quality Instrumentation

Sanitation District No. 1 of Northern Kentucky
1045 Eaton Drive
Fort Wright, KY 41017
(859) 578-7460

Revision Number: 1
August 2006

Introduction

This document contains information and directions on using Hydrolab water quality instrumentation (DS5 Water Quality Multiprobe and Surveyor® 4a Water Quality Data Display). This standard operating procedures document (SOP) has been developed to maintain properly functioning equipment, and to ensure the quality of the data collected.

1.0.0 Instrumentation Maintenance

The following procedures are to be utilized to maintain the Hydrolab instrumentation.

1.1.0 DS5 Multiprobe

The outside housing of the sonde should be kept free of sediments, bio-films, oils, etc. by cleaning with soap and water. The storage cup must be installed (filled with tap water) at all times when the unit is not in use to protect the sensors from damage and from drying out. Refer to section 6.1.1 of the *DS5 User's Manual*. The unit's operating range is 23°F to 122°F (-5°C to 50°C). Exposure of the unit to temperatures outside of this range may result in mechanical or electronic damage. Refer to section 5.1.2 of the *DS5 User's Manual*. The DS5 contains an internal lithium system battery that is good for approximately two years. Refer to section 6.2.3 of the *DS5 User's Manual* for replacement procedures.

1.1.1 Temperature Sensor

The temperature sensor should be kept clean from deposits, otherwise it does not require any scheduled maintenance. Refer to section 6.9 of the *DS5 User's Manual*.

1.1.2 Luminescent Dissolved Oxygen (LDO) Sensor

LDO sensor is not affected by fouling or other debris, unless the growth is an organism that locally consumes or produces oxygen, such as barnacles, or algae growing on the sensor cap. Nevertheless, the manufacturer recommends periodic maintenance to remove contaminates such as oil, biological growth, dirt, etc. Sensor maintenance should be conducted after every deployment cycle. Refer to the Instruction Sheet – **Hach LDO Sensor** in the *DS5 User's Manual*. Yearly maintenance of the sensor should include the replacement of the sensor cap.

1.1.3 pH Sensor

The pH reference electrolyte and porous reference junction should be replaced at least twice a year. Refer to section 6.8 of the *DS5 User's Manual* for these procedures. The pH glass electrode can be generally cleaned with a cotton ball/"Q" tip using mild detergent and water; while a cotton ball/"Q" tip with methanol can be used to remove any oil, sediment or biological growth on the glass, as needed. Once maintenance has been performed on the sensor, the sensor should re-equilibrate for approximately 12 hours in tap water before it is calibrated, especially if methanol has been used. If the 12-hour re-equilibrate period cannot be met, record the estimated re-equilibrate time in the Comments section of the Sanitation District No.1 Multiprobe Instrumentation Calibration & QA Sheet and note if stable "instream" readings are achievable before calibration.

1.1.4 Conductivity Sensor

The annular rings inside the slot in the sensor housing of the conductivity sensor should be cleaned with a small bottle brush using a mild detergent and water, as needed. Methanol and a cotton swab should be used to remove any films or deposits on the electrodes. Refer to section 6.6 of the *DS5 User's Manual* for these procedures.

1.1.5 Self –Cleaning Turbidity Sensor

The self-cleaning turbidity sensor offers higher accuracy turbidity measurements and a wiper mechanism to reduce the effects of fouling. An internal motor automatically wipes the optical face at the start of every measurement. Turbidity sensor maintenance is required when any of the optical surfaces have a coating, or when a zero check using Hach StablCal <0.1 reads>0.9 NTU. Refer to the Instruction Sheet – **Self-Cleaning Turbidity Sensor** in the *DS5 User's Manual*. During unattended deployment, the turbidity wiper should be replaced every 3 months, or as needed (a gap should not be present between the wiper and the lens after reattachment).

1.1.6 Depth Sensor

The depth sensor generally does not need maintenance. If deposits (calcium, biological growth, etc.) begin forming in the port rinse with a very weak acid, such as acetic. Refer to the Sensor Specific Instruction Sheet of the *DS5 User's Manual*.

1.1.7 Circulator

The circulator is used during deployment to ensure adequate flow across the sensors for reliable readings. Refer to section 6.1.3 of the *DS5 User's Manual*.

1.1.8 Internal Battery Power

The DS5 contains an optional internal battery pack that is installed during manufacturing that consists of 8 "C" alkaline batteries that provide 12 volts when fully charged. When the battery pack becomes exhausted (below 6.4 volts) the batteries should be replaced in order for the logger to continue unattended monitoring. Refer to section 6.2 of the *DS5 User's Manual* for replacement procedures. The DS5 also contains an internal lithium system battery that is good for approximately two years. Refer to section 6.2.3 of the *DS5 User's Manual* for replacement procedures.

1.2.0 Surveyor® 4a Data Display

The data display should be protected from mechanical shock and excessive vibrations. The unit's operating range is 23°F to 122°F (-5°C to 50°C). Exposure of the unit to temperatures outside of this range may result in mechanical or electronic damage. Refer to section 3.1 of the *Surveyor 4 User's Manual* for maintenance and cleaning procedures.

1.2.1 Surveyor® 4a Internal Battery Power

The Surveyor 4a contains an internal 7.2-volt rechargeable nickel metal hydride battery. The battery power is exhausted at 6.5 volts and should be recharged for approximately 3.5 hours to ensure a full charge. The Surveyor 4a also contains an internal lithium system battery that is good for approximately two years. Refer to section 3.1 of the *Surveyor 4 User's Manual* for charging and replacement procedures.

1.2.2 Internal Barometer

The barometric pressure sensor does not require any scheduled maintenance. The sensor should be calibrated every six months and checked monthly with an accurate mercury barometer or the barometric pressure provided by the local weather service, corrected to site altitude. Refer to appendix 3 of the *Surveyor 4 User's Manual*.

1.3.0 External Rechargeable Battery Pack

The external rechargeable battery pack provides 12 volts when fully charged. The battery pack is exhausted below 9 volts and should be recharged for 12 hours to ensure a full charge. To prevent "charge memory", recharge the battery pack only when the battery power is exhausted. Refer to section 3.3 of the *DS5 User's Manual*.

1.4.0 Cables

Cables should be kept clean and protected from abrasion, unnecessary tension, repetitive flexure (fatigue), and bending over sharp radii (such as a bridge railing). Connections that plug into terminals are not waterproof and should be kept dry at all times. When cables are not in use, be sure to insert all dummy plugs and dust caps to protect the electrical connectors. Refer to section 6.3.2 of the *DS5 User's Manual*.

1.5.0 Flow Cell

The pressure in the flow cell should not exceed 15psi. Refer to section 5.2.5 of the *DS5 User's Manual*.

2.0.0 Instrumentation Setup

Communication to the *DS5* for setup or calibration can be established via the *Surveyor 4a* or a computer using Hydras 3LT software. The following settings should be configured for normal operation.

2.1.0 Parameter Display

For routine monitoring the following parameter display should be utilized. Refer to section 4.1 of the *DS5 User's Manual.*

- Date/Time Format – MDY/HMS
- Temperature – Celsius
- LDO – mg/L
- LDO – Percent Saturation
- pH – units
- Specific Conductance – μS/cm
- Turbidity – NTU
- Depth25 – Feet
- Battery – Choose appropriate display (internal vs. external and/or volts vs. % remaining)
- Radix – Decimal Point
- Interval – 000001

2.2.0 Parameter Setup

For routine monitoring, the following sensor setup should be utilized. Refer to section 4.1 of the *DS5 User's Manual.*

- Specific Conductance – mS/cm, Fresh Water Temperature Compensation, Autorange
- Salinity – ppt, Method 2311

2.2.1 Using the Surveyor for Parameter Setup

Refer to section 4.1.1 of the *DS5 User's Manual.*

2.2.2 Using Hydras 3 LT for Parameter Setup

Refer to section 4.1.2 of the *DS5 User's Manual.*

2.2.0 System Setup

For routine monitoring the following system setup should be utilized. Refer to *DS5 User's Manual* for additional information.

- Circulator – On during use, Off during calibration
- Audio – Off during normal profiling use, On during logging runs
- Terminal Baud Rate – 19200
- Autolog – Off during normal profiling use, On during logging runs

2.3.0 SDI-12 Setup

For SDI-12 communications with an external data logger the following setup should be utilized. Refer to **Appendix B External Communications** of the *DS5 User's Manual.*

- SDI Address – 1
- SDI Delay – 120 (Note: multiprobe has 5 second built in delay, thus actual delay = 125)

3.0.0 Instrumentation Calibration
Refer to section 4.2 of the *DS5 Users Manual* for sensor calibration procedures. The multiprobe and the standards must be at thermal equilibrium before the calibration procedures are performed. If a stand is used to hold the sonde during calibration, secure the sonde only around the end caps, **never** around the housing. Use either distilled or deionized water as rinse water during the calibration procedures. The multiprobe should be calibrated and post checked after each use to track any electronic drift. Record all calibration information on the Sanitation District No.1 Multiprobe Instrumentation Calibration & QA Sheet – Attachment A.

3.1.0 Procedures
Multiprobe calibration is performed using the stated procedures for each parameter as described. If calibration fails, refer to the appropriate section under Multiprobe Maintenance, Section 6.1 of the *DS5 User's Manual.* After performing the recommended maintenance, reattempt the calibration procedure.

The multiprobe sensor accuracy for each parameter (utilizing certified standards) is stated as follows:

LDO: ± 0.1 mg/L (0 - 8 mg/L)
± 0.2 mg/L (>8 mg/L)
pH: ± 0.2 units

Conductivity: ± 1% of reading (± 10 µS/cm for a 1000 standard)
Turbidity: ± 1 % (0 - 100 NTUs)
± 5 % (400 – 3,000 NTUs)

3.2.0 Temperature
The temperature sensor is factory-set and does not require further calibration. Refer to section 4.2.4 of the *DS5 User's Manual*. The accuracy of the sensor is ± 0.1°C.

3.3.0 Luminescent Dissolved Oxygen (LDO)
There are three standard methods for calibrating the LDO sensor. Each method requires a single point calibration for measurement of concentration in mg/l. In order to calibrate the sensor for percent saturation reading, the local barometric pressure (corrected to local altitude above sea level) must be determined independently by the user and input into the software during calibration. Once calibrated, the sensor reading is verified to an oxygen solubility calculation as a QA/QC check. Refer to the Sanitation District No.1 Multiprobe Instrumentation Dissolved Oxygen Calibration Technical Sheet (Attachment B) for the elevation correction factors and the oxygen solubility calculation. In order to retain calibration accuracy between multiple deployments, store with sensor fully immersed in water at all times. Calibration will be completed by using of Method 1 – **Air Saturated Water.** Refer to the Instruction Sheet **– Hach LDO Sensor** in the *DS5 User's Manual*.

3.4.0 pH
Refer to section 4.2.8 of the *DS5 User's Manual* for pH calibration procedures. Since in-stream pH levels are generally above 7.0, the pH sensor is calibrated using a standard of 10.0 to determine the slope. If levels below 7.0 are expected, calibrate using a standard of 4.0 to determine the slope.

3.5.0 Conductivity
Refer to section 4.2.5 of the *DS5 User's Manual* for specific conductance calibration procedures. Since in-stream conductivity concentrations are generally below 1000µS/cm the specific conductance sensor is calibrated using a standard of 1000µS/cm to determine the slope. If lower concentrations are expected, calibrate using a standard of 500µS/cm to determine the slope.

3.6.0 Turbidity
Refer to the Instruction Sheet **– Self-Cleaning Turbidity** Sensor in the *DS5 User's Manual* for turbidity calibration procedures. Since in-stream turbidity readings can be highly variable the turbidity sensor is calibrated using a standard of 800 NTUs to determine the slope. If the sensor fails to properly calibrate, reset the sensor.

3.7.0 Depth
Refer to the **Sensor Specific Instruction Sheet** of the *DS5 User's Manual* for depth calibration procedures. The depth sensor is zeroed in air at the monitoring site to account for the current barometric pressure.

3.8.0 Time
Refer to the **Sensor Specific Instruction Sheet** of the *DS5 User's Manual* to enter the correct time (HHMMSS) and date (MMDDYY).

3.9.0 Quality Assurance/Quality Control
The following procedures are to be utilized to preserve and maintain QA/QC for the calibration of the Hydrolab instrumentation.

3.9.1 QA Standards
Calibration standards may be reused between calibration periods by employing procedures that prevent contamination. Only the quantity of standard used during the actual sensor calibration is saved for reuse. The quantity of standard used for the sensor rinse should always be discarded. Refer to the appropriate calibration section for each sensor in the *DS5 User's Manual.* Standard that is retained for reuse is kept in clean polyethylene bottles with Teflon sealed caps. Used standard is never remixed with the certified standard in the original container. Fresh or "certified" standard is continually added to the polyethylene bottles during the calibration steps to replenish the quantity used for the sensor rinses.

The standards original container is identified with date received and date opened using a permanent marker. Standards that have exceeded the manufacturer's expiration date are discarded.

3.9.2 QC Calibration Sheets
Calibration sheets are retained as quality control records and are reviewed to address individual multiprobe/sensor issues that may arise, such as electronic "drift".

4.0.0 Data Logging Setup & Data Retrieval
Refer to Section 4.3.3.1 & 4.3.3.2 of the *DS5 User's Manual* for logging and data retrieval.

4.1.0 Logging Setup
Before the DS5 is setup for an unattended logging run, check the logging status in regards to available memory and remove any nonessential files, if needed. In addition, make sure the status of the audio, circulator, and enabled parameters are correct before the logging run is setup. Enable Autolog if desired.

Make sure the DS5 is correctly deployed before the logging run begins.

4.2.0 Retrieval
Once the DS5 has been retrieved from an unattended logging run, check the logging status in regards to the created log file. The log file should be transferred from the DS5 as soon as practicable (refer to Section 4.3.3.2 of the *DS5 User's Manual*). Transfer the log file from the DS5 to a computer in spreadsheet importable form by utilizing the Hydras 3LT software (when specifying a file name for the transfer, save the log file with a .csv extension, this will allow the log file to be directly opened in Microsoft Excel).

5.0.0 Attended Profiling
The DS5 can be utilized for discrete profiling at different stream depths or equipped with a flow cell for continuous profiling (e.x. surface profiling on a boat utilizing a pitot tube) or pumping.

5.1.0 Quality Assurance
- The unit should be recalibrated after each use to assess sensor drift.
- The unit should be cleaned periodically to maintain sensor performance.

6.0.0 Unattended Deployment

The DS5 can be positioned upright (probes pointing down) or horizontally for deployment. Avoid placing the unit in areas of swift currents, areas that might receive deep deposits of sediment during periods of heavy rainfall, or areas where potential vandalism may occur. Attempt to use any available protection that a site may provide (e.x. attach to downstream of bridge piling to protect from floating debris).

6.1.0 Temporary/Portable Installations

PVC piping can be utilized as a protective capsule to house the multiprobe at unsecured locations.

6.1.1 Specifications

- Cut 4” diameter PVC pipe to the desired length (approximately 3’) to create protective sleeve.
- Drill approximately 1” diameter holes throughout the sleeve to allow adequate water flow through the capsule.
- Drill approximately 3/4” diameter holes throughout the top of the end caps.
- Glue one end cap to the bottom of the sleeve.
- Place the other end cap on the open end of the sleeve and drill 5/8” hole through the end cap and the sleeve.
- Place a ½” bolt through the end cap and the sleeve and secure with two nuts.

6.1.2 Deployment

- Wrap the DS5 with duct insulation (keeping away from the probes).
- Place the DS5 into the PVC capsule (probes pointing down).
- Place the top end cap on the PVC capsule and align the 5/8” holes.
- Suspend the DS5 inside of the PVC capsule with the ½” bolt passing through the capsule and the DS5 bail.
- Secure the PVC capsule to an appropriate structure with heavy-duty cables and locks.

6.1.3 Quality Assurance

- The unit should be cleaned and recalibrated at least once a week depending on water quality conditions (i.e. solids loading and biological growth – bio-films).
  - Download the logging file and check the battery status.
  - Clean and recalibrate the sensors.
  - Setup the next logging file.
- Use portable unit to check permanent station readings before and after calibration.
- Use portable unit to check temporary station readings (logged data) between calibration schedules to assess sensor drift.

7.0.0 References

Hydrolab DS5X, DS5, and MS5 Water Quality Multiprobes, User Manual. February 2006 Edition 3. Hach Company.

Surveyor® 4 Water Quality Data Display, User’s Manual. Revision D. Hydrolab Corporation. April 1999.

Hydras 3 LT Quick Start, Software Manual. December 2005 Edition 2. Hach Company.

Attachment A: SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION CALIBRATION & QA SHEET

Instrument Model ____________ Serial Number ____________
Date ________ Analyst(s) ________ Instrument I.D. ____________
Site Location ____________ Note ____________

CALIBRATION READINGS	POST CHECK READINGS
1) Dissolved Oxygen (DO)	1) Dissolved Oxygen (DO)
Elevation (ft) ⇒ Correction Factor ________	Elevation (ft) ⇒ Correction Factor ________
Uncorrected BP Conversion (mmHg) ________	Uncorrected BP Conversion (mmHg) ________
Temperature (°C) ________	Temperature (°C) ________
Probe DO Reading (mg/L) ________	Probe DO Reading (mg/L) ________
Percent Saturation ________	Percent Saturation ________
O_2 Solubility Calculation (mg/L) ________	O_2 Solubility Calculation (mg/L) ________
Comments: Air Saturated Water	Comments: ________
2) Conductivity	2) Conductivity
Standard (µS/cm) / Reading / Adjusted	Standard (µS/cm) / Reading
________ ____ ____	________ ____
________ ____ ____	________ ____
Comments: Specific Conductance	Comments: Specific Conductance
3) pH	3) pH
Buffer / Reading / Adjusted	Buffer / Reading
4.00 ____ ____	4.00 ____
7.00 ____ ____	7.00 ____
10.00 ____ ____	10.00 ____
Comments: ________	Comments: ________
4) Turbidity	4) Turbidity
Standard (NTU) / Reading / Adjusted	Standard (NTU) / Reading
________ ____ ____	________ ____
________ ____ ____	________ ____
Comments: ________	Comments: ________

NOTE: Do NOT make adjustments during Post Check. Simply record values observed.

Attachment B: SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION DISSOLVED OXYGEN CALIBRATION TECHNICAL SHEET

Pressure Conversions

1. Inches to Metric Conversion
   1in = 25.4mm
   Example: 30.15in * (25.4mm/1in) = 765.8mm

2. Corrected to Uncorrected Pressure Conversion
   Obtain the corrected pressure from the National Weather Service.
   Corrected Pressure - (2.5 * (Elevation/100)) = Uncorrected Pressure
   Example: 765.8mm - (2.5 * (455/100)) = 754.4mm

Table 1: Barometric pressure correction factors for selected monitoring sites.

Stream	Site	Gage Datum	Correction
Banklick Creek	KY Route 1829	540.3	13.5
Cruises Creek	KY Route 17	656.9	16.4
Elijahs Creek	Elijahs Creek Road	759.1	19.0
Four Mile Creek	Popular Ridge Road	535.2	13.4
Gunpowder Creek	Camp Ernest Road	683.1	17.1
Mud Lick Creek	KY Route 14	487.7	12.2
Twelve Mile Creek	KY Route 1997	505.9	12.6
Woolper Creek	Woolper Road	490.7	12.3

Note: Gage Datum = feet above mean sea level
Note: Correction = mm Hg

Table 2: Barometric pressure correction factors for selected sites.

Stream	Site	Elevation	Correction
Ohio River	Markland Normal Pool	455	11.4
Licking River	12th Street	460	11.5
District Office	Prep Room	505	12.6

Note: Elevation = approximate feet above mean sea level
Note: Correction = mm Hg

SANITATION DISTRICT NO.1 MULTIPROBE INSTRUMENTATION
DISSOLVED OXYGEN CALIBRATION TECHNICAL SHEET

Oxygen Solubility Calculation

To verify the probe DO reading, utilize the following steps.

1. Determine the DO solubility of the standard's temperature at 760mm
   Example: Stable Temperature = 20.7°C
   From Table 2 -- 20.7°C at 760mm = 8.96mg/L

2. Determine the DO solubility of the standard's temperature at the current pressure
   Example: 20.7°C, 754.4mm Hg
   DOsol(760mm Hg) * Current Pressure / 760mm Hg
   = DOsol(Current Pressure)
   8.96 * (754.4/760) = 8.89mg/L

Table 2: Solubility of oxygen in water in equilibrium with air at 760mm Hg pressure and 100% relative humidity (EAWAG 1973). Units = mg/L

(°C)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	14.60	14.56	14.52	14.48	14.44	14.40	14.36	14.33	14.29	14.25
1	14.21	14.17	14.13	14.09	14.05	14.02	13.98	13.94	13.90	13.87
2	13.83	13.79	13.75	13.72	13.68	13.64	13.61	13.57	13.54	13.50
3	13.46	13.43	13.39	13.36	13.32	13.29	13.25	13.22	13.18	13.15
4	13.11	13.08	13.04	13.01	12.98	12.94	12.91	12.88	12.84	12.81
5	12.78	12.74	12.71	12.68	12.64	12.61	12.58	12.55	12.52	12.48
6	12.45	12.42	12.39	12.36	12.33	12.29	12.26	12.23	12.20	12.17
7	12.14	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90	11.87
8	11.84	11.81	11.78	11.76	11.73	11.70	11.67	11.64	11.61	11.58
9	11.56	11.53	11.50	11.47	11.44	11.42	11.39	11.36	11.34	11.31
10	11.28	11.25	11.23	11.20	11.17	11.15	11.12	11.10	11.07	11.04
11	11.02	10.99	10.97	10.94	10.91	10.89	10.86	10.84	10.81	10.79
12	10.76	10.74	10.72	10.69	10.67	10.64	10.62	10.59	10.57	10.55
13	10.52	10.50	10.47	10.45	10.43	10.40	10.38	10.36	10.34	10.31
14	10.29	10.27	10.24	10.22	10.20	10.18	10.15	10.13	10.11	10.09
15	10.07	10.04	10.02	10.00	9.98	9.96	9.94	9.92	9.89	9.87
16	9.85	9.83	9.81	9.79	9.77	9.75	9.73	9.71	9.69	9.67
17	9.65	9.63	9.61	9.59	9.57	9.55	9.53	9.51	9.49	9.47
18	9.45	9.43	9.41	9.39	9.37	9.36	9.34	9.32	9.30	9.28
19	9.26	9.24	9.23	9.21	9.19	9.17	9.15	9.13	9.12	9.10
20	9.08	9.06	9.05	9.03	9.01	8.99	8.98	8.96	8.94	8.92
21	8.91	8.89	8.87	8.86	8.84	8.82	8.81	8.79	8.77	8.76
22	8.74	8.72	8.71	8.69	8.67	8.66	8.64	8.63	8.61	8.59
23	8.58	8.56	8.55	8.53	8.51	8.50	8.48	8.47	8.45	8.44
24	8.42	8.41	8.39	8.38	8.36	8.35	8.33	8.32	8.30	8.29
25	8.27	8.26	8.24	8.23	8.21	8.20	8.18	8.17	8.16	8.14
26	8.13	8.11	8.10	8.08	8.07	8.06	8.04	8.03	8.01	8.00
27	7.99	7.97	7.96	7.94	7.93	7.92	7.90	7.89	7.88	7.86
28	7.85	7.84	7.82	7.81	7.80	7.78	7.77	7.76	7.74	7.73
29	7.72	7.70	7.69	7.68	7.66	7.65	7.64	7.63	7.61	7.60
30	7.59	7.57	7.56	7.55	7.54	7.52	7.51	7.50	7.49	7.47

APPENDIX B

NORTHERN KY SANITATION DISTRICT NO.1
CHAIN OF CUSTODY

SANITATION DISTRICT NO.1 OF NORTHERN KENTUCKY
1045 Eaton Drive
Fort Wright, KY 41017
Phone: (859)578-7460 Fax: (859)331-2436

Chain Of Custody Record

Page ______ of ______

Project Name	**Watershed**	**Survey Location**

Contact Person	**Sampler(s) Signature**	**Survey Type (Circle One)** Wet or Dry

Lab ID	Sample ID Code	Date	Time	Composite / Grab	Pole / Bucket / Glove	Sample Location	No. of Containers	Analysis Required: E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate					Remarks

Relinquished By: Sampler	Date	Time	Accepted By: Lab Runner	Date	Time	Remarks
Relinquished By: Lab Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

APPENDIX C

NORTHERN KY SANITATION DISTRICT NO.1
FIELD DATA SHEET

SANITATION DISTRICT NO.1 FIELD DATA SHEET

PROJECT NAME: ______________________ DATE: ______________________

SITE / STREAM NAME: ______________________ START TIME: ______________________

SITE LOCATION: ______________________ END TIME: ______________________

LABORATORY: ______________________ SAMPLERS: ______________________

SAMPLE TYPE

GRAB COMPOSITE

CIRCLE ONE

SAMPLE MATRIX

SEDIMENT WATER

CIRCLE ONE

EQUIPMENT ID: MULTIPROBE SONDE: ______________________

STREAM CONDITIONS: ______________________

SITE CONDITIONS: ______________________

WEATHER CONDITIONS: SUNNY CLOUDY OVERCAST WINDY RAIN SNOW AIR TEMP (F): ________

(CIRCLE APPROPRIATE CONDITIONS)

PROJECT DESCRIPTOR: ______________________

SITE / SAMPLE ID (BANK & DEPTH)	TEMP. (C)	pH	D.O. (mg/L)	SP. COND. (µS/cm)	TURBIDITY (NTU)	FLOW	SAMPLE TIME

FIELD OBSERVATIONS:

IF FOUND, RETURN TO:
SANITATION DISTRICT NO.1
1045 EATON DRIVE
FORT WRIGHT, KY 41017
(859) 578-7460

Ambient Sampling
Field Monitoring & Sampling Plan
For Northern Kentucky Watersheds

Northern Kentucky Sanitation District No.1
1045 Eaton Drive
Fort Wright, KY 41017

2017

Table of Contents

Figures

Tables

Appendices

1. *INTRODUCTION*

Sanitation District No. 1 (SD1) a clean water agency that serves over 30 communities in Campbell, Kenton and Boone Counties, Kentucky, as both the wastewater and storm water utility, is implementing a watershed management approach to cost-effectively meet numerous regulatory requirements (e.g., Combined Sewer Overflow (CSO) Program and Municipal Separate Storm Sewer System (MS4) Program). Additionally, SD1 has entered into a Consent Decree (CD) with state and federal environmental regulators to address sanitary overflows in these communities. In complying with these regulatory requirements, SD1 is applying an adaptive approach for identifying impairments and prioritizing areas for action. This approach will help ensure that available resources are most effectively used. SD1 has developed an Adaptive Watershed Management Plan that identifies Watershed Characterization in sixteen sub watersheds to relate in-stream conditions to watershed characteristics. The results of this Watershed Characterization will be used to identify impaired watersheds and prioritize them for consideration of control alternatives.

SD1 initiated a comprehensive watershed wide monitoring program in 2006 that involved the collection of instream water quality data in each of the sixteen watersheds in Northern Kentucky to characterize background conditions in the region. These sixteen watersheds represent varying conditions with respect to the amount of development, as well as sources of stream pollution. The variation in the stream conditions can range from undeveloped watersheds that have been categorized as “exceptional” waters by the State, while other watersheds are more highly developed and are identified as “impaired” by the State. As a result of the vast differences between these watersheds, SD1 has implemented a biweekly sampling program over a two year period to further characterize stream conditions under a wide range of environmental conditions at 20 locations throughout Northern Kentucky.

After the biweekly sampling program was concluded in June 2017, the ambient sampling program began in July 2017. This sampling program has the same sampling protocol, but the schedule and sites have changed. Instead of 20 locations there are 15.

The following ambient sampling *Field Monitoring and Sampling Plan* (FMSP) is designed to ensure that all monitoring activities undertaken result in representative data necessary to support the characterization of the watershed being sampled.

Monitoring and sampling stations have been selected to provide appropriate coverage to meet the assessment and modeling needs of the watershed characterization process.

1.1 Program Overview

This FMSP describes the water quality monitoring program for the ambient sampling of Northern Kentucky streams. The purpose of the FMSP is three fold:

- To supplement the Quality Assurance Project Plan (QAPP)
- To provide project and field staff with an understanding of the program and how to complete the base flow monitoring program; and,
- To define the level of effort and analytical needs.

The FMSP is intended to provide practical assistance in obtaining representative and reliable data in a technically sound and safe manner.

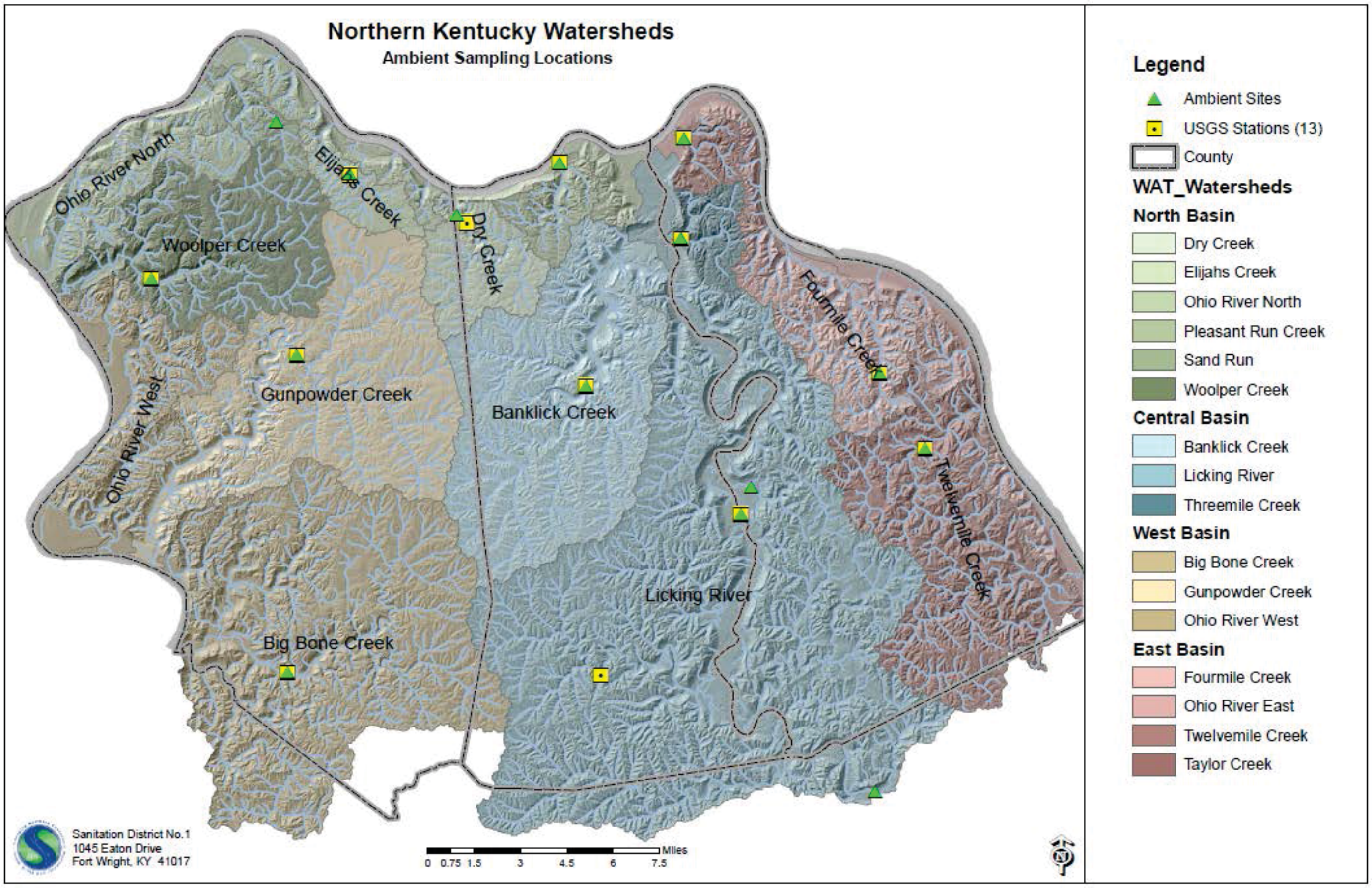
The procedures and protocols presented in this document address the following water quality and quantity monitoring program components:

- Monitoring and sampling criteria
- Stream water quality monitoring
- Sample handling and transportation
- QA/QC requirements
- Program Health and Safety

This program was designed to collect data that will be used to assess variation of water quality concerns identified in Northern Kentucky watersheds. The ambient data collected in Northern Kentucky streams is required to support water quality modeling, and pollutant source identification.

Figure 1 shows locations in the watersheds of the Northern Kentucky area that have been identified as monitoring and sampling stations. The sampling locations shown in Figure 1 are discussed in more detail in Section 3.

Figure 1 Monitoring and Sampling Stations



1.2 Monitoring Team

The monitoring team consists of the Project Manager, the Field Manager, and sampling crew. Responsibilities of key team members are listed in Table 1.

Table 1 Team Member Responsibilities

Position	SD1 Team Member	Responsibilities
Project Manager	Mindy Scott	• Assess suitability of sampling events • Perform System Audits • Circulation of reports and results • Staff Training • Review Reporting • Ensure necessary resources are available • Creation of event reports • QA/QC review
Field Manager	Elizabeth Fet	• Implementation of FMSP • Initiate sampling events • Coordinate with laboratory • Mobilize field crews • Collection and review of field logs, lab results, and other program documentation • Ongoing management of field staff and equipment

Prior to the first sampling event, a flowchart will be created which contains all members of the different sampling crews and laboratory contacts along with their respective contact numbers (home, work, and/or cellular numbers). This will allow for a network of communication prior to and during the monitored events. A communication network for the sampling team is essential to the ability to adapt the sampling program to changing environmental or weather conditions and/or equipment malfunctions.

2. *Monitoring and Sampling Criteria*

The objective of the ambient monitoring and sampling program is to represent varying conditions with respect to the amount of development, as well as sources of stream pollution in each watershed. SD1 is implementing this program to further characterize stream conditions under a wide range of environmental conditions.

The criteria used to define the ambient sampling include:

- Weather conditions will vary, but sampling will be conducted unless deemed unsafe

The goal will be to conduct the sampling in varying weather conditions. The sampling will be distributed throughout the monitoring period by basin to characterize Northern Kentucky streams during fluctuating flow conditions.

Local conditions may require these criteria to be modified as the study progresses. Best professional judgment will be necessary to assess the suitability of a particular biweekly sampling event.

3. STREAM CHARACTERIZATION

Stream monitoring and sampling will be conducted at designated stations along Northern Kentucky streams as shown in Figure 1. Water quality monitoring and sampling will be conducted as follows:

- Samples will be collected at all sites on the designated day as shown on the corresponding schedule according to the surface water quality monitoring program protocols;
- All sites will be characterized on-site for in-stream water quality measurements (temperature, dissolved oxygen, pH, conductivity and turbidity).

Table 2 describes each of the stations as depicted in Figure 1. Station selection was based on an initial watershed reconnaissance, which focused upon suitable site configuration for stream sampling and location relative to key pollutant source inputs. Once final sampling locations were identified, latitude and longitude coordinates were obtained with a Global Positioning System (GPS) unit and recorded.

Standard operating procedures (SOPs) referenced in the following sections are provided in Appendix A.

Table 2 Ambient Monitoring Locations

Basin	Watershed/Sites	Locations	Description
Central	Licking (3)	LIR19.3	Visalia Bridge 536 (USGS)
		LIR35.5	Butler, KY
		POC0.9	Bridge on Indian Trace by Joann Lane
	Banklick (1)	BLC8.1	Richardson Road Bridge (USGS)
	Threemile (1)	THC0.7	Threemile Creek Road (USGS)
East	Fourmile (1)	FMC6.9	Poplar Ridge Road (USGS)
	Twelvemile (1)	TMC3.0	Route 1997 (USGS)
	Taylor (1)	TYC0.6	Donnermeyer Drive under 471 (USGS)
North	Woolper (1)	WPC5.0	Woolper Road (USGS)
	Elijahs (1)	EJC2.8	Elijah Creek Road (USGS)
	Dry Creek (1)	DRC1.4	Dry Creek WWTP (USGS)
	Pleasant Run (1)	PRC0.3	Bridge on Oak Street (USGS)
	Sand Run (1)	SDR4.0	Thornwilde Subdivision
West	Gunpowder (1)	GPC14.7	Camp Ernst Road (USGS)
	Big Bone (1)	MLC3.0	Bridge at US 42 (USGS)
		15 total sites	

3.1 On-Site Water Quality Measurements

All sites will be subject to on-site measurements during sampling events. On-site measurements will include DO, pH, temperature, conductivity and turbidity.

On-site water quality instrumentation will be calibrated and maintained in accordance with *Standard Operating Procedures Hydrolab Series 5 Water Quality Instrumentation.*

3.2 Ambient Sampling

Most sampling locations are accessible by bridges or by wading. Table 3 presents the monitoring schedule for the surface water sampling program for biweekly sampling. All sampling will be performed by SD1 staff. Biweekly samples will be collected as grab samples in accordance with *Standard Operating Procedures for the Collection of*

Discrete Water Samples. Biweekly sampling events will be completed by day, utilizing two person crews as described in Table 3.

All grab samples will be collected with a sampling pole, stainless steel bucket or glove method. Sampling events will start at the downstream site and progress upstream. This approach to biweekly sampling is designed to collect a representative sample of current conditions in the stream. Immediately after sample collection, on-site measurements will be taken as previously described.

Table 3   Ambient Monitoring Schedule

Day One

Watershed	Site	Description
Big Bone	MLC3.0	Bridge at US 42 (USGS)
Gunpowder	GPC14.7	Camp Ernst Road (USGS)
Woolper	WPC5.0	Woolper Road (USGS)
Elijahs	EJC2.8	Elijah Creek Road (USGS)
Sand Run	SDR4.0	Thornwilde Subdivision

Day Two

Watershed	Site	Description
Licking River	POC0.9	Bridge on Indian Trace by Joann Lane
	LIR19.3	Visalia Bridge 536 (USGS)
	LIR35.5	Butler, KY
Twelvemile	TMC3.0	Route 1997 (USGS)
Fourmile	FMC6.9	Poplar Ridge Road (USGS)

Day Three

Watershed	Site	Description
Banklick	BLC8.1	Richardson Road Bridge (USGS)
Threemile	THC0.7	Threemile Creek Road (USGS)
Taylor	TYC0.6	Donnermeyer Drive under 471 (USGS)
Pleasant Run	PRC0.3	Bridge on Oak Street (USGS)
Dry Creek	DRC1.4	Dry Creek WWTP (USGS)

3.3 Summary

Table 4 presents a summary of the field monitoring and sampling plan for Northern Kentucky watersheds.

Table 4 Summary of Water Quality Monitoring and Sampling Program

Type	Locations	Description	Parameters
Ambient Sampling	15 total locations, throughout Northern Kentucky 4 basins (North, Central, West, East)	♦ Samples collected one week per month (March, April, June, August, October and November) ♦ Samples collected twice per month (May, July, and September) ♦ 1 grab sample per site	♦ On-site measurements will include: ***temperature, dissolved oxygen, pH, conductivity and turbidity.*** ♦ Water quality parameters will include: ***bacteria (EC), nitrogen (TKN, NH_3, NO_3-NO_2), phosphorus (total and ortho), total suspended solids, and $CBOD_5$.***

Table 5 summarizes the number of samples to be collected exclusive of quality control protocols.

Table 5 Summary of Number of Samples to be Collected

Task	Day One	Day Two	Day Three
Day Sampled	Tuesday	Wednesday	Thursday
No. of Events per week	1	1	1
No. of Sites	5	5	5
Bacteria			
E. coli	5	5	5
Nutrients			
NH_3	5	5	5
NO_3- NO_2	5	5	5
TKN	5	5	5
Total Phosphorus	5	5	5
Ortho Phosphate (field filtered)	5	5	5
Solids			
TSS	5	5	5
Other			
$CBOD_5$	5	5	5
Total Sample Load	**45**	**45**	**45**

4. *Field Measurements*

In-stream dissolved oxygen, temperature, pH, conductivity, and turbidity will be measured using appropriate field instruments concurrent with sample collection at each of the sampling locations. Each on-site parameter will be measured at each location during each sampling event. Table 6 lists the parameters, location of measurement at each site, and method of measurement.

Field measurements will be conducted following the Standard Operating Procedures in Appendix A. Field instruments will be calibrated before initiating monitoring activities for each event. A post-monitoring calibration check will also be conducted at the end of each monitoring event. All calibration and maintenance activities will be documented on the Multiprobe Instrumentation Calibration and QA Sheet (see Appendix A).

Measurements will be documented on the Field Data Sheet (see Appendix C). Documentation will include: date/time, location, type of measurement, personnel, equipment and associated calibration specifications, and general site observations (e.g., weather conditions).

Table 6. Field Measurements

Parameter	Location of Measurement	Method
Temperature	Mid-channel, mid-depth where possible	Hydrolab
Conductivity		
pH		
Dissolved Oxygen		
Turbidity		

5. *SAMPLING HANDLING AND CUSTODY*

The following sections outlines the sample labeling procedures, sample handling, chain-of-custody and record keeping required.

5.1 Sample Labeling

All samples will be assigned a unique identification code such that all necessary information can be attained from the sample label. The labels will be available in an electronic template and can be printed once the information has been added to the template. The code will identify the following:

Label:	___ ___ ___ ___. ___
	1 2 3 4 5

Characters 1-5:	Sample Site ID
Example:	FMC0.5

In addition to the label, the sample bottles will be clearly marked using waterproof ink with the following information:

- Client – SD1
- Analyses – List of requested analyses to be performed from the container
- Preservative – Preservative in sample container
- Date – Date sample was collected
- Time – Time sample was collected
- Crew – Crew identification

5.2 Sampling Collection, Handling and Transport

General guidelines for sample collection are listed below. Refer to *Standard Operating Procedures for the Collection of Discrete Water Samples* for detailed procedures.

- All samples collected in intermediate sampling containers should be transferred to their appropriate laboratory sample bottle as quickly as possible.
- Sampling location codes will be used to distinguish each distinct sampling location.
- Sample labels and chains of custody must be filled out completely.

The following procedures will be followed when handling and transporting samples:

- Samples will be preserved using ice and transported in sample coolers. It should be ensured that plenty of ice is used for each sample cooler to maintain the temperatures inside the cooler at approximately 4° C.
- Laboratory chain-of-custody forms will be included with all sample submissions. Field staff will keep copies.
- Sample bottles and coolers should be handled with care to prevent breakage/spillage.
- All sample bottle labels must be properly completed and placed firmly on each bottle by the field sampling crews.

5.3 Chain-of-Custody

Field crews will complete chain-of-custody forms to document the transfer of sample custody to the designated custodian and subsequent personnel, see Appendix B. Signatures of all personnel involved in the collection, transport, and receipt of each sample will be recorded on the chain-of-custody forms.

In certain instances, sample custody will be transferred to runners to transport the samples directly to the laboratory at designated times during sampling to avoid missing holding times. The chain-of-custody form outlines sample location, identification, collection time and date, and specific parameters to be analyzed for each sample. A properly completed chain-of-custody form must accompany all samples.

Use of the chain-of-custody form will terminate when laboratory personnel receive the samples and sign the form. The laboratory will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the chain-of-custody form. Any discrepancy between the sample bottle and the chain-of-custody form, any leaking sample containers, or any other abnormal situation will be reported to the Laboratory Manager. The Laboratory Manager will inform the Project Manager of any such problem, and corrective actions will be discussed and implemented.

5.4 Field Logs and Records

Field crews will document all activities associated with the monitoring program at each monitoring site, including unusual or anomalous conditions. In addition, a description of any problems encountered during the monitoring period and/or any deviations to the FMSP will also be documented. This information may subsequently be used for data interpretation and analyses.

All pertinent information will be recorded on Field Data Sheets which are included as Appendix C.

At the conclusion of each monitored event, all Field Data Sheets will be submitted to the Field Manager to serve as a chronological representation of the monitored event. At a minimum each data field sheet should include the following information:

- Project name, site/river name, sample type;
- Crew identification, date, start time/end time;
- Weather conditions, stream conditions, site conditions;
- Physical parameter data (on-site measurements);
- On-site water quality meter identification number used to measure physical parameter data;
- Field observations.

All entries will be completed with a permanent ink pen with no erasures, correction fluid, or tape used. Erroneous entries will be noted using a single line drawn through the mistake that is then dated and initialed.

5.5 Sample Containers and Preservation

Table 7 presents details of sample containers and preservatives to be used. The laboratory will provide all bottles pre-preserved.

Table 7 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Maximum Storage Time
Bacteria				
E. coli	Pre-Sterilized Polyethylene or Glass	120 ml	Add $Na_2S_2O_7$ [1] Refrigerate to 4°C	12 hours[2]
Nutrients				
NH_3 TKN NO_3-NO_2 Total Phosphorus	Polyethylene or Glass	1000 ml	Add H_2SO_4, pH<2 Refrigerate to 4°C	28 days
Ortho Phosphate	Polyethylene or Glass	120 ml	Field filter Refrigerate to 4°C	48 hours
Conventional				
TSS	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	7 days
$CBOD_5$	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	48 hours

1. Sodium Thiosulfate ($Na_2S_2O_7$) prevents continuation of bacteriocidal action.
2. The maximum allowable holding time for bacteria samples will be 12 hours with a goal of 6 hours when practical.

6. QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The purpose of any quality assurance/quality control (QA/QC) program is to ensure that all sampling protocols and procedures are followed such that samples are representative of the water quality to which they are associated. The program is designed to be a systematic process, which together with the laboratory QA/QC program ensures a high degree of confidence in the data collection. The proposed QA/QC program includes the following elements:

- Training of all field staff;
- Field quality control procedures;
- Equipment cleaning protocol;
- QA/QC samples; and,
- Equipment calibration.

6.1 Training

Training sessions will be carried out for all field staff on proper sampling, sample handling and submission and general field procedures. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field crews will receive training involving the operation, maintenance and calibration of water quality meters, and all other on-site equipment used throughout the field program. SOPs for all program elements will be distributed to staff and available at all times.

6.2 Field Quality Control

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, necessary precautions must be taken to protect samples from contamination and deterioration. Procedures detailed in *Standard Operating Procedures for the Collection of Discrete Water Samples* and *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation* will be followed to ensure field quality control.

6.3 Equipment Cleaning Protocol

All sampling equipment (i.e. intermediate containers, sampling buckets, etc.) will follow the QA/QC protocol outlined in *Standard Operating Procedures for the Collection of Discrete Water Samples* to ensure representative sample collection. When using the sampling pole or stainless steel bucket, only step 2 (Blank Water Rinse) of the decontamination procedure needs to be utilized.

6.4 QA/QC Samples

The monitoring team will use three types of QA/QC samples collected in the field to assist in validating chemical data sets – sample duplicates, equipment blanks, and field blanks. Each type of QA/QC sample is described in the following sections. Tables 8 and 9 present the schedule and number of QA/QC samples to be collected during the field program.

Table 8 QA/QC Sample Schedule

Ambient Sampling			
Day	Tuesday	Wednesday	Thursday
	Dup*, FB, MB	Dup*, FB, MB	Dup*, FB, MB
MB= Method Blank Dup = Duplicate FB = Field Blank * = Dup will rotate between days			

Table 9 Number of QA/QC Samples

Ambient Sampling	Field Blanks[2]	Method Blanks[3]	Duplicate Samples[4]	Total per Event
Day 1	1	1	1	3
Day 2	1	1	0	2
Day 3	1	1	0	2
Totals	**3**	**3**	**1**	**7**

1. Each QA/QC sample set is performed on the complete series of samples submitted for laboratory analysis.
2. One set of field blanks per day will be collected during each day of the week.
3. One set of method blanks (at one site) per day will be collected during each day of the event.
4. One set of duplicates (at one site) will be collected during each week.

6.4.1 *Sample Duplicates*

Sample duplicates will be collected for laboratory analysis for each parameter. The purpose of these analyses is to evaluate sample collection precision by comparing the duplicate analytical results. One set of duplicate samples at a sampling location, randomly identified, will be collected by each field crew during the sampling event. Duplicates will be rotated among streams between sampling rounds. Approximately 10 percent of the samples will be collected in duplicate.

6.4.2 *Method Blanks*

Method blanks (MB) will be collected for laboratory analysis for orthophosphate only. The purpose of these analyses is to assess potential cross-contamination of samples by the method in which the sample was collected. These blanks will be taken at the conclusion of each sampling shift by each crew.

6.4.3 *Field Blanks*

Field blanks will be collected for laboratory analysis for all parameters. The purpose of these analyses is to determine if samples collected have been contaminated by field handling and cleaning methods. Each field crew will collect these blanks immediately following the collection of the AEB equipment blanks.

6.5 Equipment Calibration

On-site physical parameters will be measured in-stream by water quality meters and recorded on data sheets. These instruments will be calibrated each sampling day before use according to the manufactures operating manual as outlined in *Standard Operating Procedures for Hydrolab Series 5 Water Quality Instrumentation*.

At the conclusion of the sampling event, each meter will be checked with the standards used during calibration. The purpose of these readings is to evaluate the meter's precision (electronic drift) by comparing the readings recorded during calibration and the readings recorded during the check at the end of the sampling day.

At the conclusion of each sampling event, all Calibration Sheets will be submitted to the Field Manager to serve as a record of the meter's performance during the sampling event.

7. Program Safety

The most critical component of a sampling program is crew safety. Safety is of paramount importance as stream sampling can be extremely dangerous. The element of danger is accentuated if personnel are unfamiliar with their surroundings and/or procedures, consequently staff must be properly trained in both safety and monitoring procedures, following a well thought out program.

With stream monitoring, common sense is essential. Two hazards that field staff may face more often, especially if wet weather occurs during sampling, are high stream conditions and slippery footing. If stream levels are deemed to be too high or too fast, under no circumstances should any field staff enter the stream or operate near its banks. With surfaces being wet and slippery, special care must be taken when walking and working around bridges.

Wading is one of the easiest methods to collect samples from many streams, and it may also be extremely dangerous. Wading permits the investigator to examine stream flow and decide where to sample. Rubber boots or even chest-high waders are standard equipment. If the wader has any uncertainty about their ability to wade a stream, they should be attached by a rope to a rigid mooring and wear an approved floatation device.

If creek conditions are high and fast, field staff will wear a safety belt or harness and will be appropriately tethered when working in close proximity to the creek. Along with being attached by rope, field staff must wear an approved floatation device.

There must be a minimum of two field staff working together during any sampling event.

7.1 General Safety Practices

- Water depth during wading operations must be checked with a pole before steps are taken.
- When wading equipment is worn, the support straps must be outside the clothing.
- In all situations field parties are required to leave accurate sampling schedules and expected itineraries in the office.
- Sampling must never be carried out in weather that is considered by the Field Manager or field member to be hazardous to the well-being of the field staff and/or equipment.
- Field staff are required to wear approved floatation devices and be tethered if conditions warrant use.
- First aid kits will be issued to all field crews.
- Each field crew will have a cellular phone and have been instructed on emergency procedures and numbers.
- Each field crew will report upon leaving and returning from any sampling or field work to their Field Manager.
- Each field crew will have appropriate lights, markers, etc. to be able to perform their work safely under poor visibility/nightfall.
- Each field crew will have the appropriate road safety equipment as required.

7.2 Health Hazards

Disease causing bacteria, viruses, and parasites are always present in sewers and discharge streams. They occur in both liquid sewage and dry sludge which coats pipes, and other surfaces. The serious threats are Hepatitis A (virus), Hepatitis B (virus), Tetanus (bacteria), Typhoid (bacteria), and Polio (virus). Proper hygiene methods must be followed. Wash hands before eating or smoking. Protective clothing must be laundered and equipment kept clean. Workers should avoid touching their eyes to prevent an inflammation. Cuts and abrasions of the skin should be covered by bandages or gloves to minimize the chance of infection by organisms.

APPENDIX A

STANDARD OPERATING PROCEDURES
FOR FIELD MONITORING AND SAMPLING

Standard Operating Procedures

for the

Collection of Discrete Water Samples

Northern Kentucky Sanitation District No. 1
1045 Eaton Drive
Fort Wright, KY 41017

Revision Number: 1
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Introduction
This document describes the procedures for the collection of discrete water samples in Northern KY watersheds by Sanitation District No.1. These methods allow for the collection of grab or composite samples utilizing various sample collection techniques. This standard operating procedures document (SOP) has been developed to maintain consistent data collection procedures, and to ensure the quality of the data collected.

1.0.0 Field Equipment

The following equipment is needed to implement the sampling techniques.

- Stainless Steel Bucket w/ Rope
- Sampling Pole
- Kemmerer Sampling Bottle Kit
- Churn Sample Splitter
- Chemical Decontamination Agent (Solvent or Weak Acid)
- Chemical Waste Bucket
- Blank Water (Distilled or Reagent Grade Deionized – RGDI)
- Sample Bottles
- Coolers and Ice
- Scrub Brush
- Disposable Gloves
- Field Sampling Plan
- Permanent Marker (Sharpie)

Individuals handling solvents or acids should wear rubber gloves and eye protection to prevent possible injuries.

The following parameters can be collected with the ensuing sampling techniques: bacteria (fecal coliform and *E. coli*), oxygen demand (BOD_5 , $CBOD_5$, COD), chlorophyll *a*, nutrients (total phosphorus, orthophosphate, nitrate-nitrite, Total Kjeldahl Nitrogen, ammonia), total hardness, metals, and solids (TSS, TDS).

Refer to Attachment 1 for an alternative collection procedure for parameters that do not require preservatives utilizing the glove method.

Refer to Attachment 2 for filtration procedures for orthophosphate collection.

2.0.0 Preparation

Before collecting samples, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative, and the name of the collecting entity and sampling crew member) on all bottles using a permanent marker and affix the labels to the bottles. Ideally, the labels are filled out (except date and time) and attached to the sample bottles before the sampling event occurs. In addition to the sample label, identify the lid of each container with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers should be wiped down or washed with a mild soap and thoroughly rinsed if it has any contaminants present. In addition all sampling equipment must be inspected for proper operation.

The sampler's hands should be washed with a mild soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the sample bottles or lids.

3.0.0 Procedures

Keep all sampling bottles closed until they are ready to be filled. At each collection site, the sampler will wear a new set of gloves for decontamination procedures and new set of gloves for sample collection. If sampling from a boat or structure, collect the sample from the upstream side. Avoid placing the sampling device in contact with the streambed or bank. Once the sample is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.1.0 Stainless Steel Bucket

Prior to sampling, the stainless steel bucket must be inspected to ensure that is in good condition, and that the nylon rope is not torn or frayed.

3.1.1 Decontamination Procedures

The stainless steel bucket must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the outer lip and the inside of the bucket with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the bucket thoroughly with the chemical.
- Discard the chemical into the waste container.
- Rinse the inside of the bucket with blank water.
- Discard the blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the outer lip and the inside of the bucket with blank water.
- Discard the blank water.
- Repeat Step 3.

3.1.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – River Rinse

- Rinse the bucket with river water by submerging the bucket into the stream at the collection site.
- Remove the bucket from the stream and discard its contents downstream of where the sample will be collected.

Step 2 – Sample Collection

- Lower the bucket into the stream to obtain a surface grab sample.
- Remove the bucket from the stream.
- Fill the required sample bottles.

3.2.0 Sampling Pole

The pole must be inspected to ensure it is clean and all parts are working properly. Prior to sampling, ensure the bottle is properly attached and snapper band is securely fastened. Once pole is extended, verify that the locking mechanism is secured.

3.2.1 Decontamination Procedures

The sampling pole and bottle attachment must be cleaned before each sample is collected.

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the entire pole with an Alconox detergent solution (blank water).
- Discard the detergent solution.
- Rinse the entire pole with blank water.
- Discard the blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Blank Water Rinse

- Rinse the bottle attachment with blank water.
- Discard blank water.
- Repeat Step 2.

3.2.2 Sample Collection Procedures

Discrete surface grab samples (most often used for shallow water sampling from a bridge or stream bank) are collected using the following procedures.

Step 1 – Sample Collection

- Attach a clean unpreserved bottle onto the pole.
- Lower the bottle into the stream to obtain a surface grab sample.
- Make sure the bottle does not touch the bottom of the stream and try to avoid floating debris entering the bottle.
- Remove the bottle from the stream.
- Repeat as necessary to fill the required sample bottles. (Attempt to proportional divide the sample volume equally between sample bottles in order to average out any temporal variations.)
- Detach the bottle from the pole and:
    a) If using a sample bottle, place in the cooler.
    b) If using a transfer bottle, discard when finished.

3.3.0 Kemmerer Sampling Bottle

Prior to sampling, the Kemmerer must be inspected to ensure that the triggering mechanism is functioning properly, and that the nylon rope is not torn or frayed.

3.3.1 Decontamination Procedures

The Kemmerer must be cleaned before each sample is collected.

Step 1 – Chemical Rinse – Solvent or Weak Acid (Optional)

- Rinse the inside of the Kemmerer thoroughly with the chemical.
- Purge a small amount of the chemical from the drain valve into the waste container.
- Open the top and discard the remaining chemical into the waste container.
- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve into the waste container.
- Open the top and discard the remaining blank water into the waste container.

Step 2 – Blank Water Rinse

- Rinse the inside of the Kemmerer with blank water.
- Purge a small amount of the blank water from the drain valve.
- Discard the remaining blank water.
- Repeat Step 2.

3.3.2 Sample Collection Procedures

Discrete water column grab samples (most often used for deep water sampling from a boat) are collected using the following procedures.

Step 1 – River Rinse

- Open the Kemmerer bottle.
- Rinse the Kemmerer with river water by submerging it into the stream at the collection site.
- Remove the Kemmerer from the stream.

Step 2 – Sample Collection

- Lower the Kemmerer to the appropriate depth (utilize the boat fathometer to determine mid-depth and bottom depth).

    a) Surface – Lower the Kemmerer to a depth of approximately one-foot below the surface.
    b) Mid-Depth – Lower the Kemmerer to the appropriate depth.
    c) Bottom – Lower the Kemmerer to a depth of approximately two-feet from the bottom (If Kemmerer contacts bottom sediment, repeat decontamination procedures before sample collection).

- Activate the closing mechanism of the Kemmerer to acquire sample volume.
- Remove the Kemmerer from the stream.
- Purge a small amount of sample volume from the drain valve.
- Fill the required sample bottles.

3.4.0 Churn Sample Splitter

Prior to sampling, the churn sample splitter must be inspected to ensure that is in good condition, and that it is functioning properly.

3.4.1 Decontamination Procedures

The churn sample splitter must be cleaned before sub-samples are homogenized. In addition, the appropriate sample collection device must also be cleaned (stainless steel bucket – 3.1, sampling pole – 3.2 or Kemmerer – 3.3).

Step 1 – Alconox Detergent Wash (Optional)

- Using a small brush, scrub the plunger and the inside of the churn splitter with an Alconox detergent solution (blank water).
- Purge a small amount of the wash solution from the spigot.
- Discard the remaining detergent solution.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat the rinsing cycle until all the detergent has been removed.

Step 2 – Chemical Rinse – Weak Acid (Optional)

- Rinse the plunger and the inside of the churn splitter thoroughly with the chemical.
- Purge a small amount of the chemical from the spigot into the waste container.
- Discard the remaining chemical into the waste container.
- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot into the waste container.
- Discard the remaining blank water into the waste container.

Step 3 – Blank Water Rinse

- Rinse the plunger and the inside of the churn splitter with blank water.
- Purge a small amount of the blank water from the spigot.
- Discard the remaining blank water.
- Repeat Step 3.

3.4.2 Sample Collection Procedures

Sub-samples (vertical or horizontal), obtained with a stainless steel bucket, sampling pole or Kemmerer bottle are homogenized into composite samples using the following procedures.

Step 1 – River Rinse

- River rinse by filling the churn splitter with the sampling device at the collection site.
- Purge a small amount of the stream water from the spigot.
- Discard the remaining contents.

Step 2 – Sample Collection

- Obtain sub-samples following either stainless steel bucket, sampling pole, or Kemmerer collection procedures.
- Fill the churn splitter with approximately equal volumes from each sub-sample.

Step 3 – Homogenizing Sub-samples

- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.0.0 Quality Assurance

Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1.0 Duplicate Samples

To collect duplicate grab samples fill the required bottles from the same stainless steel bucket, sampling pole, or Kemmerer. To collect duplicate composite samples fill the required bottles from the Churn Splitter sample volume.

4.2.0 Blanks

Blanks should be collected during each day of the survey. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blanks

Pour blank water from an unopened container directly into the sample bottle.

4.2.2 Equipment Blanks

Equipment blanks should be collected at the beginning and end of each survey day.

Stainless Steel Bucket

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the stainless steel bucket with enough blank water to fill the sample bottles.
- Fill the required sample bottles.

Sampling Pole

- The method for this device does not require a blank.

Kemmerer Bottle

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the Kemmerer with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the Kemmerer.
- Fill the required sample bottles.

Churn Sample Splitter

- Perform the "Blank Water Rinse" (Decontamination Procedure) for a total of three rinses.
- Fill the appropriate collection device (Kemmerer or stainless steel bucket) with enough blank water to fill the sample bottles.
- Purge a small amount of blank water from the appropriate collection device.
- Pour the blank water from the collection device into the churn splitter.
- Mix the contents of the churn splitter, at a uniform churning rate, for 10 strokes prior to withdrawal of the first sample.
- Purge a small amount of sample volume from the spigot.
- While continuing to churn the sample volume, fill the required sample bottles.

4.2.3 Trip Blanks (Optional)

Depending on study design, a trip blank may be utilized. This is a sample of RGDI water taken from the laboratory to the sampling site and returned to the laboratory unopened.

5.0.0 Chain of Custody Procedures

All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

Attachment 1
Collection of Unpreserved Parameters Utilizing the Glove Method

Introduction
This attachment describes the procedures for the collection of grab samples into unpreserved bottles utilizing the glove method. This method has been implemented to eliminate the use of sampling equipment (i.e. stainless steel bucket or Kemmerer) for collecting surface samples. The elimination of equipment reduces cleaning procedures and possible sources of contamination. In addition, this method significantly reduces sampling time.

1.0 Field Equipment
The following equipment is needed to implement the Glove Method collection technique.

- Disposable Gloves
- Sterilized Unpreserved Sample Bottles
- Cooler and Ice
- Permanent Marker (Sharpie)
- 1 Gallon Container of Blank Water (Distilled or RGDI)
- Anti-Bacteria Soap
- Knife

2.0 Preparation
Before collecting the sample, properly fill out the label (date, time, sampling point, sample ID number, analysis required, preservative and the name of the collecting entity and crew member) using a permanent marker and affix the label to the bottle. Ideally, the label is filled out (except data and time) and attached to the sample bottle before the sampling event occurs. In addition to the sample label, identify the lid of the bottle with the sample ID number using the permanent marker.

Prior to collecting samples, both the coolers and the sample bottles should be visually inspected for presence of any dirt, chemicals, or other contaminants. If a sample bottle has any contaminants present, discard it and use another. The coolers may be wiped down or washed with a mild soap and thoroughly rinsed if they have any contaminants present.

The sampler's hands should be washed with anti-bacteria soap and water immediately before the sampling event begins. When actually collecting the samples, disposable gloves shall be worn and care taken to avoid touching or otherwise contaminating the inner surface of the bottle or lid.

3.0 Procedures
Keep sample bottles closed until they are to be filled. At the collection site, the sampler will wear a new set of gloves and detach the lock mechanism from the lid. Fill the bottle by holding the bottle upright and plunging it into the stream directed toward the current. Keep the lid closed (so as not to lose the dechlorination tablet) until you have reached a depth of 6 to 12 inches below the surface. When the sample is collected, leave ample air space in the bottle to facilitate mixing by shaking. Avoid placing the sample bottle in contact with the streambed or bank. If sampling from a boat or structure, collect the sample from the upstream side.

Fill the bottle to the appropriate level (if more water is collected than needed, carefully pour out the excess) and properly close the lid. If taking a bacteria sample shake the bottle for 30 seconds to expedite dissolving the dechlorination tablet.

After the sample is collected and sealed, the sample bottle should be placed in a cooler and covered with crushed ice. A new set of sterile gloves will be worn for each sample collected.

4.0 QA Samples
Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

4.1 Duplicate Samples
To collect duplicate samples, plunge bottles into the river and fill one immediately after another.

4.2 Blanks
Blanks should be collected at the completion of each survey day. The sampler should wear a new set of gloves for each blank processed. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

4.2.1 Field Blank
Pour blank water from an unopened gallon container directly into the sample bottle.

4.2.2 Method Blank
With a clean pocketknife, cut off the top of the container used for the first field blank. Simulate stream collection by plunging the bottle, while wearing gloves, into the cut open gallon container. Keep the bottle upright and let the water flow over the top of the bottle until it is filled.

5.0 Chain of Custody Procedures
All samples are to be recorded on a Chain of Custody form with its identifying information. The Chain of Custody form is to be signed and submitted to the laboratory along with the samples.

If the sample bottles used have a tie, this tie must be cut in order to open the bottle, and should provide a measure of sample security and integrity.

6.0 Reference
USEPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA/600/8-78/017.

Attachment 2
Collection of Orthophosphate Samples

Introduction
This attachment describes the additional procedures needed for the collection of orthophosphate samples.

1.0 Additional Field Equipment

The following additional equipment is needed to implement the orthophosphate filtration method.

- Disposable 60cc Syringes (Luer-Lok tip)
- Disposable 25 mm Filter Cartridges (1μm Glass Fiber Filter and 0.45μm Nylon Membrane Filter)
- Sample Bottles

2.0 Procedures

A new disposable syringe and filter cartridge (syringe filtration unit) will be used for each sample.

2.1 Decontamination Procedures

The syringe filtration units must be cleaned before each sample is filtered.

Step 1 - Blank Water Rinse

- Rinse the inside of the syringe by plunging 50mls of blank water through the housing.
- Attach the filter cartridge to the syringe.
- Rinse the inside of the entire unit by plunging 50mls of blank water through the unit.

2.2 Sample Collection Procedures

Samples can be filtered from the Kemmerer bottle, sampling pole, stainless steel bucket, or churn splitter using the following procedures.

Step 1 – Sample Filtration/Collection

Fill the syringe filtration unit with sample from the appropriate collection device.
Place the plunger into the syringe.
Purge a small amount of sample volume through the filter.
Discharge water through the filtration unit into a sample bottle.
Repeat the previous three bullets until enough sample has been filtered into the sample bottle.
Discard the syringe filtration unit.

3.0 Quality Assurance

Quality assurance samples should comprise at least 10 percent of the total number of stream samples collected.

3.1 Duplicate Samples

To collect duplicate samples continue to fill the syringe filtration unit from the same Kemmerer, sampling pole, or stainless steel bucket drop and filter into the required bottles.

3.2 Blanks

Blanks should be collected during each day of the survey. Once the blank is collected and sealed, the sample bottle should be immediately placed in a cooler and covered with crushed ice.

3.2.1 Field Blanks

Pour blank water from an unopened container directly into the sample bottle.

3.2.2 Equipment Blanks

Equipment blanks should be collected at the beginning and end of each survey day.

Unfiltered Equipment Blank

An equipment blank utilizing the appropriate collection device should be collected at the beginning of each survey day.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the required sample bottle.

Filtered Equipment Blank

An equipment blank utilizing the syringe filtration unit should be collected at the end of each survey day. The syringe filtration unit is decontaminated using the previously outlined procedure before the blank is collected.

- Fill the appropriate collection device (Kemmerer, sampling pole (utilize clean transfer bottle), stainless steel bucket, or churn splitter) with enough blank water to fill the sample bottle.
- Purge a small amount of blank water from the appropriate collection device.
- Fill the syringe filtration unit with sample from the appropriate collection device.
- Place the plunger into the syringe.
- Purge a small amount of blank water through the filter.
- Discharge water through the filtration unit into a sample bottle.
- Repeat the previous three bullets until enough volume has been filtered into the sample bottle.
- Discard the syringe filtration unit.

APPENDIX B

NORTHERN KY SANITATION DISTRICT NO.1
CHAIN OF CUSTODY

SANITATION DISTRICT NO.1 OF NORTHERN KENTUCKY
1045 Eaton Drive
Fort Wright, KY 41017
Phone: (859) 578-7460 Fax: (859) 331-2436

Chain Of Custody Record

Page ____ of ____

Project Name	Watershed	Survey Location
Ambient Monitoring	Various	Ambient Monitoring Tuesday Sites

Contact Person	Sampler(s) Signature	Survey Type (Circle One)
Mindy Scott		Wet or Dry

Lab ID	Sample ID Code	Date	Time	Composite / Grab	Pole / Bucket / Glove	Sample Location	No. of Containers	E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate					Remarks
								Analysis Required									
	MLC3.0			G		Bridge at US42 (USGS)	5	X	X	X	X	X					
	GPC14.7			G		Camp Ernst Road (USGS)	5	X	X	X	X	X					
	WPC5.0			G		Woolper Road (USGS)	5	X	X	X	X	X					
	EJC2.8			G		Elijah Creek Road (USGS)	5	X	X	X	X	X					
	SDR4.0			G		Thornwilde Subdivision	5	X	X	X	X	X					
	DUP			G		duplicate	5	X	X	X	X	X					
	FB					Field Blank	5	X	X	X	X	X					
	MB					Method Blank	1					X					

Relinquished By: Sampler	Date	Time	Accepted By: Lab Runner	Date	Time	Remarks
Relinquished By: Lab Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

SANITATION DISTRICT NO.1 OF NORTHERN KENTUCKY
1045 Eaton Drive
Fort Wright, KY 41017
Phone: (859)578-7460 Fax: (859)331-2436

Chain Of Custody Record

Page ______ of ______

Project Name	**Watershed**	**Survey Location**
Ambient Monitoring	Various	Ambient Monitoring Wednesday Sites

Contact Person	**Sampler(s) Signature**	**Survey Type (Circle One)**
Mindy Scott		Wet or Dry

Lab ID	Sample ID Code	Date	Time	Composite / Grab	Pole / Bucket / Glove	Sample Location	No. of Containers	Analysis Required: E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate					Remarks
	POC0.9			G		Bridge on Indian Trace by Joann Lane	5	X	X	X	X	X					
	LIR19.3			G		USGS Gage Station Visalia bridge	5	X	X	X	X	X					
	LIR35.5			G		Butler,KY	5	X	X	X	X	X					
	TMC3.0			G		Route 1997 (USGS)	5	X	X	X	X	X					
	FMC6.9			G		Poplar Ridge Road (USGS)	5	X	X	X	X	X					
	DUP			G		duplicate	5	X	X	X	X	X					
	FB					Field Blank	5	X	X	X	X	X					
	MB					Method Blank	1					X					

Relinquished By: Sampler	Date	Time	Accepted By: Lab Runner	Date	Time	Remarks
Relinquished By: Lab Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

SANITATION DISTRICT NO.1 OF NORTHERN KENTUCKY
1045 Eaton Drive
Fort Wright, KY 41017
Phone: (859)578-7460 Fax: (859)331-2436

Chain Of Custody Record

Page ____ of ____

Project Name	**Watershed**	**Survey Location**
Ambient Monitoring	Various	Ambient Monitoring Thursday Sites

Contact Person	**Sampler(s) Signature**	**Survey Type (Circle One)**
Mindy Scott		Wet or Dry

Lab ID	Sample ID Code	Date	Time	Composite / Grab	Pole / Bucket / Glove	Sample Location	No. of Containers	Analysis Required: E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate					Remarks
	BLC8.1			G		Richardson Road Bridge	5	X	X	X	X	X					
	THC0.7			G		Threemile Creek Rd (USGS)	5	X	X	X	X	X					
	TYC0.6			G		Donnermeyer Dr under 471 (USGS)	5	X	X	X	X	X					
	PRC0.3			G		Bridge on Oak Street	5	X	X	X	X	X					
	DRC1.4			G		Dry Creek WWTP (USGS)	5	X	X	X	X	X					
	DUP			G		duplicate	5	X	X	X	X	X					
	FB					Field Blank	5	X	X	X	X	X					
	MB					Method Blank	1					X					

Relinquished By: Sampler	Date	Time	Accepted By: Lab Runner	Date	Time	Remarks
Relinquished By: Lab Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

APPENDIX C

NORTHERN KY SANITATION DISTRICT NO.1
FIELD DATA SHEET

SANITATION DISTRICT NO.1 FIELD DATA SHEET

PROJECT NAME: Ambient
DATE:
SITE / STREAM NAME:
START TIME:
SITE LOCATION: Various
END TIME:
LABORATORY: Dry Creek
SAMPLERS:

SAMPLE TYPE
GRAB COMPOSITE
CIRCLE ONE

SAMPLE MATRIX
SEDIMENT **WATER**
CIRCLE ONE

EQUIPMENT ID: MULTIPROBE SONDE:
STREAM CONDITIONS:
SITE CONDITIONS:
WEATHER CONDITIONS: SUNNY CLOUDY OVERCAST WINDY RAIN SNOW
(CIRCLE APPROPRIATE CONDITIONS)
AIR TEMP (F):

PROJECT DESCRIPTOR: Ambient Monitoring - Thursday Locations

SITE / SAMPLE ID (BANK & DEPTH)	TEMP. (C)	pH	D.O. (mg/L)	SP. COND. (μS/cm)	TURBIDITY (NTU)	FLOW (Feet/sec)	SAMPLE TIME
BLC8.1							
THC0.7							
TYC0.6							
PRC0.3							
DRC1.4							
FB							
MB							
DUPLICATE:							

FIELD OBSERVATIONS:

IF FOUND, RETURN TO:
SANITATION DISTRICT NO.1
1045 EATON DRIVE
FORT WRIGHT, KY 41017
(859) 578-7460

Appendix E: Monitoring Results of SD1 Sampling in Banklick Creek (2008-2021)

Survey_Desc	Coll_Agency	Station_ID	Station_Desc	Date	Time	Par_Name	Result	Meas_Units
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC0.3	Banklick Creek at RM 0.3 (Rt. 177)	6/25/2008	11:45:00 AM	Ecoli	160	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/25/2008	10:40:00 AM	Ecoli	160	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	6/25/2008	2:20:00 PM	Ecoli	134	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	6/25/2008	1:45:00 PM	Ecoli	282	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	6/25/2008	10:00:00 AM	Ecoli	359	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/25/2008	3:00:00 PM	Ecoli	189	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	6/25/2008	3:30:00 PM	Ecoli	132	#/100ml
2008 SD1 Central Basin Base Flow (6/24-25/08)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	6/25/2008	3:10:00 PM	Ecoli	75	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC0.3	Banklick Creek at RM 0.3 (Rt. 177)	8/19/2013	12:55:00 PM	Ecoli	48	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/19/2013	3:00:00 PM	Ecoli	49	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	8/19/2013	3:30:00 PM	Ecoli	74	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/20/2013	10:05:00 AM	Ecoli	1462	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	8/20/2013	12:45:00 PM	Ecoli	395	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	8/20/2013	1:25:00 PM	Ecoli	118	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	8/20/2013	9:10:00 AM	Ecoli	325	#/100ml
2013 SD1 Central Basin Base Flow (8/19-20/13)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	8/20/2013	9:35:00 AM	Ecoli	105	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/9/2015	9:05:00 AM	Ecoli	8300	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/9/2015	9:35:00 AM	Ecoli	12030	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/23/2015	9:35:00 AM	Ecoli	420	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/23/2015	10:10:00 AM	Ecoli	1380	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/6/2015	8:35:00 AM	Ecoli	448	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/6/2015	9:10:00 AM	Ecoli	2490	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/20/2015	10:10:00 AM	Ecoli	24200	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/20/2015	10:45:00 AM	Ecoli	4880	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/3/2015	9:05:00 AM	Ecoli	244	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	9/3/2015	9:35:00 AM	Ecoli	52	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/17/2015	9:25:00 AM	Ecoli	212	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	9/17/2015	9:50:00 AM	Ecoli	160	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/1/2015	9:25:00 AM	Ecoli	688	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	10/1/2015	10:00:00 AM	Ecoli	228	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/15/2015	9:45:00 AM	Ecoli	236	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	10/15/2015	10:10:00 AM	Ecoli	112	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/29/2015	8:45:00 AM	Ecoli	3870	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	10/29/2015	9:13:00 AM	Ecoli	4610	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/12/2015	9:05:00 AM	Ecoli	280	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	11/12/2015	9:40:00 AM	Ecoli	352	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/14/2016	9:05:00 AM	Ecoli	236	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	4/14/2016	9:40:00 AM	Ecoli	420	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/28/2016	8:55:00 AM	Ecoli	15530	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	4/28/2016	9:25:00 AM	Ecoli	7700	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/12/2016	9:30:00 AM	Ecoli	1460	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	5/12/2016	10:00:00 AM	Ecoli	2068	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/26/2016	8:45:00 AM	Ecoli	196	#/100ml

Survey_Desc	Coll_Agency	Station_ID	Station_Desc	Date	Time	Par_Name	Result	Meas_Units
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	5/26/2016	9:25:00 AM	Ecoli	148	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/9/2016	8:45:00 AM	Ecoli	1040	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/9/2016	9:15:00 AM	Ecoli	580	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/23/2016	9:20:00 AM	Ecoli	24200	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/23/2016	9:50:00 AM	Ecoli	14140	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/7/2016	10:00:00 AM	Ecoli	440	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/7/2016	10:15:00 AM	Ecoli	944	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/21/2016	9:00:00 AM	Ecoli	648	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/21/2016	9:25:00 AM	Ecoli	384	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/4/2016	9:50:00 AM	Ecoli	408	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/4/2016	10:20:00 AM	Ecoli	228	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/18/2016	9:05:00 AM	Ecoli	9210	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/18/2016	9:40:00 AM	Ecoli	8160	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/1/2016	9:20:00 AM	Ecoli	344	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	9/1/2016	9:50:00 AM	Ecoli	344	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/15/2016	9:35:00 AM	Ecoli	264	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	9/15/2016	10:05:00 AM	Ecoli	568	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/29/2016	8:40:00 AM	Ecoli	888	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	9/29/2016	9:10:00 AM	Ecoli	1040	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/13/2016	9:25:00 AM	Ecoli	640	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	10/13/2016	12:00:00 AM	Ecoli	164	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/27/2016	9:30:00 AM	Ecoli	396	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	10/27/2016	9:55:00 AM	Ecoli	204	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/10/2016	8:40:00 AM	Ecoli	76	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	11/10/2016	9:05:00 AM	Ecoli	84	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/13/2017	9:15:00 AM	Ecoli	276	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	4/13/2017	9:50:00 AM	Ecoli	816	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/27/2017	9:15:00 AM	Ecoli	64	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	4/27/2017	9:40:00 AM	Ecoli	172	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/11/2017	8:55:00 AM	Ecoli	552	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	5/11/2017	9:25:00 AM	Ecoli	504	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/25/2017	9:00:00 AM	Ecoli	13000	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	5/25/2017	9:30:00 AM	Ecoli	14140	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/8/2017	9:00:00 AM	Ecoli	216	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/8/2017	9:20:00 AM	Ecoli	256	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/22/2017	8:35:00 AM	Ecoli	372	#/100ml
2015-2017 SD1 Biweekly Watershed Sampling	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/22/2017	9:00:00 AM	Ecoli	1304	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC0.3	Banklick Creek at RM 0.3 (Rt. 177)	6/27/2017	9:52:00 AM	Ecoli	252	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	6/27/2017	9:30:00 AM	Ecoli	444	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	6/27/2017	8:50:00 AM	Ecoli	1460	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/27/2017	2:25:00 PM	Ecoli	244	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	6/28/2017	10:00:00 AM	Ecoli	268	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	6/28/2017	11:05:00 AM	Ecoli	580	#/100ml
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	6/28/2017	9:00:00 AM	Ecoli	316	#/100ml

Survey_Desc	Coll_Agency	Station_ID	Station_Desc	Date	Time	Par_Name	Result	Meas_Units
2017 SD1 Central Basin Base Flow (6/27 - 29/17)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	6/28/2017	9:35:00 AM	Ecoli	116	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/13/2017	9:45:00 AM	Ecoli	284	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/27/2017	9:05:00 AM	Ecoli	14140	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/17/2017	9:15:00 AM	Ecoli	32	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/7/2017	9:30:00 AM	Ecoli	100	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/21/2017	9:40:00 AM	Ecoli	68	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/19/2017	9:30:00 AM	Ecoli	52	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/16/2017	10:00:00 AM	Ecoli	740	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	3/29/2018	9:31:00 AM	Ecoli	1644	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/19/2018	9:45:00 AM	Ecoli	228	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/10/2018	9:25:00 AM	Ecoli	256	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/24/2018	9:20:00 AM	Ecoli	384	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/14/2018	9:42:00 AM	Ecoli	408	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/12/2018	9:15:00 AM	Ecoli	92	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/26/2018	9:45:00 AM	Ecoli	92	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/23/2018	8:40:00 AM	Ecoli	100	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/13/2018	9:13:00 AM	Ecoli	332	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/27/2018	8:40:00 AM	Ecoli	776	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/18/2018	9:50:00 AM	Ecoli	36	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/15/2018	8:40:00 AM	Ecoli	14140	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	3/21/2019	8:45:00 AM	Ecoli	40	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	4/25/2019	9:35:00 AM	Ecoli	1140	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/9/2019	9:00:00 AM	Ecoli	176	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/23/2019	9:45:00 AM	Ecoli	220	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/13/2019	9:10:00 AM	Ecoli	408	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/11/2019	9:20:00 AM	Ecoli	92	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/25/2019	8:45:00 AM	Ecoli	120	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/15/2019	10:20:00 AM	Ecoli	64	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/12/2019	9:05:00 AM	Ecoli	52	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/26/2019	9:20:00 AM	Ecoli	12	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/24/2019	9:20:00 AM	Ecoli	24	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/14/2019	9:15:00 AM	Ecoli	112	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/7/2020	9:30:00 AM	Ecoli	68	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	5/21/2020	9:15:00 AM	Ecoli	1844	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	6/11/2020	9:05:00 AM	Ecoli	668	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/16/2020	9:10:00 AM	Ecoli	96	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/30/2020	9:05:00 AM	Ecoli	32	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/13/2020	9:25:00 AM	Ecoli	24	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/10/2020	9:00:00 AM	Ecoli	24	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	9/24/2020	9:05:00 AM	Ecoli	104	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	10/8/2020	9:40:00 AM	Ecoli	20	#/100ml
2016-Present SD1 Ambient Watershed Sampling	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	11/19/2020	9:15:00 AM	Ecoli	28	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/6/2021	10:05:00 AM	Ecoli	256	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	7/6/2021	9:55:00 AM	Ecoli	328	#/100ml

Survey_Desc	Coll_Agency	Station_ID	Station_Desc	Date	Time	Par_Name	Result	Meas_Units
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/6/2021	9:25:00 AM	Ecoli	212	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	7/6/2021	9:05:00 AM	Ecoli	116	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	7/6/2021	8:50:00 AM	Ecoli	192	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	7/6/2021	9:45:00 AM	Ecoli	88	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	7/6/2021	9:35:00 AM	Ecoli	116	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/13/2021	10:20:00 AM	Ecoli	5656	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	7/13/2021	10:10:00 AM	Ecoli	1104	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/13/2021	9:45:00 AM	Ecoli	1164	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	7/13/2021	9:25:00 AM	Ecoli	3684	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	7/13/2021	8:50:00 AM	Ecoli	1140	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	7/13/2021	9:55:00 AM	Ecoli	1460	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	7/13/2021	9:40:00 AM	Ecoli	2452	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/20/2021	10:50:00 AM	Ecoli	264	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	7/20/2021	10:40:00 AM	Ecoli	296	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/20/2021	10:25:00 AM	Ecoli	352	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	7/20/2021	10:00:00 AM	Ecoli	452	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	7/20/2021	9:45:00 AM	Ecoli	640	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	7/20/2021	10:30:00 AM	Ecoli	200	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	7/20/2021	10:15:00 AM	Ecoli	180	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	7/27/2021	10:10:00 AM	Ecoli	68	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	7/27/2021	10:00:00 AM	Ecoli	204	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	7/27/2021	9:40:00 AM	Ecoli	36	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	7/27/2021	9:15:00 AM	Ecoli	124	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	7/27/2021	9:00:00 AM	Ecoli	136	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	7/27/2021	9:50:00 AM	Ecoli	164	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	7/27/2021	9:30:00 AM	Ecoli	108	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC1.2	Banklick Creek at RM 1.2 (Winston Avenue Bridge (Ky 16))	8/3/2021	9:55:00 AM	Ecoli	60	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC3.9	Banklick Creek at RM 3.9 (Eaton Dr bridge)	8/3/2021	9:40:00 AM	Ecoli	240	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC8.1	Banklick Creek at RM 8.1 (Richardson Rd. bridge)	8/3/2021	9:20:00 AM	Ecoli	44	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC11.6	Banklick Creek at RM 11.6 (Independence Station Rd.)	8/3/2021	9:00:00 AM	Ecoli	1164	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BLC15.6	Banklick Creek at RM 15.6 (Maher Rd. bridge)	8/3/2021	8:45:00 AM	Ecoli	68	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	BPC0.1	Bullock Pen Creek at RM 0.1 (bridge off Bullock Pen Rd.)	8/3/2021	9:30:00 AM	Ecoli	92	#/100ml
2021 SD1 Five in Thirty Day Event (7/6-8/3/21)	SD1	FWC0.1	Fowler Creek at RM 0.1 (Rt. 17 bridge)	8/3/2021	9:15:00 AM	Ecoli	168	#/100ml

Appendix F: Method for Estimating Discharge

Site	Event Date				
	7/6/2021	7/13/2021	7/20/2021	7/27/2021	8/3/2021
	Discharge	Discharge	Discharge	Discharge	Discharge
BLC 1.2	9.6	57.9	30.8	11.2	5.9
BLC 3.9	8.5	51.2	27.2	9.9	5.2
BLC 8.1	5.1	30.8	16.4	6.0	3.2
BLC 11.6	2.5	15.3	8.2	3.0	1.6
BLC 15.6	0.8	5.0	2.6	1.0	0.5
BPC 0.1	1.9	11.2	6.0	2.2	1.2
FWC 0.1	1.3	8.1	4.3	1.6	0.8

	MAF (cfs)	Ratio
BLC 1.2	65.4	1.8793103
BLC 3.9	57.8	1.6609195
BLC 8.1	34.8	1
BLC 11.6	17.3	0.4971264
BLC 15.6	5.62	0.1614943
BPC 0.1	12.7	0.3649425
FWC 0.1	9.11	0.2617816

Actual discharge measured at gage at time of sample

Estimated Discharge based on MAF Ratio - (Actual Discharge from BLC 8.1 X MAF Ratio for Site)