Source: SD1

Fourmile Creek
Watershed Characterization Report

Prepared for: Sanitation District No. 1 of Northern Kentucky

January 2009

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

Table of Contents

List of Figures

List of Tables

1. WATERSHED SUMMARY

Watershed characterization reports are being developed for sixteen watersheds located in Northern Kentucky that lie within Sanitation District No.1's (SD1's) service area. The purpose of the watershed characterization reports is to describe the physical and natural features, land cover, infrastructure, waterbody conditions, potential pollutant sources and other features in each watershed. This information will allow SD1 and other interested parties to develop an understanding of important features, pollutant sources and water quality in the watersheds. This information will also assist SD1 and others in goal-setting, prioritization of improvement projects, and the assessment of the effectiveness of these projects. The watershed characterization reports meet the system characterization element for the receiving water that is required for a combined sewer overflow (CSO) Long-Term Control Plan (LTCP). Additionally, the Consent Decree requires that the Watershed Plans include elements of a LTCP.

The Fourmile Creek watershed is 17.8-square miles in size and is located entirely within Campbell County in the East Study Basin (Figure 1). This creek originates near Alexandria and flows northward to the Ohio River. The watershed is primarily rural and approximately 34% is developed.

The Kentucky Division of Water (KDOW) has designated this creek and its tributaries for warm water aquatic habitat, primary contact recreation, secondary contact recreation and domestic water supply (at applicable points of withdrawal). KDOW has identified 8.2 miles of this creek as impaired. A comparison of recent data to applicable water quality criteria revealed elevated bacteria concentrations and dissolved oxygen violations. Biological data indicate variable conditions in Fourmile Creek. Aquatic habitat assessments indicate available habitat cannot support a diverse and productive aquatic ecosystem.

Potential pollutant sources in this watershed include: one combined sewer overflow (CSO), sanitary sewer overflows (SSOs), other KPDES dischargers, septic systems, and storm water runoff. The potential for these sources to generate fecal coliform bacteria has been assessed using a Watershed Assessment Tool (WAT!)[1]. The WAT! identifies the potential sources within a watershed and estimates their possible impact. It also allows SD1 to compare and rank the 16 different Northern Kentucky watersheds.

The WAT! calculated a lower than average fecal coliform loading potential for year-round conditions and a very high loading potential for base flow conditions. Overland storm water runoff is predicted to be the dominant source under year-round conditions and septic systems are predicted to be the dominant source under base flow conditions.

The WAT! ranking is one of several factors that should be considered when prioritizing watersheds for improvement projects. Other factors include high public interest due to the presence of a Source Water Assessment and Protection Zone 1 and the absence of any waters with special designations or threatened or endangered species in the watershed.

[1] The WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

Next steps in this watershed may include coordination with the health department and investigation of dry weather bacteria sources. Coordination with the permitting authority may also be beneficial, as many permit violations were identified through a review of recent effluent monitoring data. Additional sampling could help to identify sources contributing to the low dissolved oxygen, while habitat, biological and storm flow bacteria sampling would help to assess conditions as improvement projects are implemented.

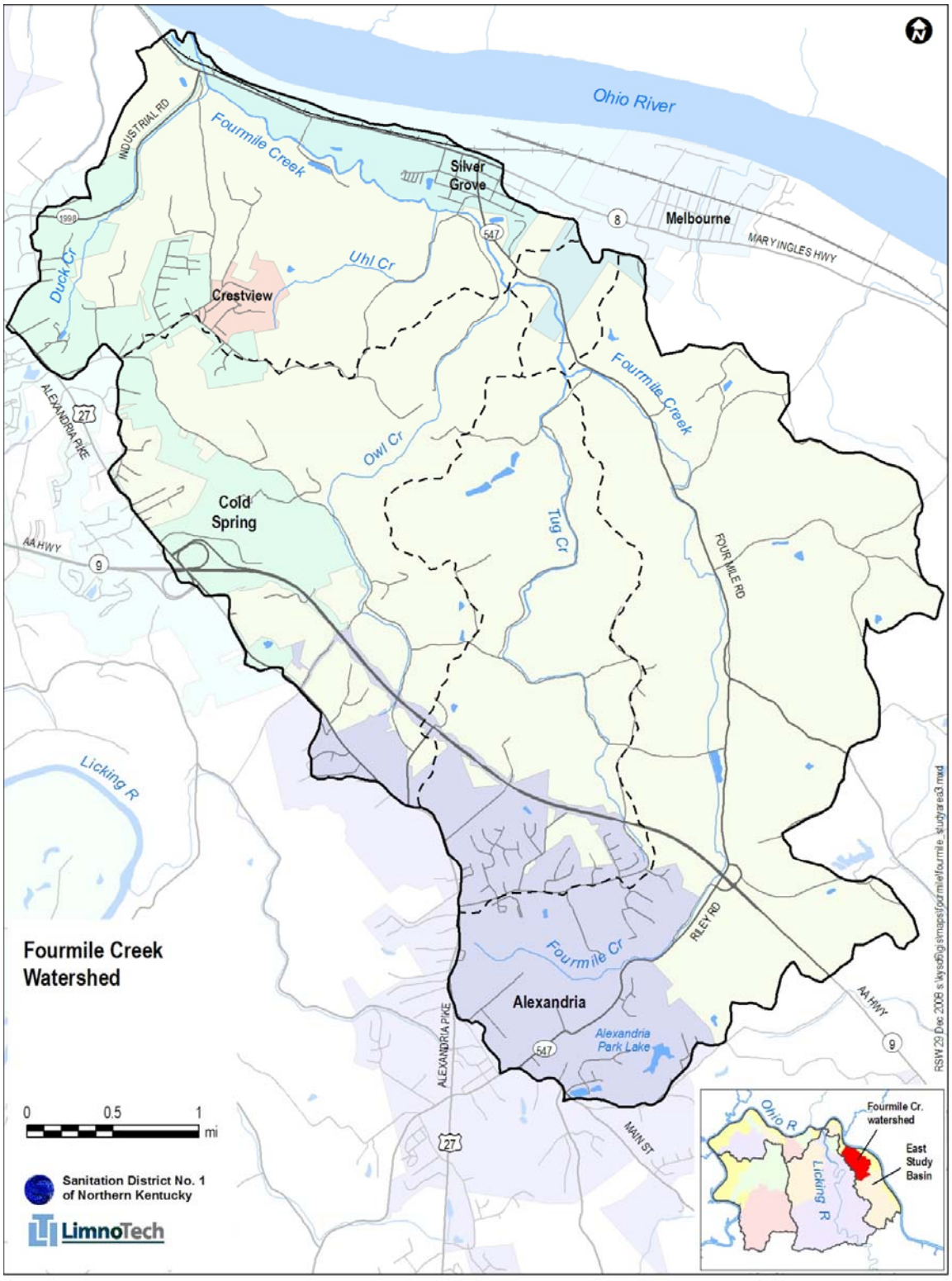

Figure 1. Fourmile Creek Watershed

This page is blank to facilitate double sided printing.

2. WATERSHED FEATURES

Fourmile Creek originates near the community of Alexandria, Kentucky and flows northward for 9.4 miles to the Ohio River. The watershed is 17.8 square miles in size and is located entirely in Campbell County.

2.1 PHYSICAL AND NATURAL FEATURES

The following sections describe key features of the watershed and creek, including hydrology, geology, topography, soils, climate, and habitat. These features are important because they affect land uses, and shape the chemical, biological, and hydrological characteristics of Fourmile Creek.

2.1.1 Hydrology

An active USGS continuous monitoring station (03238772) is located on Fourmile Creek at Poplar Ridge Road near Alexandria, KY[2]. The watershed draining to the station is 3.1 square miles, comprising approximately 17% of the Fourmile Creek watershed. Daily discharge measurements are available at the station from March 2001 to the present[3]. The average flow at the station is 4.5 cfs (3/10/2001 - 9/30/2007), and 95% of flows are less than 20 cfs. Base flows at this location have been measured at less than 0.5 cfs, with flows increasing by up to three orders of magnitude during a storm event. The maximum flow recorded at the USGS station is 170 cfs. The periods of high flow tend to be very brief and only last one to two days. In contrast, during extended periods of dry weather, flows at the station become intermittent. Between March 2001 and September 2007 there were 105 days with zero flow.

Fourmile Creek is fed by four major tributaries: Tug Creek, Owl Creek, Uhl Creek and Duck Creek. There are no natural lakes in the watershed, but two reservoirs exist in the City of Alexandria. Smaller impoundments have also created some small reservoirs in the upper reaches of tributaries to Tug and Fourmile Creeks. One study (MACTEC, 2007) indicates that Fourmile Creek was straightened at one location between 1961 and 1970 and a second location between 1974 and 1979. These two locations are downstream of Uhl Creek, and one straightening is thought to be related to the location of a landfill.

The 100-year floodplain is generally restricted to the low-lying areas adjacent to Fourmile Creek, Tug Creek, Owl Creek and Uhl Creek. No recurring flooding problems were identified in the Fourmile Creek watershed (FEMA, 2007); however, there are persistent drainage issues at the culverts under Route 8 near the confluence with the Ohio

[2] Historical flows are also available for Fourmile Creek at Highway 547 (RM 5.1) near Alexandria (gage 03238780) for the period October 1999 through March 2001. The drainage area upstream of this gage is 5.3 square miles. This gage was moved from this location to the current location at the request of the land owner.

[3] This analysis only uses approved data from USGS, and at the time of the analysis data was approved through 9/30/2007.

River. The combined impacts of Ohio River backwater and the bottleneck caused by the culverts have resulted in significant ponding of water just upstream from Route 8.

2.1.2 Geology

The Fourmile Creek watershed is located in the Outer Bluegrass Physiographic[4] Region, which is underlain primarily by Ordovician-age interbedded limestone and shale. Although roughly one-third of this watershed is underlain by bedrock with a moderate potential for karst development (Paylor and Currens, 2002), rocks in this region generally contain higher percentages of shale layers and do not develop extensive karst features (Ray et al., 1994)[5].

The rolling upland areas in this watershed are underlain by the Grant Lake Limestone/Fairview formation, which produces broad stream valleys. The mainstem of this creek and the majority of the tributaries cut through the erodible shale found in the Kope formation. Near the mouth, Fourmile Creek traverses unconsolidated glacial deposits. Groundwater yield varies depending on geological formation. There is almost no groundwater available on the ridgetops, but wells in the valley bottoms may yield 100-500 gallons per day. This water may be hard and contain salt and hydrogen sulfide. Near the Ohio River, iron content may also be high (Carey and Stickney, 2005).

2.1.3 Topography

Rolling hills and tight valleys in the uppermost parts of the watershed give way to gentle slopes and wide flat valleys as the creek flows towards the Ohio River. The lowest elevation in the watershed (453.6 feet at normal Ohio River pool) occurs at the confluence of Fourmile Creek with the Ohio River, in Silver Grove, KY. The highest elevations in this watershed are found at the western edge of the watershed along a ridge occupied by Alexandria Pike. The highest point is near the intersection of Alexandria Pike and Riley Road in the southwest corner of the watershed (890 feet above mean sea level). The headwaters of Fourmile Creek, Tug Creek, and Duck Creek have similarly high elevations.

2.1.4 Soils

The nature of watershed soils influences the magnitude and timing of runoff, the potential for soil erosion, and chemical characteristics of the receiving waters. Most (89%) of the soils in the Fourmile Creek watershed are classified as hydrologic soil group C (NRCS, 2006), meaning that they have slow infiltration rates when thoroughly wetted.

Approximately one-third of the soils in the watershed are ranked “highly erodible”, and the remaining two-thirds of the watershed soils are ranked “fairly erodible” as indicated by an index for erodibility (NRCS, 2006). The erodibility of soils is important when soils are disturbed through activities such as land clearing for new development. Much of this

[4] Physiographic regions are based on differences in geology, topography and hydrologic regime. The State of Kentucky is divided into five physiographic regions (Ray et. al., 1994).

[5] In areas with karst, an almost immediate connection between groundwater and surface water can exist, short-circuiting any attenuation of pollutant loads that might otherwise occur.

watershed is rural, but development is expected to increase in the future (Section 2.2). Severe streambank erosion is currently occurring within this watershed (Figures 2 and 3).

Figure 2. Fourmile Creek at KY 8 (RM 0.5)

Figure 3. Fourmile Creek at Riley Road (RM 8.2)

2.1.5 Climate

The temperatures in this area are generally lowest in January and highest in July. Precipitation averages 41.2 inches annually, with the wettest months observed between March and July. Minimum precipitation is recorded in the fall and late winter as shown in Figure 4 (NCDC, 2008).

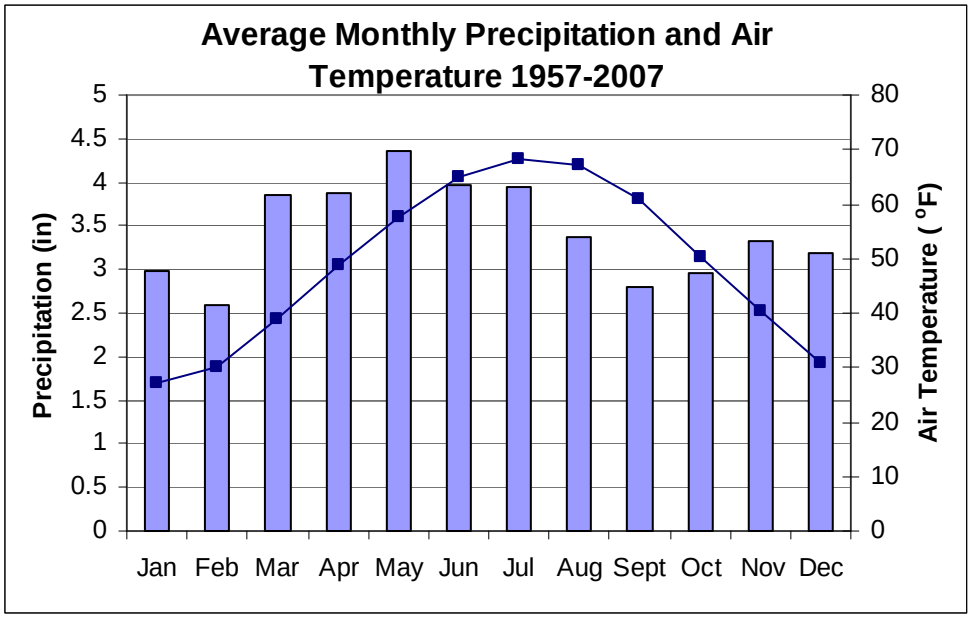

Figure 4. Average Monthly Precipitation and Air Temperature at the Cincinnati Northern Kentucky Airport (1957-2007)

2.1.6 Habitat

The Fourmile Creek watershed lies within the Outer Bluegrass ecoregion[6], which is characterized by sinkholes, springs, entrenched rivers and intermittent and perennial streams (Woods et al. 2002). Wetlands are not common in this ecoregion and comprise less than 0.5% of this watershed. Streams typically have relatively high levels of suspended sediment and nutrients. Glacial outwash, which tends to be highly erodible, exists in a few areas.

Pre-settlement conditions in this ecoregion consisted of open woodlands with barren openings, and vegetation was mostly oak-hickory, with some white oak, maple-oak-ash and American beech-sugar maple forests (Woods et al. 2002). As described in Section 2.2.1, natural habitats have been altered from pre-settlement conditions.

[6] Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources (Woods et al., 2002).

Outside of the City of Alexandria, the creek supports a variety of aquatic habitats, but the riparian zone is narrow (less than 30 feet) and erosion is a problem (Figure 3)[7]. Farther downstream, effects of sedimentation and eutrophication can be observed, along with a reduction in habitat diversity (Figure 5). Near the mouth, Fourmile Creek is wide and receives backwaters from the Ohio River.

Aquatic habitat assessments[8] have been conducted within Fourmile Creek and its tributaries. All sites have been ranked as "not supporting" of diverse aquatic communities for all surveys described in Table 1. Primary parameters that appear to be contributing to the poor ranking for habitats at these stations appear to result from the 'poor' to 'marginal' conditions of bank stability, bank vegetation, flow, riparian zones and sediment deposition.

Table 1. Aquatic Habitat and Biological Sampling

Stream	River Mile	Habitat		Macroinvertebrates		Diatoms		Fish	
		Date	Ranking	Date	Ranking	Date	Ranking	Date	Ranking
Fourmile Creek	0.5	2007	Not supporting	2007	Poor			2007	Good
	2.8	1999, 2004	Not supporting					1999, 2004	Excellent, Fair
	6.9	2007	Not supporting	2007	Fair			2007	Fair
	8.2	2007	Not supporting	2007	Poor	1999	Poor	2007	Good
Alexandria Park Lake	0.6							2004[a] 2005[a] 2006[a]	
Owl Creek	0.4	2007	Not supporting	2007	Fair			2007	Fair
Tug Creek	0.4	2007	Not supporting	2007	Good			2007	Fair

[a]A ranking was not calculated for these samples because this site is a lake and there is no method for calculating fish community rankings for lake ecosystems.

[7] Riparian zones are important to aquatic systems for several reasons: they provide wood recruitment which creates habitat, they support invertebrate food sources for fish and provide organic matter for instream invertebrates, they shade the water and allow cool temperatures to be maintained within the stream, and they filter sediment and toxics from entering the stream.

[8] The assessments were conducted using EPA-established protocols and rated several components of physical habitat within the stream such as epifaunal substrate, embeddedness, sediment deposition, channel flow status, bank stability, and riparian vegetation width, among others.

Figure 5. Fourmile Creek at Uhl Road (RM 2.5)

2.2 LAND COVER CHARACTERISTICS

Land cover and land use play an important role in the quantity and quality of runoff into receiving waters. Current and future land cover in the Fourmile Creek watershed are described below.

2.2.1 Current Land Cover

The Kentucky Division of Geographic Information, Commonwealth Office of Technology provided a GIS dataset showing 2005 Kentucky land cover. This dataset was updated and improved to approximate 2007 land cover conditions (Figure 6) using a variety of other datasets that represent current impervious conditions (roads, parking lots, buildings), open space lands (including parks), and surface waters.

The Fourmile Creek watershed is predominantly forested (47%), with lesser amounts covered with developed lands (34%) and pasture/hay (12%). During a site visit, it was observed that much of the forest is mixed with agricultural land uses.

Developed lands, including developed open spaces such as parks, are primarily located in the northern and western portions of the watershed. Roughly 6% of the watershed is impervious.

Developed lands include the community of Crestview and portions of the communities of Alexandria, Cold Spring, Silver Grove, and Melbourne. Parks include the Alexandria fairgrounds, neighborhood and school parks, ball fields and a campground.

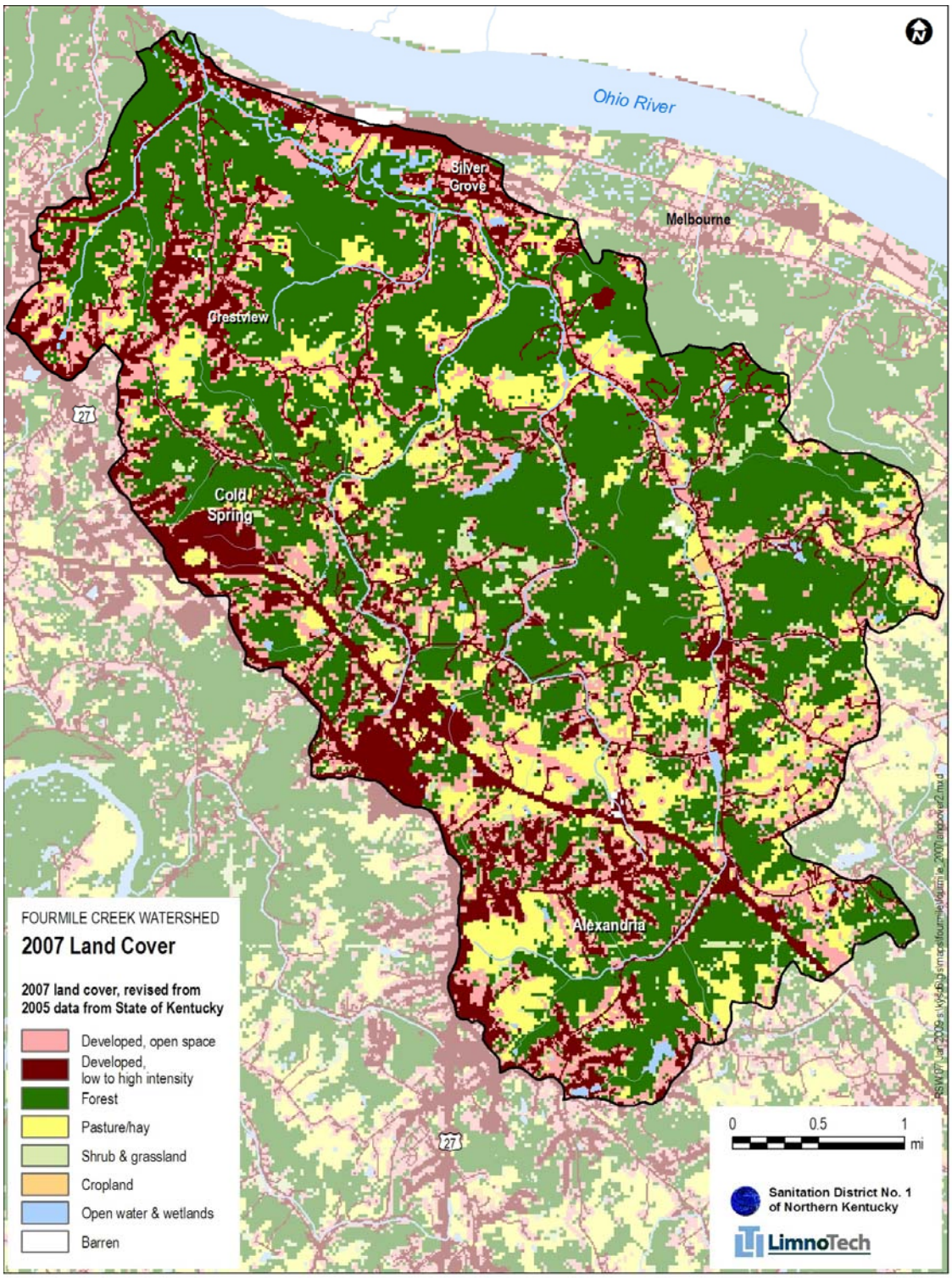

Figure 6. 2007 Land Cover

2.2.1.a Animal operations

There are no permitted concentrated animal feeding operations (CAFOs) or animal feeding operations (AFOs) in the watershed (Kentucky Geographic Network, 2008, 2008a). There are farms with beef cattle, swine, and horses (Campbell County Conservation District, 2007), but information on these animals is limited. A tour of the watershed confirmed that livestock are present, but not prevalent in this watershed.

2.2.1.b Septic and Cavitat Systems

SD1 estimates that approximately fifteen percent of all parcels in the Fourmile Creek watershed are potentially serviced by septic systems. These systems are found throughout the watershed. Three areas were identified in the Owl Creek subwatershed as having septic problems. These "septic hotspots" are areas in older subdivisions that either have very small lots that have unrepairable failing systems, or have systems that have been repaired to the extent practicable on the site, but are not fully functional (NKHD, 2008a).

The Northern Kentucky Health Department does not currently have estimates of septic system failure rates in Campbell County. Anecdotal reports from Health Department inspectors suggest that 10% of the septic systems in Northern Kentucky may be operating improperly due to incorrect installation, lack of maintenance or age of the system (NKHD, 2008). Furthermore, the Health Department has indicated that, based on slope, soil, and substrate characteristics, septic systems installed in Campbell County are prone to more frequent failures than those located in Boone or Kenton Counties (NKHD, 2008).

Furthermore, SD1 has identified at least ten addresses served by "cavitat" systems. Cavitat systems use older technology to treat sewage and are a possible source of bacteria within this watershed. Five are located within the Owl Creek subwatershed, in older subdivisions, and five are located just upstream of Fourmile Creek RM 4.1.

2.2.2 Future Conditions

Southern Campbell County has been under a construction moratorium due to a lack of sewage treatment capacity. The Eastern Regional Water Reclamation Facility (ERWRF) was recently opened in the adjacent Twelvemile Creek watershed, and the construction moratorium was partially lifted as of May 2008. As such, development in this watershed is expected to increase. The realignment/expansion of portions of US 27 (Alexandria Pike) is another factor that may contribute to development in this area. US 27 traverses the western border of the Fourmile Creek watershed.

2.2.2.a Future land cover

Future land cover was developed by modifying 2007 land cover to reflect potential future conditions (roughly 2030) obtained from SD1 and the Northern Kentucky Area Planning Commission (NKAPC).

It is predicted that development will become the dominant land cover, comprising 46% of the watershed (Figure 7). An estimated 9% of the watershed will be covered with impervious surfaces.

Local interest in protecting farmland might alter forecasted future development patterns. A recent report (AFT, 2005) surveyed farmland owners in Campbell County and found that "65% of the landowners want their land to stay in agricultural production for the foreseeable future, about 20-30 years. About 32% would like to keep their land in agriculture even after they no longer own it, and 21% are willing to explore options for protecting their land for the future." Several areas in Campbell County, including Camp Springs, are actively pursing agri-tourism as the new focus for their economic and land development activity (Jacobs, Edwards and Kelcey, 2008).

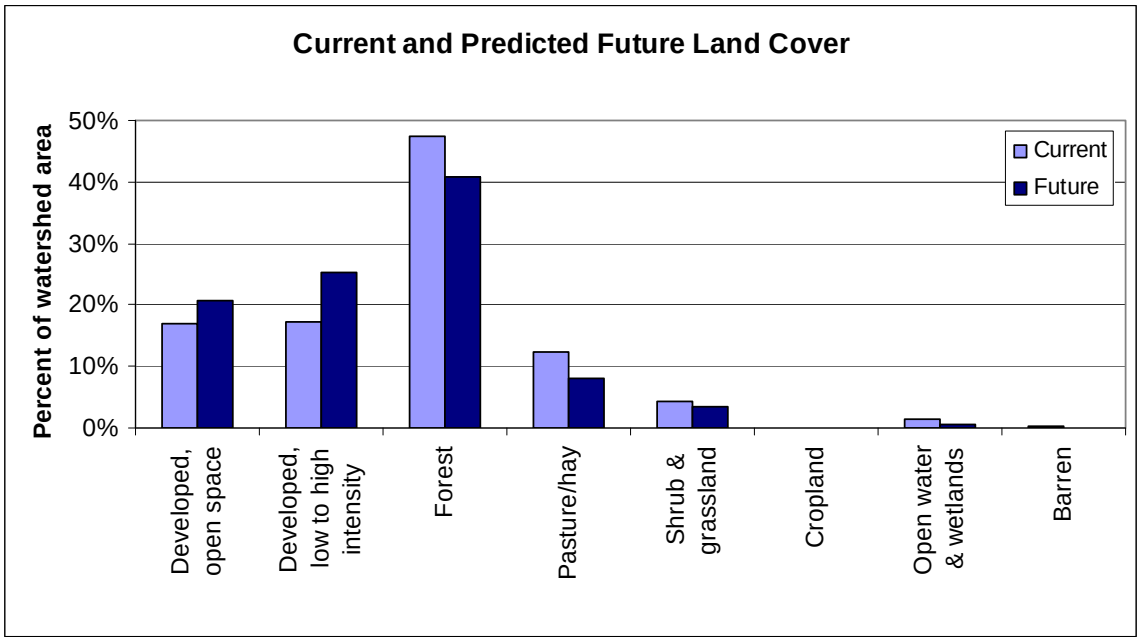

Figure 7. Current and Predicted Future Land Cover

2.3 INFRASTRUCTURE FEATURES

This section summarizes infrastructure features for the Fourmile Creek watershed[9].

Approximately 33% of this watershed is located within SD1's sanitary sewer service area. This area contains approximately 47.4 miles of separate sanitary sewer lines.

Approximately 74% of this watershed lies within SD1's storm water service area. Within the service area, the storm water system is comprised of approximately 161.2 miles of streams and channels and approximately 22.4 miles of pipes. The extent of the sanitary and storm water service area within this watershed is shown in Figure 8.

2.3.1 Point Sources and Infrastructure

The occurrence of KPDES-permitted discharges, sewer overflows and storm water discharges are discussed below.

[9] SD1 is undertaking a characterization and assessment of the sewer system, and overflows identified herein are subject to change. Information on the sanitary and storm water system in Section 2.3 was queried from SD1's geodatabase accessed on November 21, 2008.

2.3.1.a KPDES dischargers

There are thirty-six KPDES-permitted dischargers in the Fourmile Creek watershed. One discharger has a permit for two outfalls. All thirty-seven permitted outfalls are for sanitary wastewater, and the majority (24) are covered under general permits for residences.

Based on a review of recent effluent monitoring data (January 2007 to June 2008), it was observed that fifteen of the permitted outfalls have violated permit limits for at least one of the following parameters: total chlorine, total ammonia, dissolved oxygen, E. coli, fecal coliform, $CBOD_5$, BOD_5, total suspended solids, and pH. KDOW requires effluent monitoring for the residential general permits (monitoring is required twice a year); however, data were not available for 16 of these facilities in this watershed. KDOW estimates that residential dischargers, as a general group, fail at a rate that is believed to be higher than 10% (KDOW, 2007).

Permitted dischargers are presented in Table 2. CSOs are not included in this tally, and are discussed separately.

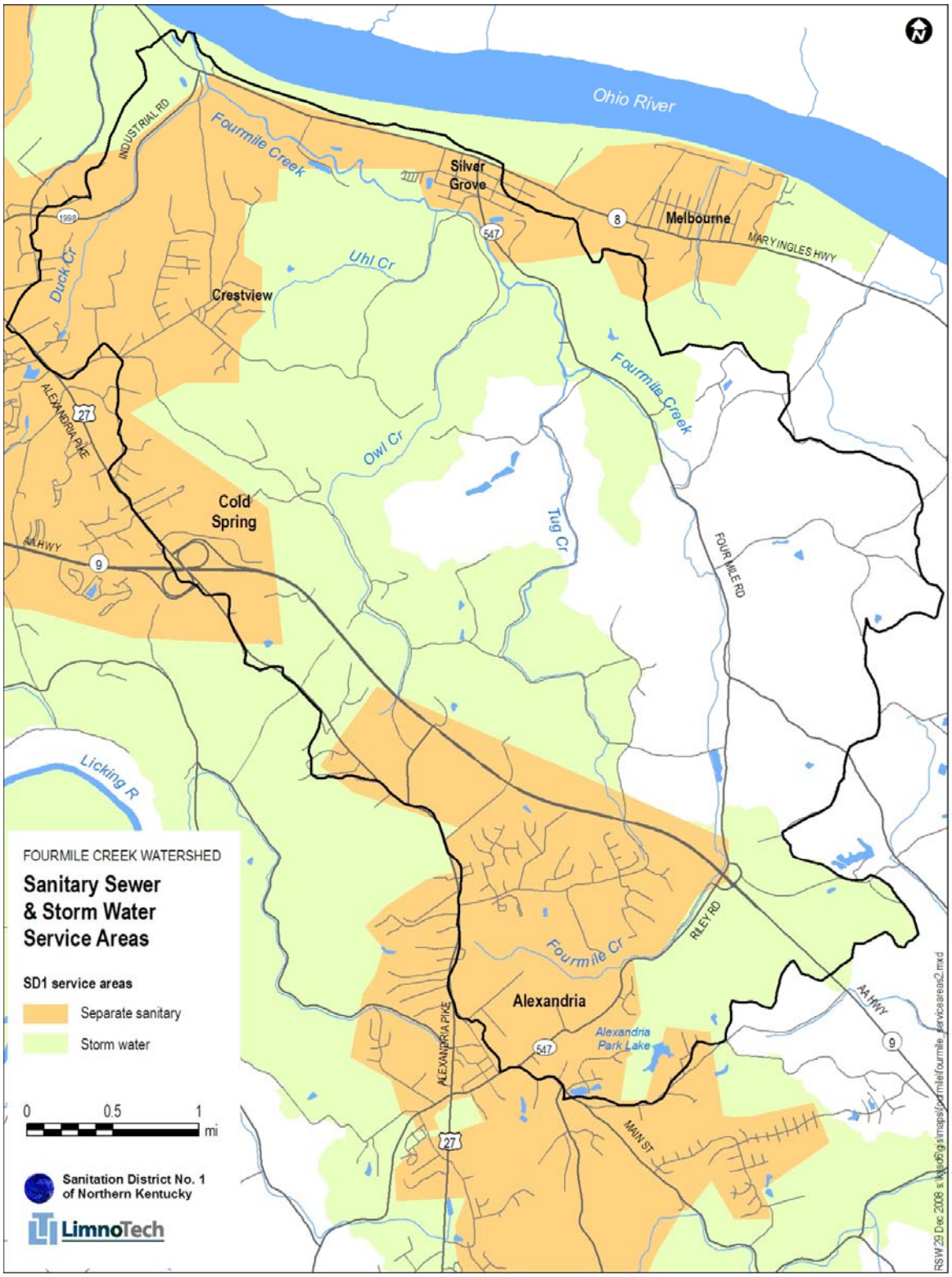

Figure 8. Sanitary Sewer and Storm Water Service Areas

Table 2. KPDES Permitted Dischargers

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Permit Violations
Duck Creek	KYG401024	Residence	0011	Minor	Sanitary wastewater Type B	NA
Uhl Creek	KYG400889	Residence	0011	Minor	Sanitary wastewater Type B	NA
Owl Creek	KY0034231	Higdons Mobile Home Village	0011	Minor	Sanitary wastewater	Total chlorine, total ammonia
Owl Creek	KY0034711	South Hills Subd	0012	Minor	Sanitary wastewater	Total chlorine, total ammonia
			0022	Minor	Sanitary wastewater	Total chlorine, total ammonia
Owl Creek	KY0078000	Campbell Ridge Apts	0011	Minor	Sanitary wastewater	Dissolved oxygen, total chlorine
Owl Creek	KY0086525	White, Dennis Businesses	0011	Minor	Sanitary wastewater	NA
Owl Creek	KY0089079	Pike Cold Spring STP	0011	Minor	Sanitary wastewater	Dissolved oxygen, E. coli, fecal coliform
Owl Creek	KY0089117	Summit Church Of Christ	0011	Minor	Sanitary wastewater	CBOD5, dissolved oxygen, fecal coliform, total ammonia, TSS
Owl Creek	KYG400182	Residence	0011	Minor	Sanitary wastewater Type B	None
Owl Creek	KYG400552	Residence	0011	Minor	Sanitary wastewater Type B	NA
Owl Creek	KYG400553	Residence	0011	Minor	Sanitary wastewater Type B	BOD5, TSS
Owl Creek	KYG401546	Residence	0011	Minor	Sanitary wastewater Type B	NA
Owl Creek	KYG401717	Residence	0011	Minor	Sanitary wastewater Type B	NA
Owl Creek	KYG402029	Residence	0011	Minor	Sanitary wastewater Type B	NA
Tug Creek	KY0034495	Douglas Subd	0012	Minor	Sanitary wastewater	CBOD5, dissolved oxygen, fecal coliform, pH, total ammonia, TSS
Tug Creek	KYG400398	Residence	0011	Minor	Sanitary wastewater Type B	None
Tug Creek	KYG401720	Residence	0011	Minor	Sanitary wastewater Type B	NA
Tug Creek	KYG401845	Residence	0011	Minor	Sanitary wastewater Type B	NA
Tug Creek	KYG401926	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG400268	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KY0034479	Camp Springs Tavern	0012	Minor	Sanitary wastewater	None
Fourmile Creek	KY0075752	St Joseph Parish	0012	Minor	Sanitary wastewater	Total chlorine
Fourmile Creek	KY0076139	Northern Ky Saddle Club	0012	Minor	Sanitary wastewater	Dissolved oxygen, total chlorine
Fourmile Creek	KY0092843	Yung Farm Estates Subd	0011	Minor	Sanitary wastewater	CBOD5, fecal coliform, total chlorine, TSS

Table 2. KPDES Permitted Dischargers - Continued

Receiving Water	KPDES ID	Facility Name	Outfall	Permit Type	Outfall Description	Permit Violations
Fourmile Creek	KY0096105	Reitman Auto Parts Inc	0011	Minor	Sanitary wastewater	Dissolved oxygen, total chlorine
Fourmile Creek	KYG400091	Residence	0011	Minor	Sanitary wastewater Type B	None
Fourmile Creek	KYG400132	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG400215	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG400255	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG400751	Residence	0011	Minor	Sanitary wastewater Type B	BOD5, fecal coliform
Fourmile Creek	KYG400816	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG400993	Residence	0011	Minor	Sanitary wastewater Type B	BOD5, fecal coliform, total ammonia, TSS
Fourmile Creek	KYG401222	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG401282	Residence	0011	Minor	Sanitary wastewater Type B	NA
Fourmile Creek	KYG401568	Residence	0011	Minor	Sanitary wastewater Type B	None
Fourmile Creek	KYG401767	Residence	0011	Minor	Sanitary wastewater Type B	Fecal coliform, total ammonia, TSS

NA – Monitoring data were not available

2.3.1.b Sewer overflows

There is one combined sewer overflow (CSO) located in this watershed (Table 3) and sewer separation is being done to reduce its overflow volume. SD1 plans to have this CSO permitted in the next KPDES permit cycle.

Table 3. Combined Sewer Overflow Point

Manhole ID	Direct Discharge to Waterbody	Typical Year Spill Frequency (No.)[a]	Typical Year Volume (million gallons)[a]
0010220[b]	Trib to Fourmile Creek	29	2.43

[a] The results presented were generated by models based on SD1's current understanding of the collection system infrastructure. These models are predictive tools and are based on numerous variables and assumptions on the characteristics of the collection system, and may differ from actual measured field conditions. These models are subject to change based on improved knowledge of the system, improvements to the system, and changes in land use and development. These results are subject to change and should therefore not be relied on or considered definitive.

[b] This is a "to be permitted" CSO, i.e., SD1 has (or will) identified this location for KPDES permitting.

There are seven sanitary sewer overflows (SSOs) in this watershed (Table 4). Four of these are pump stations that have had spills occur due to wet weather.

Table 4. Sanitary Sewer Overflow Points

Manhole ID	Direct Discharge to Waterbody	Typical Year Spill Frequency (No.)[a]	Typical Year Volume (million gallons)[a]
0020014	No[b]	1	0.002
0020005	Fourmile Cr.	32	21.53
2150050	No[b]	0	0
Riley Rd. #1 pump station (2230PS3)	Fourmile Cr.	NA	NA
Enzweiller pump station (2210PS2)	No[b]	NA	NA
Silver Grove pump station (0020PS1)	Fourmile Cr.	NA	NA
Crestview pump station (2150PS1)	No[b]	0	0

[a] The results presented were generated by models based on SD1's current understanding of the collection system infrastructure. These models are predictive tools and are based on numerous variables and assumptions on the characteristics of the collection system, and may differ from actual measured field conditions. These models are subject to change based on improved knowledge of the system, improvements to the system, and changes in land use and development. These results are subject to change and should therefore not be relied on or considered definitive.

[b] Greater than 50 feet from waterbody

NA indicates model data not available

2.3.1.c Storm water discharges

Storm water pipe outlets are primarily concentrated along Alexandria Pike and AA Highway, and in developed areas in the southern and western portion of the watershed, which are located within SD1's storm water service area. Most of the outfalls are found near the headwaters of Fourmile Creek, Tug Creek, Owl Creek and Duck Creek. In

addition to storm water outfalls, there are approximately 20 suspected illicit activity points (SIAs) in the separate storm water area. SIAs are locations were there was possible evidence of illicit discharges during SD1's storm water mapping project (2001-2002). These locations are being further investigated to determine if they are recurring.

The eastern third of the watershed is located outside of the storm water service area, so outfalls and other illicit discharges may be located in these areas, but were not inventoried by SD1.

2.3.2 Recently Completed Infrastructure Projects

There are several infrastructure projects that have been recently completed.

- Macke Pump Station Project. The pump station has been extensively rehabilitated to replace an existing maintenance-intensive pump station. The new pump station eliminated a constructed bypass and provides back-up power to the pump station via an onsite engine generator.
- Pinehill/Skyview Terrace Sewer Replacement Project. Completed in 2006, this project replaced a failing sewer damaged in a landslide behind several houses in the Fourmile Creek watershed. The project eliminated a broken pipe that was leaking sewage into backyards.
- Viewpoint Drive Sewer Assessment Project. Completed in 2005, this project involved extending sewer lines, giving 72 properties the opportunity to connect to sewer service. Approximately 60% of this area is located in the Owl Creek subwatershed. The remainder is in the Licking River watershed.

2.3.3 Ongoing or Planned Infrastructure Improvement Projects

There are several ongoing and planned infrastructure improvement projects for the Fourmile Creek watershed. These projects are mainly part of the overall Eastern Regional Improvements that are being constructed to address overflows in the southern Campbell County area. More details on these projects are shown below.

- ***Eastern Regional Riley Road Pump Station and Gravity Sewer*** – These collection system improvements will provide a new pump station, gravity and force main connections to route flows to the new ERWRF. Gravity lines from Riley Road #1 to the new Riley Road PS will enable SD1 to remove the Riley Road #1 pump station which has known overflows. The anticipated completion date for this work is 2009.
- ***Douglas Subdivision*** – It is anticipated that this KPDES-permitted treatment plant will be removed when residents are able to secure state revolving funds (SRF) and replace it with a pump station to route flows to Riley Road #2. The anticipated completion date for this work is 2007 or 2008.
- ***Silver Grove Storm Sewer Separation*** –SD1 is conducting an ongoing study of the Silver Grove/Highland Heights area. This study focuses on the capacity problems located in both Silver Grove and Highland Heights, which are located

just north of the Fourmile Creek watershed. As the sewer separation projects in Silver Grove progress, this will continue to reduce CSO volume.

- ***Pump Station Backup Power and Pump Station Overflow Elimination Plan –*** As part of the Consent Decree, SD1 is required to provide backup power to all pump stations, and address overflows from pump stations with constructed bypasses. In the Fourmile Creek watershed, seven pump stations will need to be retrofitted with back up power supplies. Additionally, Riley Road #1 and Crestview constructed overflows must be eliminated by 2010 and 2015 respectively. Field crews are scheduled to begin inflow/infiltration (I/I) investigations in the area of the Crestview pump station. Crestview has a constructed bypass that overflows in wet weather, in addition to an SSO within the vicinity. In addition, wet weather flows into Enzweiller pump station will be addressed along with the back-up power as part of the implementation of the pump station back-up power plan.

Table 5 provides details on the anticipated start and completion dates, the total cost of the projects, and the expected goals of SD1 projects. In addition, one SSO (0020005) will be evaluated for improvements as part of the Watershed Plans.

Table 5. Ongoing or Planned Infrastructure Improvement Projects

Capital Improvement Project Title	Goals	Anticipated Start Date	Anticipated Completion Date	Project Total
Eastern Regional – Contract 7	New Riley Rd PS	Already started	2009	$7,100,000
Eastern Regional – Contract 3	Convey new pump station flow to ERWRF. Eliminates Riley Rd. #1 PS	Already started	2009	$6,100,000[a]
Silver Grove Storm Sewer Separation	Will reduce storm water that enters combined sewer in Silver Grove	Already started	Ongoing	NA
Pump Station Backup Power and Remediation	Ensure that all pump stations have backup power or other appropriate measures for addressing power outages	Already started	To be determined	To be determined

[a]This work will occur in both the Fourmile and Twelvemile Creek watersheds, however, it is not possible to separate out the cost by watershed, and so the total project cost is presented.

2.4 SENSITIVE AREAS

The federal CSO Control Policy (USEPA, 1994) states EPA's expectation that a permittee's Long-Term Control Plan (LTCP) give the highest priority to controlling CSOs in sensitive areas. The CSO Control Policy indicates that sensitive areas include:

- Waters designated as Outstanding National Resource Waters;
- Waters with threatened or endangered species and their habitat;
- Waters with primary contact recreation (such as bathing beaches);
- Public drinking water intakes and their designated protected areas;
- National Marine Sanctuaries (NMS); and
- Shellfish beds.

These six criteria were evaluated individually. None of the waters in the Fourmile Creek watershed have been designated by the State of Kentucky as Outstanding National Resource Waters (401 KAR 10:030). No state or federal threatened or endangered species were identified within the watershed, based on a review by the Kentucky State Nature Preserves Commission (KSNPC, 2006, 2006a)). No National Marine Sanctuaries have been designated within the project study area (NOAA, 2008). There are no known commercial shellfish beds within the Fourmile Creek watershed, nor is shellfish harvest for consumption by private individuals known to occur. The remaining two criteria are discussed below.

2.4.1 Primary Contact Recreation Waters

Kentucky does not have a tiered approach for primary contact recreation (PCR). This means that the State has designated that all PCR waters should be suitable for full body contact recreation during the recreation season of May 1 through October 31 (401 KAR 10:001E). The State water quality standards do not define full body contact recreation, so the bacteria criteria that have been developed are based on the presumption that people will ingest the water and could therefore become ill if the water was sufficiently contaminated with bacteria.

Fourmile Creek and its tributaries are designated for PCR. It is not clear whether or not swimming activity occurs in the creek, as public surveys regarding that information are unavailable. No public swimming beaches were identified in the watershed. Additional data will be gathered about the uses of the creek.

2.4.2 Public Drinking Water Intakes or Their Designated Protection Areas

There are no public drinking water intakes from surface water or groundwater within this watershed. There are three public drinking water intakes located in the Ohio River, approximately 2 to 3 miles downstream from this watershed. The Northern Kentucky Water District and Greater Cincinnati Water Works operate the intakes (Figure 9).

Source Water Assessment and Protection (SWAPP) zones for the Ohio River intakes are determined by the Ohio River Valley Water Sanitation Commission (ORSANCO). SWAPP zones are not used in a regulatory sense, but are delineated to identify potential contaminants upstream of water intakes and are used to support identification of sources potentially impacting the intakes. ORSANCO has determined that portions of this watershed are located within SWAPP Zone 1, the zone of critical concern, which extends twenty-five miles upstream of the water intakes.

2.5 PUBLIC INTEREST/WATERSHED GROUP ACTIVITIES

This watershed has been monitored since 1998 by several organizations (Section 4.2). No active watershed groups were identified, but interest in the adjacent Twelvemile Creek watershed is high due to the location of that watershed upstream of three drinking water intakes. The Fourmile Creek watershed is also upstream of the water intakes, and was therefore ranked as having high public interest.

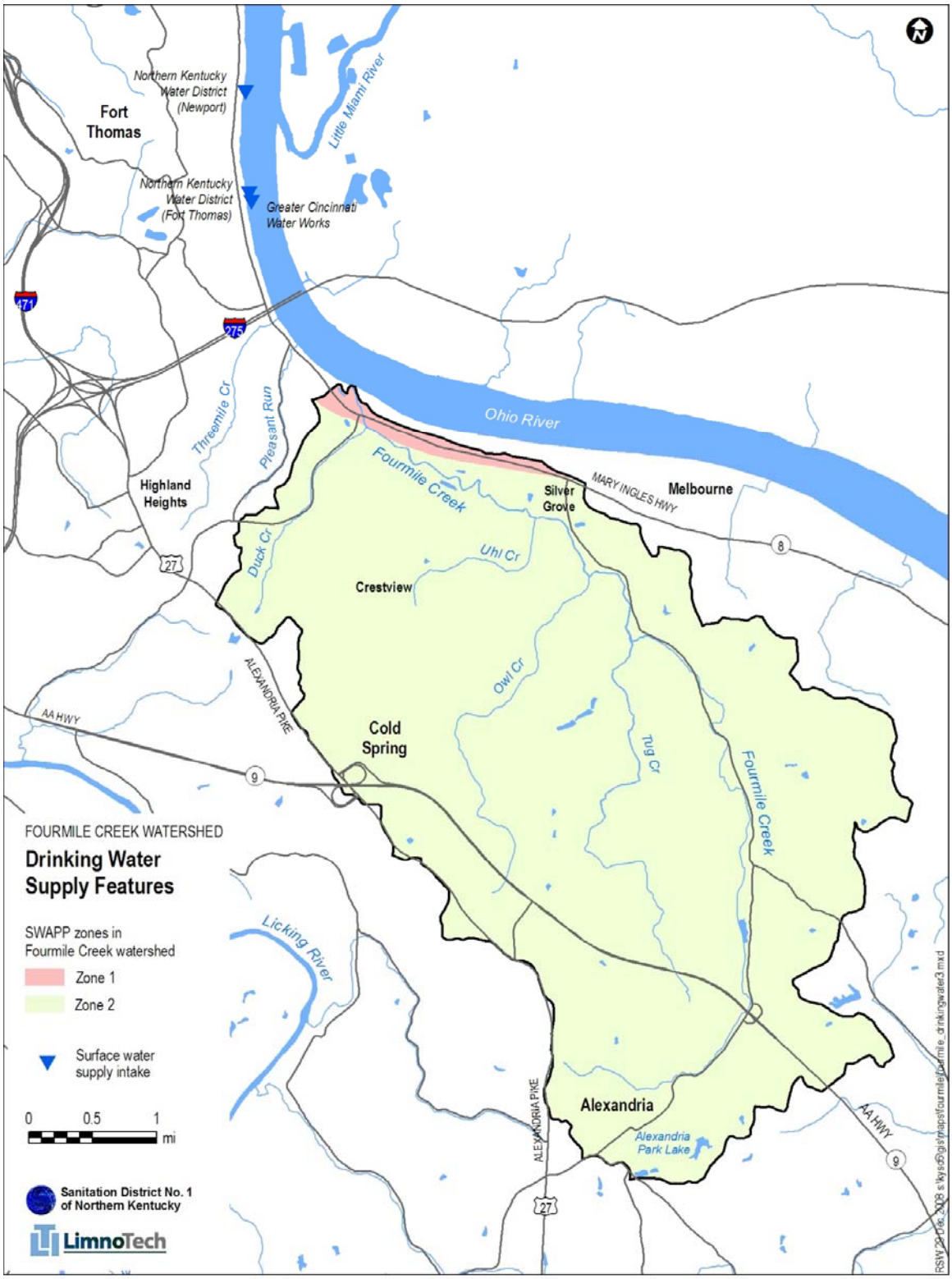

Figure 9. Drinking Water Supply Features

This page is blank to facilitate double sided printing.

3. WATERBODY USES

This section describes designated and current uses for Fourmile Creek and its tributaries.

3.1 DESIGNATED USES

Fourmile Creek and its tributaries are designated for warm water aquatic habitat, primary contact recreation, secondary contact recreation and domestic water supply, applicable at existing points of public water supply withdrawal (401 KAR 10:026). These are defined below.

- **Warm water aquatic habitat** means any surface water and associated substrate capable of supporting indigenous warm water aquatic life.
- **Primary contact recreation** waters means those waters suitable for full body contact recreation during the recreation season of May 1 through October 31.
- **Secondary contact recreation** waters means those waters that are suitable for partial body contact recreation, with minimal threat to public health due to water quality.
- **Domestic water supply** means surface waters that with conventional domestic water supply treatment are suitable for human consumption through a public water system as defined in 401 KAR 8:010, culinary purposes, or for use in any food or beverage processing industry; and meet state and federal regulations under the Safe Drinking Water Act, as amended, 42 U.S.C. 300f - 300j.

3.2 CURRENT USES

Available information on current uses in the watershed is presented below.

- Instream habitat in this watershed is rated “not supporting”, indicating that available habitat cannot support a diverse and productive ecosystem.
- The creek supports some pollution tolerant fish species, but diversity within the fish community exists. Fish Index of Biotic Integrity (IBI) ratings based on 2007 data range from fair to good. Macroinvertebrate scores range from poor to fair for the mainstem of Fourmile Creek, and fair to good for the tributaries.
- A statewide fish consumption advisory was issued on April 11, 2000 due to low levels of organic mercury found in fish taken from Kentucky waters (KDOW 2007a).
- There are currently no swimming advisories for Fourmile Creek. However, KDOW and the Division of Public Health Protection and Safety recommend against swimming or other full-body contact with surface waters immediately following heavy rainfall events, especially in dense residential, urban and livestock production areas (KDOW, 2007b).
- The reservoir in Alexandria is a popular fishing location and a fishing access site is located on this lake (http://kygeonet.ky.gov/kdfwr/viewer.htm).
- There are no water supply intakes from surface waters in this watershed.

- There are no active public water supply groundwater wells in this watershed (KDOW, 2008a; KDOW, 2007c).

4. WATERBODY CONDITIONS

This section describes monitoring programs and observed water quality and biological conditions in this watershed.

4.1 303(d) STATUS AND POLLUTANTS OF CONCERN

The segment of Fourmile Creek from River Mile (RM) 0.2 to RM 8.5 is listed on Kentucky's 2008 303(d) list of impaired waters along with one lake (Table 6; KDOW, 2008). The creek listing is based on fecal coliform data collected by the Kentucky Division of Water in 1999 near the mouth of Fourmile Creek (RM 0.5). The lake is listed based on mercury in fish tissue. TMDL development has not been initiated and neither the creek nor the lake is identified as having a TMDL planned for the near future (KDOW, 2008).

Table 6. 303(d) Listings

Waterbody Segment	Designated Uses (use support)	Pollutants	Suspected Sources
Fourmile Creek RM 0.2 – 8.5	Primary Contact Recreation (Nonsupport)	Fecal coliform	Municipal Point Source Discharges; Sanitary Sewer Overflows (Collection System Failures)
Alexandria Park Lake 6.1 acres	Fish Consumption (Partial support)	Mercury in fish tissue	Source unknown

4.2 MONITORING PROGRAMS

Water quality data have been collected in this watershed by Northern Kentucky University (NKU), Licking River Watershed Watch (LRWW), KDOW, USGS and SD1. Data currently compiled by SD1 from known monitoring programs are presented in Table 7, however, only data which have been fully analyzed are discussed in Section 4.3 Water Quality Data Analysis. Water quality data exist for the main stem of Fourmile Creek, as well as Tug Creek and Owl Creek.

Data not included in this report will be reviewed and included in subsequent updates.

Table 7. Summary of Water Quality Monitoring Data

Entity	Dates	Parameters Sampled	Sampling Locations[b]	Number of Samples
KDOW	1999	Fecal coliform, DO, pH, temperature	Fourmile Cr. RM 0.5	5 samples (Once a month; May - Sept.)
KDOW	1999, 2004	DO, pH, conductivity, turbidity, temperature	Fourmile Cr. RM 2.8	2 samples (8/31/1999 & 8/11/2004)
LRWW	1999, 2002	Fecal coliform	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	2 samples (7/16/1999 & 7/12/2002)
LRWW	2000	Fecal coliform	Fourmile Cr. RM 4.6	1 sample (7/14/2000)
LRWW	2004	Fecal coliform, E. coli	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	3 samples (May, July, Sept.)
NKU	1998	Fecal coliform, DO, pH	Fourmile Cr. RM 1.4	1 sample (7/14/1998)
NKU	1998	Alkalinity, bromide, chloride, fluoride, hardness, conductivity, sulfate, TOC, TSS, nutrients, metals	Fourmile Cr. RM 1.4	1 sample (10/11/1998)
NKU	1998	Alachlor, atrazine, chlorpyrifos-methyl, metolachlor, 2,4-D, Dichlorophenoxyacetic acid	Fourmile Cr. RM 1.4	1 sample (5/16/1998)
NKU	1999	Atrazine, chlorpyrifos-methyl, 2,4-D, Dichlorophenoxyacetic acid	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	1 sample (5/25/1999)
NKU	1999	Alkalinity, chloride, hardness, conductivity, sulfate, TOC, TSS, nutrients	Fourmile Cr. RM 1.4	1 sample (9/13/1999)
NKU	2000	Alkalinity, chloride, hardness, conductivity, sulfate, TOC, TSS, nutrients	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	1 sample (Sept.)
NKU	2000-2001	Fecal coliform, Fecal Streptococci	Fourmile Cr. RM 4.6; Tug Cr. RM 2.7	1 sample (July 2000, June 2001)
NKU	2001	Fecal coliform, E. coli, DO, pH, temperature	Owl Cr. RM 0	1 sample (8/25/2001)
NKU	2000-2001	Atrazine, metolachlor	Fourmile Cr. RM 1.4, 4.6; Tug Cr. RM 2.7	2 samples (May 2000, June 2001)
NKU	2002	Atrazine	Owl Cr. RM 0	1 sample (5/18/2002)
NKU	2003	Fecal coliform, DO, pH, temperature	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	1 sample (5/17/2003)
NKU	2003	Fecal coliform, alkalinity, boron, chloride, DO, hardness, pH, conductivity, silicon, sulfur, sulfate, TSS, temperature, nutrients, metals	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	1 sample (Sept.)
NKU	2003	Fecal coliform	Fourmile Cr. RM 1.4; Tug Cr. RM 2.7	1 sample (7/10/2003)
SD1	2006	Fecal coliform, E. coli, DO, pH, conductivity, turbidity, temperature	Fourmile Cr. RM 0.5, 2.5, 4.1, 6.9, 8.2	2 samples for baseline survey (10/9/2006 & 10/24/2006)

Table 7. Summary of Water Quality Monitoring Data - Continued

Entity	Dates	Parameters Sampled	Sampling Locations[b]	Number of Samples
SD1	2007	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, TSS, temperature, turbidity, nutrients	Fourmile Cr. RM 0.5, 6.9, 8.2; Tug Cr. RM 0.4; Owl Cr. RM 0.4	1 sample (5/1/2007)
SD1	2007, 2008 [a]	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, TSS, temperature, nutrients	Fourmile Cr. RM 0.5, 6.9, 8.2; Tug Cr. RM 0.4; Owl Cr. RM 0.4	3 Wet Weather Events in June, July, Oct. 2007, Oct. 2008 (18 samples from each station for all events)
SD1	2008 [a]	Fecal coliform, E. coli, carbonaceous biological oxygen demand (5-day), DO, pH, conductivity, TSS, temperature, turbidity, nutrients	Fourmile Cr. RM 0.5, 6.9, 8.2; Tug Cr. RM 0.4; Owl Cr. RM 0.4	1 sample (10/14/08)
USGS	1999-2001	Discharge	Fourmile Cr. RM 5.1 (Station No. 03238780)	Daily discharge
USGS	2001-present[a]	Discharge, temperature, DO, pH, conductivity, turbidity	Fourmile Cr. RM 7.0 (Station No. 03238772)	15-minute intervals

[a]Data not analyzed in Section 4.3, including USGS data collected after WY 2005

[b] RM = River mile

4.2.1 Future Sampling

SD1 plans to continue monitoring Fourmile Creek during base flow conditions with at least one survey per year. The five sampling locations are: Fourmile Creek RM 0.5, Fourmile Creek RM 6.9, Fourmile Creek RM 8.2, Tug Creek RM 0.4 and Owl Creek RM 0.4. Typical analysis will include bacteria, nutrients, solids, oxygen-demanding constituents and physical parameters. Additionally, surveys to assess the degree of stream hydromodification are currently underway by SD1.

The USGS will continue to operate the stage gage, and measure flow and water quality (physical parameters) at RM 7.0 (station 03238772). This station is operated and funded via a cooperative agreement between USGS and SD1.

Outfall sampling was initiated in 2007 to better characterize water quality and loadings from CSOs, SSOs and storm water runoff. One storm water outfall location is being sampled in this watershed and analyzed for bacteria, nutrients, solids, metals and oxygen-demanding constituents. This sampling program plan is anticipated to continue until ten events are monitored.

4.3 WATER QUALITY DATA ANALYSIS

Historical water quality data (1998-2005) have been analyzed to identify past water quality problems in this watershed. Data are available for the main stem of Fourmile Creek, as well as Owl Creek and Tug Creek. Historical exceedances of bacteria and dissolved oxygen have been observed. The dissolved oxygen violations were only observed at the USGS station.

Recent data (2006-present) have been analyzed in more detail to describe current stream conditions, because these data better reflect the effect of existing sources of instream water quality. Elevated bacteria, as well as dissolved oxygen violations were observed. It should be noted that the data collected at the USGS station are not included in this assessment of recent data. These data are being reviewed and will be included in the next update of this report.

4.3.1 Historical Data

Both discrete measurements and the continuous water quality data were analyzed to identify historical water quality problems.

Historical data reveal elevated bacteria at five locations (Table 8). Historical violations of the dissolved oxygen criteria were identified through a review of water year 2001-water year 2005 data conducted by Cumberland Environmental Group (CEG, 2007). Measurements at locations not shown or for parameters not discussed met the respective water quality criteria.

Table 8. Historical Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform bacteria		*E. coli* bacteria	
		# samples	% of samples exceeding criteria[a]	# samples	% of samples exceeding criteria [a]
Fourmile Creek	0.5	5	40%	---	n/a
Fourmile Creek	1.4	9	78%	2	100%
Fourmile Creek	4.6	3	100%	---	n/a
Owl Creek	0.0	1	100%	1	100%
Tug Creek	2.7	9	78%	1	100%

[a] There are no instances where 5 samples were collected from a single location within a 30-day period. Therefore the comparison to the geometric mean portion of the fecal coliform and E. coli criteria, which requires a minimum of 5 samples taken during a 30-day period, is not possible. Comparisons were, however, made to the part of the criteria that reads, "Content shall not exceed 400 colonies/100 ml in 20 percent or more of all samples taken during a 30-day period for fecal coliform or 240 colonies/100ml for E. coli." Even this comparison is conservative, as the criterion is meant to be applied to a dataset of 5 or more samples collected over a 30-day period.

Dissolved oxygen concentrations less than 4 mg/l have been observed at the USGS continuous monitoring station in all five water years that have been analyzed (WY 2001-2005). More violations were reported at this station than at any of the other seven Northern Kentucky stations that were operating during this period. These violations occurred between May and November, with most observed between July and September. A review of flow and dissolved oxygen data indicated that, in general, flows were very low (< 1 cfs) or zero on days where dissolved oxygen was less than 4 mg/l; 995 of the violations occurred at the lowest flows (CEG, 2007).

4.3.2 Recent Data

More recent water quality data were available for five locations along Fourmile Creek and two tributaries locations (Owl Creek and Tug Creek). The recent data collected at the USGS station are being reviewed and will be included in the next update of this report.

Summaries of recent water quality problems are presented in Tables 9 and 10. Locations with elevated bacteria and dissolved oxygen violations are identified. Measurements for parameters and locations that are not discussed met the respective water quality criteria.

Table 9. Recent Bacteria Exceedances

Stream	River Mile	Parameters exceeding criteria			
		Fecal coliform bacteria		*E. coli* bacteria	
		# samples	% of samples exceeding criteria[a]	# samples	% of samples exceeding criteria[a]
Fourmile Creek	0.5	21	76%	21	71%
Fourmile Creek	2.5	2	100%	2	50%
Fourmile Creek	6.9	21	86%	21	90%
Fourmile Creek	8.2	21	81%	21	81%
Owl Creek	0.4	19	84%	19	95%
Tug Creek	0.4	19	95%	19	95%

[a] There are no instances where 5 samples were collected from a single location within a 30-day period. Therefore the comparison to the geometric mean portion of the fecal coliform and *E. coli* criteria, which requires a minimum of 5 samples taken during a 30-day period, is not possible. Comparisons were, however, made to the part of the criteria that reads, "Content shall not exceed 400 colonies/100 ml in 20 percent or more of all samples taken during a 30-day period for fecal coliform or 240 colonies/100ml for *E. coli*." Even this comparison is conservative, as the criterion is meant to be applied to a dataset of 5 or more samples collected over a 30-day period.

Table 10. Recent Dissolved Oxygen Violations

Stream	River Mile	Parameters violating criteria	
		Dissolved oxygen	
		# measurements	% of measurements in violation[a]
Fourmile Creek	0.5	16	19%
Fourmile Creek	8.2	16	6%

[a] The dissolved oxygen criterion is 4 mg/l.

A discussion of recent water quality issues follows below by parameter.

4.3.2.a Bacteria

Fecal coliform data are available for both storm and base flow conditions. As shown in Figure 10, elevated base flow fecal coliform levels were observed along Fourmile Creek, at RM 0.5, 2.5, and 6.9. The maximum base flow fecal coliform concentration of 620 cfu/100 ml was recorded at RM 0.5. Storm flow exceedances of the criteria were observed at all locations sampled. The maximum average storm flow fecal coliform concentration of 19,766 cfu/100 ml was recorded in Fourmile Creek at RM 8.2.

As shown in Figure 11, base flow samples showed elevated *E. coli* in Fourmile Creek, at RM 2.5 and 6.9. The maximum base flow *E. coli* concentration of 568 cfu/100 ml was recorded in Fourmile Creek, at RM 6.9. Storm flow exceedances of the *E. coli* criterion were observed at all locations sampled. The maximum average storm flow *E. coli* concentration, 12,040 cfu/100 ml was recorded in Tug Creek at RM 0.4.

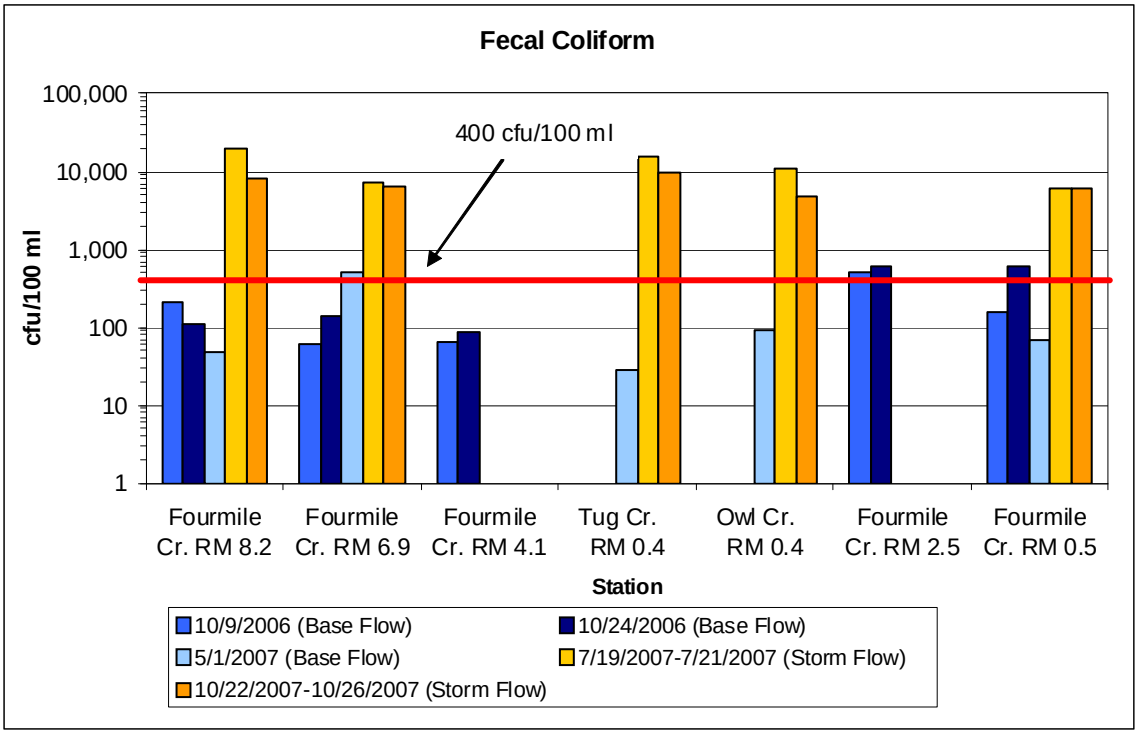

Figure 10. 2006-07 Base Flow and Average Storm Flow Fecal Coliform Concentrations Compared to 400 cfu/100 ml Criterion

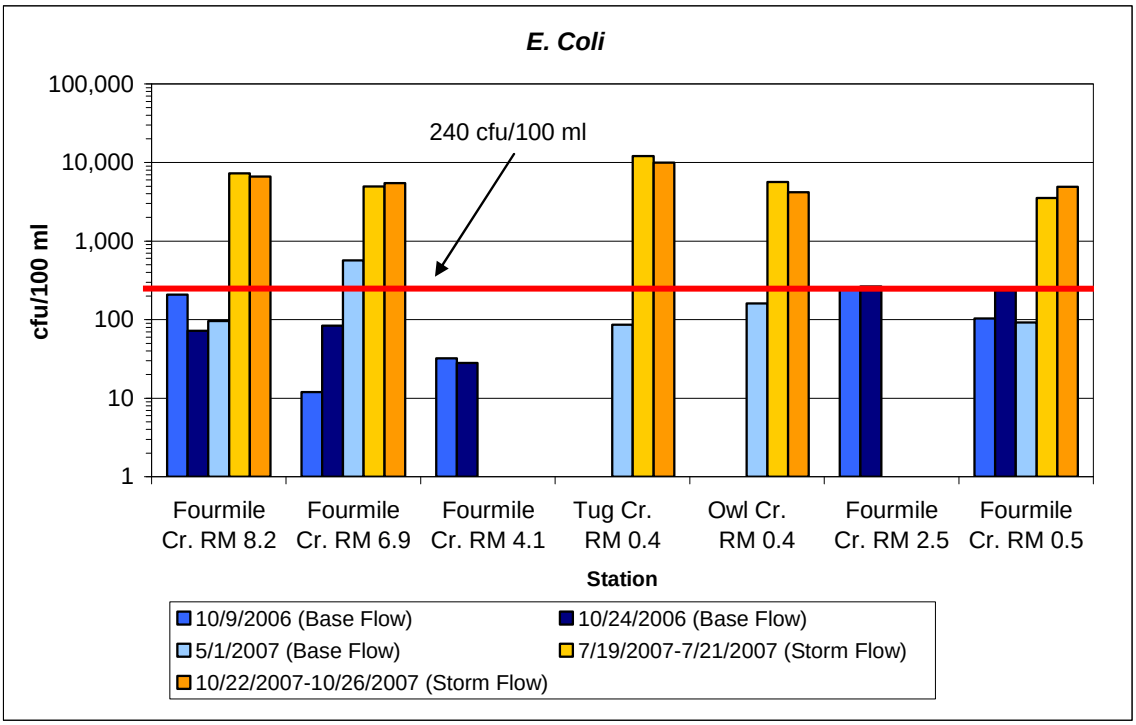

Figure 11. 2006-07 Base Flow and Average Storm Flow *E. coli* Concentrations Compared to 240 cfu/100 ml Criterion

4.3.2.b Dissolved Oxygen

Dissolved oxygen measurements were collected in the Fourmile Creek watershed between 2006 and 2007. Dissolved oxygen concentrations in the 80 samples ranged from 2.86 mg/l to 12.21 mg/L. Dissolved oxygen concentrations violated applicable criteria at two of the seven locations for which recent data were available, with violations observed in 6-19% of samples for these locations.

4.4 BIOLOGICAL CONDITIONS

Benthic algae are useful biological indicators of water quality because they are sensitive to changes in water quality and are primary producers within aquatic ecosystems. Diatoms are benthic algae that are useful indicators of biological integrity because at least a few can be found under almost any condition and they are identifiable to species (KDOW, 2008b). In 1999, Fourmile Creek received a poor rating based on diatom measurements (Table 1).

Fish communities have been sampled three times (1999, 2004, and 2007) in Fourmile Creek (Table 1). The KIBI score[10] calculated in 1999 for Fourmile Creek (RM 2.8)

[10] The data from this survey were used to calculate the Kentucky Index of Biotic Integrity (KIBI), a multimetric index using fish as an indicator of stream health. The KIBI compiles attributes of the fish community such as taxa richness and abundance, pollution tolerance/ intolerance, feeding and reproductive

indicated "excellent" conditions. A subsequent sample in 2004 from this same location produced a rating of "fair". Fish were also sampled in Alexandria Park Lake in 1999 and 2004. Because a rating index has yet to be developed for Kentucky lakes, no KIBI score could be assessed.

Additionally, in 2007, SD1 sampled fish populations at several locations in Fourmile Creek and its tributaries. On the Fourmile Creek mainstem, these sites included the Silver Grove Pump Station off of State Route 8 (RM 0.5), the USGS station off of Poplar Ridge Road (RM 6.9), and the bridge on Appleblossom Lane (RM 8.2). Fourmile Creek tributaries sampled in 2007 included Owl Creek at RM 0.4 and Tug Creek at RM 0.4. The KIBI scores indicated that the condition of the mainstem sites varies between "fair" and "good", and that the Owl Creek and Tug Creek tributary sites are in "fair" condition.

Macroinvertebrate communities are susceptible to water quality and habitat degradation, and data from these communities are used as a tool for assessing stream health. In 2007, SD1 sampled aquatic macroinvertebrates in the Fourmile Creek mainstem and its tributaries at the same locations previously mentioned. The MBI scores[11] for these sites indicated that the Fourmile Creek mainstem conditions range from "poor" to "fair", while tributary conditions range from "fair" in Owl Creek to "good" in Tug Creek.

4.5 STREAM METABOLISM

Stream metabolism can be used as a measure of ecosystem health because it responds to the complex interactions between instream conditions (physical, biological, chemical) and watershed conditions. It can be assessed by looking at the ratio of primary production (P), which is influenced by instream conditions (light and nutrient inputs), to respiration (R), which is influenced by watershed conditions (other nutrient and detritus inputs). This ratio can be calculated using continuous instream dissolved oxygen measurements, because dissolved oxygen responds to both instream and watershed inputs. Smaller ratios (e.g., P:R less than 1) suggest that stream system health is more strongly affected by watershed inputs than by instream and near stream processes.

Stream metabolism has been analyzed at the eight USGS continuous monitoring stations which deploy multi-parameter sondes. These stations are located in watersheds that have varying levels of watershed impacts; however, none are located in an unimpacted or reference watershed. For the 2000-2005 period, all eight sites have ratios that indicate the health of these streams is more strongly affected by watershed inputs than instream and near stream inputs.

For the period 2000 to 2005, Fourmile Creek (RM 6.9) has an average P/R ratio that represents the median among the monitored sites, suggesting that stream metabolism at this site approximates the organic consumption processes found in other monitored sites.

needs, and presence or absence of native species in order to provide a numerical value and corresponding narrative classification for streams.

[11] The macroinvertebrate data collected by KDOW were used to calculate the macroinvertebrate biotic index (MBI). The MBI compiles attributes of the macroinvertebrate community such as taxa richness, pollution tolerant species and pollution intolerant species. Additional metrics are added depending on the stream size and/or ecoregion.

Further, fluctuations in average annual metabolism measures for the Fourmile Creek site appear similar to the average observed at other monitoring sites for the 2000-2005 period. Continued evaluation of stream metabolism at the Fourmile Creek site will help to understand the natural variability of metabolism and the potential of changes within this watershed impacting the production/respiration balance at this site.

This page is blank to facilitate double sided printing.

5. SOURCE ANALYSIS

This section summarizes potential pollutant sources in the Fourmile Creek watershed and also for the smaller tributary subwatersheds, to provide information related to recent observed impairments. Conclusions are based on the watershed characterization and available water quality data.

5.1 WATERSHED SOURCE ANALYSIS

Potential sources of bacteria and dissolved oxygen were identified within this watershed, based on watershed characterization information presented previously. These sources are summarized in Table 11 and their location is shown in Figure 12.

Table 11. Summary of Potential Sources

	Fourmile Creek Headwaters – Tug Creek	Tug Creek	Owl Creek	Fourmile Creek Tug Creek - Mouth
Recent observed impairments[e] =>	Bacteria[c], Dissolved oxygen, Bank erosion (observed)	Bacteria[c],	Bacteria[c],	Bacteria[c], Dissolved oxygen, Bank erosion (observed)
SSOs[a]				3
SSO – pump stations[a]	1	1		2
CSO[a]				1
Septic systems	Numerous	Numerous	Numerous. 3 septic hot spots	Numerous
Cavitat systems[b]			1 neighborhood	1 neighborhood
KPDES-sanitary outfalls[d]	16	5	13	3
Storm water runoff	Urban and rural	Urban and rural	Urban and rural	Urban and rural
Watershed improvements	SSO at Riley #1 PS to be eliminated by 2010	Macke constructed PS bypass recently eliminated. SSO at Enzweiller PS to be addressed Douglas subd planned for elimination		Sewer separation ongoing to reduce CSO volume SSO at Crestview PS bypass to be eliminated by 2015 Another SSO will be evaluated for improvements as part of the Watershed Plans

[a]SD1 is undertaking a characterization and assessment of the sanitary sewers system, and sources are subject to change.

[b]Cavitat systems are an older technology used to treat sewage, which are not very effective and which are a suspected bacteria source.

[c] Potential bacteria sources contributing to the primary contact recreation use impairment are: municipal point source discharges and sanitary sewer overflows (collection system failures) (KDOW, 2008)

[d] Excludes CSOs.

[e] The 2008 303(d) list also identifies mercury as an impairment in fish in Alexandria Park Lake. The source is unknown. Potential mercury sources are not included in this table.

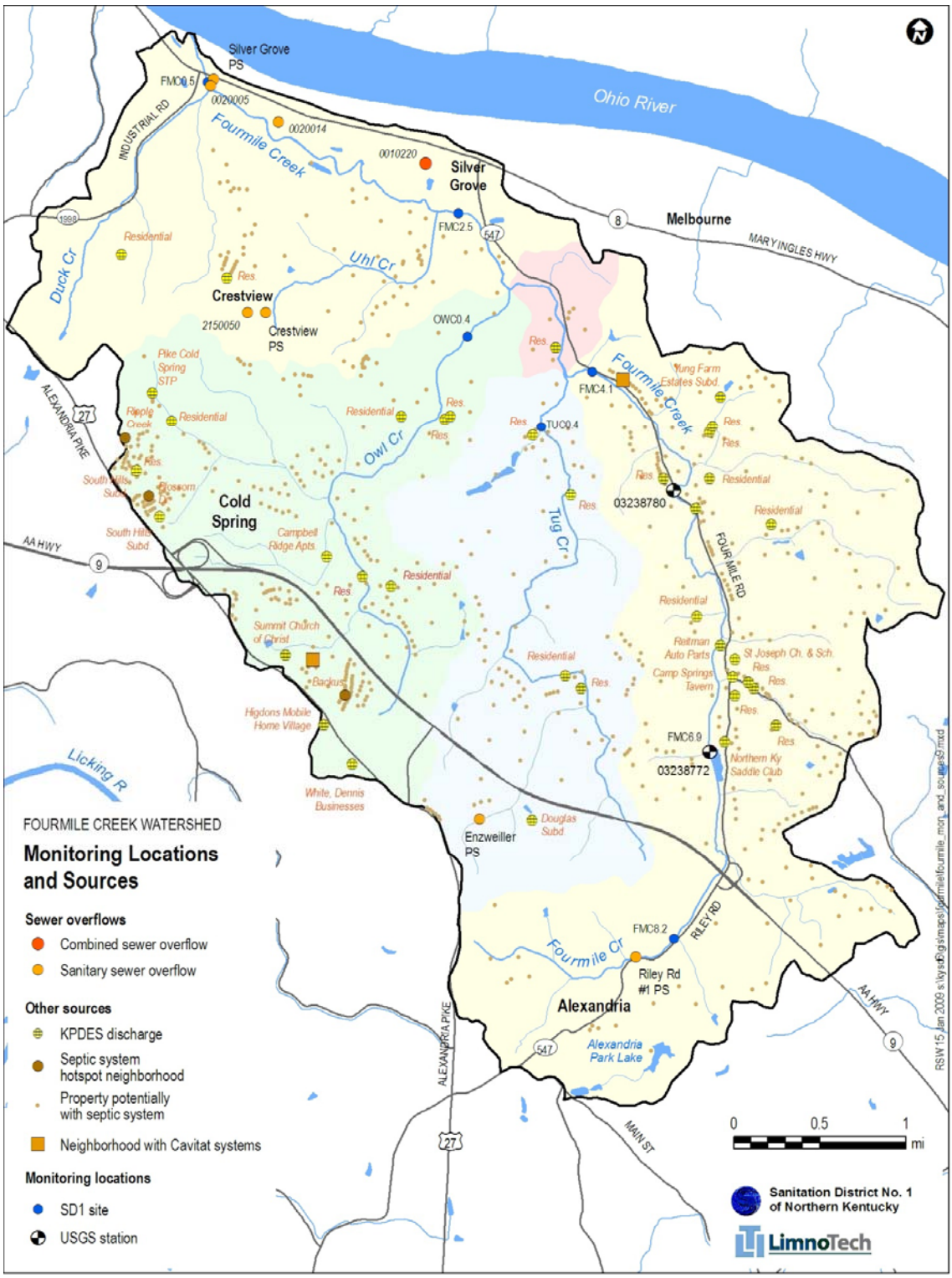

Figure 12. Monitoring Locations and Sources

6. RANKING

6.1 RESULTS

The WAT! is a tool that assesses the potential for point and nonpoint sources to generate fecal coliform, total solids and total phosphorus pollutant loads. WAT! was developed for these three pollutants because data to support modeling were readily available and they are representative indicators of potential water quality conditions. Calibration of the WAT! tool for total solids and total phosphorus is planned, and results should be available in future reports. Results for fecal coliform are discussed below.

This analysis was conducted for each of the sixteen watersheds located within SD1's study area. In addition to assessing pollutant loading potential by source, the WAT! also assesses pollutant loading potential by watershed, which allows for ranking and comparisons among the sixteen watersheds.

WAT! results[12] indicate that under year-round conditions, the Foumile Creek watershed has a low ranking (analogous to load) for fecal coliform, relative to the sixteen identified watersheds in SD1's jurisdictional area.

In addition to WAT! results, other factors such as presence of public drinking water features, presence of aquatic-dependent threatened and endangered (T&E) species, special designations, and public interest may affect watershed prioritization. These and other ranking considerations are summarized in Table 12.

Table 12. Watershed Ranking Considerations

CSO (#)	SSO (#)	SWAPP Zone	Aquatic-dependent T&E Species[a] (#)	Special Designations	Public interest	WAT Rank, year-round conditions[b]
						Bacteria
1	7	Zone 1 (due to Ohio R. intakes) and Zone 2	None	None	High	10 of 16

[a] There are no threatened or endangered (T&E) species or species of special concern in this watershed

[b] The WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

6.2 SCREENING TO DETERMINE IF ADDITIONAL DATA ARE NEEDED

Sufficient data and information are currently available or planned for collection to support a reasonable understanding of current conditions in the Fourmile Creek watershed. Septic systems are suspected to be the primary source of the base flow bacteria levels, but this has not been confirmed. Sources contributing to the dissolved oxygen violations are not known.

[12] WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

6.2.1 Data Gap Analysis

Additional data collection is recommended to provide information on sources and to track water quality improvement as projects are implemented. Specific recommendations are discussed below.

A site visit and coordination with the local health department is recommended, to investigate dry weather bacteria sources in this watershed. Furthermore, coordination with the permitting authority is also recommended, as many permit violations were identified through a review of recent effluent monitoring data.

Continued biological monitoring, habitat assessments, and storm flow bacteria sampling would help to assess whether conditions have improved once infrastructure projects are completed. Furthermore, base flow sampling for ammonia, biochemical oxygen demand and sediment oxygen demand at the USGS station (03238772) would provide information on whether the bottom sediments or watershed sources are contributing to low dissolved oxygen at this location.

6.3 SOURCE PRIORITIZATION

The sources identified through the process of watershed characterization have been quantified using the WAT!. WAT! has been applied for a five-year period (1992-1996 climatological conditions), to quantify fecal coliform contributions by source. Together the characterization and WAT! results help inform source prioritization for improvement or elimination.

6.3.1 WAT! Results

The relative fecal coliform load generated by source is shown in Figure 13. These WAT! results incorporate predicted sewer overflow volumes from infrastructure model simulations for 1992-1996 climatological conditions[13]. Flow estimates are available for the one CSO and three of the SSOs in this watershed.

Under year-round conditions, the largest source of fecal coliform bacteria is storm water runoff. Septic systems are not a significant contributor to the total annual bacteria load; however, during base flow conditions they are estimated to contribute the majority of the fecal coliform load.

[13] The results presented were generated by models based on SD1's current understanding of the collection system infrastructure. These models are predictive tools and are based on numerous variables and assumptions on the characteristics of the collection system, and may differ from actual measured field conditions. These models are subject to change based on improved knowledge of the system, improvements to the system, and changes in land use and development. These results are subject to change and should therefore not be relied on or considered definitive.

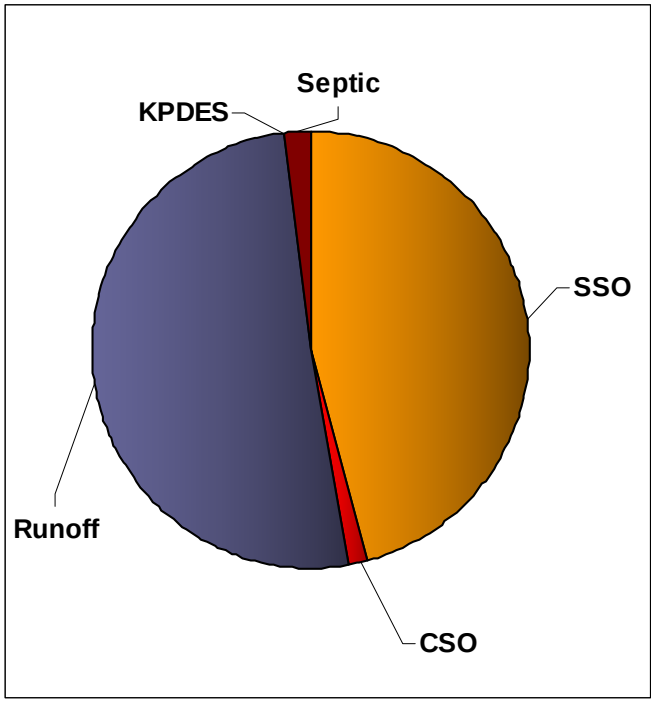

Figure 13. Initial Year-Round WAT! Results for Fecal Coliform

WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

WAT! results should be considered preliminary as ongoing work may affect the WAT! source analysis and rankings. Work is currently ongoing to refine the bacteria contribution from septic systems.

6.4 WATERSHED RANKING

The WAT! produced a ranking by watershed for sixteen watersheds based on their potential to generate fecal coliform loads over a 1-year period. The water quality impact score (analogous to load) for each of the sixteen watersheds was used as a ranking metric. Additional detail on the ranking is available in the WAT! documentation.

The WAT! produces rankings of the watersheds for both base flow and year-round conditions. By separating base flow conditions, the impacts of dry weather sources on stream conditions can be differentiated from the combined impact of dry and wet weather sources. The ranking of the Fourmile Creek watershed during year-round and base flow conditions is provided in Table 13.

Table 13. WAT! Watershed Rankings

	Rank for Year-Round Conditions[a,b]	Rank for Base flow Conditions[a,b]
Fecal coliform	10	1

[a] Rank ranges from 1 to 16. A rank of 1 indicates a high water quality impact score, which is analogous to load. The lowest rank possible is 16.

[b] WAT! is still under development. All results presented here are for illustrative purposes only. The results are subject to change and should therefore not be relied on or considered definitive.

The WAT! analysis for both total solids and total phosphorus will be presented in future reports upon completion of the WAT! calibration. Future monitoring programs will continue to populate and refine WAT! results and rankings, aiding in characterization of potential sources.

7. REFERENCES

American Farmland Trust (AFT), 2005. A Profile of Agriculture and Cost of Community Services Study. Campbell County Kentucky. Commissioned by Campbell County Conservation District.

Campbell County Conservation District, 2007. Agricultural Water Quality Self Certifications - Tracking Sheet.

Carey, D. I. and Stickney, J. F., 2005. Groundwater Resources of Campbell County, Kentucky. Kentucky Geological Survey County Report 19, Series XII, ISSN 0075-5567.

Cumberland Environmental Group, LLC (CEG), 2007. Continuous Monitoring Network Synthesis Report Water Years 2001 – 2005. Prepared for Sanitation District No. 1 of Northern Kentucky. Draft.

FEMA, 2007. Disaster information. [online]: http://www.fema.gov/news/disaster_totals_annual.fema

Five Mile Limit Policy (Water Policy Memorandum, Policy No. 84-02), Natural Resources and Environmental Protection Cabinet Department for Environmental Protection Division of Water, August 28, 1984.

Grace, M.R. and S.J. Imberger. 2006. Stream Metabolism: Performing & Interpreting Measurements. Murray Darling Basin Commission, Water Studies Centre Monash University and New South Wales Department of Environment and Climate Change. 204 pp. Accessed at http://www.sci.monash.edu.au/wsc/docs/tech-manual-v3.pdf

Jacobs, Edwards and Kelcey, 2008. Comprehensive Plan Update Campbell County, Kentucky. May 2008.

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 001E. Statement of Emergency Regulation. Definitions for 401 KAR Chapter 10.

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 026. Designation of Uses of Surface Waters. Administrative Register of Kentucky.

Kentucky Administrative Regulations (KAR). 2008. Title 401 Natural Resources and Environmental Protection Cabinet Department for Environmental Protection. Chapter 10. Regulation 030. Antidegradation Policy Implementation Methodology.

Kentucky Commonwealth Office of Technology, 2005. 2005 Kentucky Land Cover. Obtained in November, 2007.

Kentucky Division of Water (KDOW), 2007. Personal communication, Florence Regional Office. April 9, 2007.

Kentucky Division of Water (KDOW), 2007a. Fish Consumption Advisories in Kentucky. www.water.ky.gov/sw/advisories/fish.htm Last modified 7/25/2007. Accessed 2/24/2008.

Kentucky Division of Water (KDOW). 2007b. Swimming Advisories in Kentucky. URL: http://www.water.ky.gov/sw/advisories/swim.htm. Last modified 11/8/07.

Kentucky Division of Water (KDOW), 2007c. Personal communication on status of domestic and public water wells. December 2007.

Kentucky Division of Water (KDOW), Kentucky Environmental and Public Protection Cabinet. 2008. 2008 Integrated Report to Congress on the Condition of Water Resources in Kentucky. Volume II. 303(d) List of Surface Waters. Final. May, 2008.

Kentucky Division of Water (KDOW), 2008a. Kentucky Drinking Water Watch Database Version 1.2. Accessed March 2008.

Kentucky Division of Water (KDOW), Department for Environmental Protection. 2008b. Standard Methods for Assessing Biological Integrity of Surface Waters. Revision 3. Ecological Support Section, Frankfort, Kentucky. February.

Kentucky Geographic Network, 2008. April 9, 2008. http://kygeonet.ky.gov/geographicexplorer/explorer.jsf

Kentucky Geographic Network, 2008a. August 11, 2008. http://kygeonet.ky.gov/geographicexplorer/explorer.jsf

Kentucky State Nature Preserves Commission (KSNPC). July 2006. Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities by Watershed - Boone, Campbell, and Kenton Counties. Confidential Preliminary Working Draft Watershed Consent Decree, Frankfort, Kentucky.

Kentucky State Nature Preserves Commission (KSNPC). February 2006a. Campbell County Report of Endangered, Threatened, and Special Concern Plants, Animals and Natural Communities of Kentucky. Frankfort, Kentucky.

MACTEC Engineering and Consulting, Inc. (MACTEC). 2007. Draft Report Phase I Non-Intrusive Environmental Evaluation for Sewer Line Replacement between Route 1998 and Ash Street Silver Grove, Kentucky. Prepared for Sanitation District No. 1. June.

McTammany, M.E., E.F. Benefield and J.R. Webster. 2007. Recovery of stream ecosystem metabolism from historical agriculture. J.N. Am. Benthol. Soc. 26(3):532-545.

National Climatic Data Center (NCDC), NOAA Satellite and Information Service. 2008. Data obtained for Cincinnati Northern KY Airport, Covington/Cincinnati, KY, United States. WBAN 93814.

National Oceanic and Atmospheric Administration (NOAA). 2008. National Marine Sanctuaries. http://sanctuaries.noaa.gov/welcome.html. Revised February 7, 2008. Accessed February 11, 2008.

Northern Kentucky Health Department (NKHD), 2008. Personal communication, February 2008.

Northern Kentucky Health Department (NKHD), 2008a. Personal communication, August 2008

Natural Resources Conservation Service (NRCS), 2006. SSURGO/GIS format. [online] http://datagateway.nrcs.usda.gov/.

Odum, E.P. 1956. Primary production in flowing waters. Limnology and Oceanography. 1:102-117.

Paylor, Randall L. and James C. Currens. *Karst Occurrence in Kentucky.* University of Kentucky, Kentucky Geological Survey. 2002. http://kgsweb.uky.edu/olops/pub/kgs/mc33_12.pdf. Accessed on May 21, 2007.

Ray, J.A., Webb, J.S., O'Dell, P.W. (Kentucky Department of Environmental Protection, Division of Water, Groundwater Branch), 1994. Groundwater Sensitivity Regions of Kentucky.

United States Environmental Protection Agency (USEPA). April 19, 1994. Combined Sewer Overflow (CSO) Policy. *Fed. Regist.* Vol. 59 pg. 18688.

Woods, A.J., J.M. Omernik, W.H. Martin, G.J. Pond, W.M. Andrews, S.M. Call, J.A. Comstock, and D.D. Taylor. 2002. Ecoregions of Kentucky. Color poster with map, descriptive text, summary tables, and photographs, U.S. Geological Survey (map scale 1:1,000,000), Reston, Virginia.